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Fluids and Barriers of the CNS

MEETING ABSTRACTS

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01

Adult normal pressure hydrocephalus, normal tension glaucoma and neurodegeneration. Are there any additional evidence based treatment options?

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:01

Introduction: Despite generally good technical progress in controlling intraocular pressure (IOP) in ophthalmology or ICP (intracranial pressure) in neurosurgery, it is known that some patients (about 25% of the targeted populations) still suffer from experiencing visual impairments or symptoms of dementia. This presents a dilemma for ophthalmologists, neurosurgeons and their patients.
Methods: A literature search was conducted using the keywords "normal pressure hydrocephalus" AND "normal pressure glaucoma" AND "neurodegeneration OR neuroprotection" to determine whether there are any promising treatments for protecting from neurodegeneration that could give hope to patients.
Results: 117 articles were found on PubMed and Google Scholar; after exclusion, 72 articles were screened, further exclusions were made when no reference to treatment options were reported. Treatment optionsincluded sleep, breathing, clean air, without fine particles; physical activity, posture, reduction of cardiovascular risk factors including adiposity; 1 Hz flicker light and electromagnetic stimulation; nutritional supplements, including polyunsaturated fatty acids (PUFA,) Vitamin B3, flavenoids; GABA agonists, brain-derived neurotrophic factor (BDNF) and nerve growth factor (NGF), mitochondrial and endoplasmic reticulum-associated treatments, those directed against ferroptosis and inflammation, and others seem in development.
Conclusions: The evidence for a variety of different treatments available should encourage both physicians and patients to engage in the treatment process to delay blindness or dementia, or both.

02

Non-invasive intracranial pressure waveform of patients with idiopathic intracranial hypertension

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Introduction: Idiopathic Intracranial Hypertension (IIH) is characterized by elevated intracranial pressure (ICP) without an identifiable cause, often leading to optic nerve sheath distension and visual impairment. The diagnosis and management of this condition necessitate invasive interventions. This study explores the feasibility of non-invasive ICP (nICPw) waveform analysis as an adjunctive diagnostic and monitoring tool in patients with a diagnosis of IIH.
Methods: We gathered data on the P2/P1 ratio, time-to-peak (TTP), and the standard deviation (±) from a cohort of 10 patients with a previous diagnosis of IIH. Data collection occurred in two positions: lying down, and at a 30-degree incline.
Results: The P2/P1 ratios while lying down, and at a 30-degree incline were 1.21 (±0.19), and 1.38 (±0.32) respectively. TTP values in patients with shunt dysfunction were 23.3 (±7.05), and 26.01 (±3.74) while lying down, and at a 30-degree incline, respectively.
Conclusions: Our findings suggest that nICPw data from this patient population could serve as a valuable tool for establishing baseline values. A crucial next step would involve comparing these measurements with those of healthy individuals lacking shunts. It's important to note that while our study revealed similar overall readings, the establishment of baseline values should be tailored to each patient.

03

Analyzing the prevalence of hakim's triad in the presentation of normal pressure hydrocephalus

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Introduction: In 1965, Hakim outlined a triad for diagnosing normal pressure hydrocephalus (NPH), featuring urinary incontinence, gait disturbances, and cognitive impairment. This triad has since served as a major tool for identifying key symptoms of NPH. However, the actual prevalence of Hakim's triad has not been systematically evaluated.
Methods: The authors conducted a systematic review and proportional meta-analysis to assess the prevalence of Hakim's triad symptoms in NPH patient presentations. Inclusion criteria involved original studies comprising solely NPH patients and reporting the prevalence of at least one triad symptom. Exclusion criteria included non-English studies, investigations of patients with other conditions, and studies focusing on specific triad characteristics. Data extraction involved recording the number of patients with each symptom, either individually or in combination. Single-arm proportions on R were utilized for statistical analysis.
Results: From 1668 studies, 23 were included in the final analysis, including 2581 patients. Of those, 64% (95% CI: 55–74%, $I^2 = 98\%$) had urinary incontinence, 95% (95% CI: 92%-98%; $I^2 = 93\%$) had gait disturbances, and 84% (95% CI: 78%-90%; $I^2 = 98\%$) had cognitive impairment. When looking for the proportion of patients with only one of the symptoms, it yielded 24% (95% CI: 4%-43%; $I^2 = 80\%$). As for two symptoms of the triad, 24% (95% CI: 11%-37%; $I^2 = 78\%$) of patients had this outcome. After analysis, the complete triad was present in 55% (95% CI: 39%-72%; $I^2 = 96\%$) patients. No study had a patient without any symptoms of Hakim's triad.
Conclusions: Hakim's triad stands as a valuable clinical instrument for identifying individuals afflicted with NPH, exerting a profound historical influence. However, our findings revealed marked heterogeneity. Hence, physicians should avoid delaying diagnosis until the complete triad manifests. Moreover, standardized investigations are warranted to ascertain the prevalence of patients exhibiting one, two, or all triad symptoms.

04

Screening iNPH patients using fundoscopy: a novel method

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is one of the few forms of dementia that can be treated. Individuals with iNPH experience symptoms such as impaired gait, urinary incontinence and cognitive decline. Many iNPH patients are misdiagnosed with other types of dementia and often end up in nursing homes. iNPH is significantly underdiagnosed, with an estimated 5,9% of individuals aged 80 years and above affected. Approximately 75–80% of iNPH patients could benefit from a ventriculoperitoneal shunt. This study aims to evaluate fundoscopy as a non-invasive method for screening patients with suspected iNPH.
Methods: All patients with suspected iNPH who underwent a lumbar infusion test were included. Fundoscopy was performed at baseline and at various time points during the infusion test. Intracranial pressure (ICP) was continually measured using the LiquoGuard® 7. An AI algorithm to determine the arteriole-venule ratio (A/V ratio) analyzed images of the retina obtained from fundoscopy. The A/V-ratio was correlated with iNPH. Additionally, baseline ICP values and amplitudes were investigated in the two groups.
Results: A significant mean difference in the A/V ratio was found between the iNPH and non-iNPH groups (mean: -0.0427, p-value: 0.0172). When the ICP was above 20 mmHg in both groups, there was no significant mean difference between the two groups (mean: -0.0096, p-value: 0.5766).
Conclusions: Diagnosing iNPH remains challenging. Early identification of iNPH patients and accurate diagnosis are critical for optimizing treatment outcome. The A/V ratio can help distinguish between iNPH and non-iNPH groups. A screening method for iNPH would be highly beneficial for patients and could have a great impact on society, both medically and socioeconomically.

05

Tracking activity patterns in patients with idiopathic normal pressure hydrocephalus in the diagnostic process

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is to this day still a challenging condition to diagnose accurately and treat effectively. In Odense, Denmark, patients currently undergo a TAP-test followed by the completion of a self-reported questionnaire. The gait of the patient is essential in the context of iNPH, serving as a positive marker in response to cerebral spinal fluid (CSF) dynamic tests and subsequent shunt surgery. Implementing an accelerometer attached to the thigh enables the monitoring of patient activity levels both before and after the TAP-test. This method may lead to more objective and clinically relevant data, thereby enhancing the diagnostic process of iNPH.
Methods: During the preliminary examination baseline data were collected. Each patient was equipped with an accelerometer on the thigh for a duration of seven days. Following the TAP-test, the accelerometer was reattached to the patient thigh for an additional seven-day period. The accelerometer recorded data for all 24 h of the day, capturing variables such as physical activity level, intensity, duration, and posture. Activity levels were investigated to determine if they increased following the TAP-test compared to baseline data collected prior to the TAP-test.
Results: As of 23 of April 2024, 52 patients have undergone a diagnostic TAP-test with an attached accelerometer to the thigh, both prior to and after the TAP-test. Preliminary results suggest no statistically significant correlation between iNPH patient's accelerometer data at baseline and after TAP-test.
Conclusions: iNPH continues to be a challenging condition to diagnose, emphasizing the need for objective tools in the diagnostic process. While the use of an accelerometer attached to the thigh is an easy and low-priced option, current results indicate that, its implementation may not enhance the diagnostic accuracy. Consequently, further research of alternative methods to objectify the diagnosing of iNPH patients is for now required.

06

Characterization of astrocytes on topographical surfaces to reduce shunt failure

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Introduction: Through thorough analysis of over 300 patient's explanted catheters, our previous work has determined that the most prevalent cells attached to the silicone surface of failed shunts are astrocytes. Given this discovery and recent finding in the field of mechanobiology, we hypothesize that the degree of astrocyte attachment and proliferation will be affected by topographical features on the surface of silicone. Although microglia comprise a smaller proportion of cells attached to explanted catheters, their ability to induce polarization of astrocytes via pro-inflammatory mediators led us to also explore the effects of topographical features in a coculture of human astrocytes and microglia in addition to astrocyte monocultures.
Methods: Photolithography and soft lithography were used to manufacture silicone surfaces with varying topographical features that varied at the micron level in height and width totaling 95 distinct groups each with a minimum N = 4. Human astrocytes were seeded onto these surfaces and attachment and proliferation was determined as a function of feature height, size, and pitch over several time points. The effect of these surfaces in a coculture of human astrocytes and human microglia was also studied. Cellular characterization was determined via immunofluorescent and ELISAs to measure release of TNF-α and IL-1β.
Results: Human astrocytes were found to be significantly affected ($P < 0.05$) by feature size in both degree of attachment and proliferation. Lastly, the Introduction of microglia cocultured with astrocytes also had an effect on astrocyte behavior compared to the monoculture study.
Conclusions: Building on previous works, we were able to successfully characterize how human astrocytes behave with topographical features as a function feature size, depth, and pitch in vitro. Future direction will aim to assess how these patterns will translate in a dynamic environment where it is known that astrocyte behavior is affected by fluid flow.

07

Long-term clinical results of the Flow ventricular catheter for hydrocephalus: brief report

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Abstract
Background: Previously, we studied the flow in ventricular catheters under steady and pulsatile boundary conditions by means of computational fluid dynamics (CFD) in several catheter designs with homogeneous flow patterns. We developed one prototype out of them after a validation study. Then, we tested the effectiveness of the Flow ventricular catheter in a prospective, multi centre, comparative study four years ago.
Methods: The Flow catheters were inserted in pediatric (n = 30) and adult (n = 10) patients with all types of hydrocephalus. Simultaneously, regular ventricular catheters were inserted in another 43 control patients in the participating centres. Programmable valves were utilized in 70% and antisiphon devices in 20% of the cases.
Results: Initial findings disclosed no case of Flow catheter obstruction and four catheter obstructions in the control cohort, all pediatric cases, during the first year. Subsequently, cases lost included three in the Flow catheter and five in the control group. No case of Flow catheter obstruction was identified during a mean follow-up period of six years at the time of this writing, while other four cases presented with multiple shunt revisions in the control group.
Conclusions: The Flow catheter, representing the next generation of ventricular catheters with a homogeneous flow pattern, can be inserted safely in hydrocephalic patients of all types, and this comparative study still showed a possible obstruction-free functionality.
Keywords: Hydrocephalus; Ventricular Catheter; Shunt malfunction; Flow catheter; Ventricular Catheter Prototypes; New Designs; Parametric; Computational Fluid Dynamics.

08

Computational investigation on cerebrospinal fluid flow mixing states in aqueduct of patients with Hakim's disease

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Introduction: CSF flow in ventricles is a bidirectional flow synchronized with cardiac pulsation, and net CSF flow in a cardiac cycle is close to zero. Although the CSF flow has slow and steady cyclic properties in healthy conditions, Hakim's disease increases CSF flow velocity and stroke volume, known as hyperdynamic flow. We hypothesized that this hyperdynamic CSF flow may enhance CSF flow mixing through the ventricles and affect the CSF composites adjusted in each ventricle. Therefore, this study analyzed the CSF flow dynamics in aqueduct between the third and fourth ventricles using MRI-based computational simulation.
Methods: This study included 10 iNPH patients (6 males and 4 females, age: 61–83) and 44 healthy subjects (18 males and 26 females, age: 24–74). Subject-specific ventricular geometries were reconstructed from the T2-weighted MRI images, and the computational fluid dynamics simulation of the CSF flow dynamics was performed in each subject. As a computational condition, the CSF flow rate in the aqueduct was determined from the 4D flow MRI. CSF flow rate mixing in aqueduct was analyzed by massless particle tracking during 20 cardiac cycles and quantified using mix-norm ranging from 0 (not mixed) to 1 (completely mixed) as a multiscale mixing index.
Results: Steady cyclic CSF motion was observed in the healthy control group and the CSF mixing state was mild (mix-norm: 0.36 ± 0.11), with negligible CSF mixing between third and fourth ventricles. On the other hand, hyperdynamic CSF flow in patients caused excessive CSF mixing state through third and fourth ventricles (mix-norm: 0.52 ± 0.18), and mix-norm between patients and control groups were significantly different ($p < 0.001$).
Conclusions: Hyperdynamic CSF flow in patients with Hakim's disease leads to exaggerated CSF mixing through ventricles. This CSF flow mixing may alter the CSF chemical composition in each ventricle and disrupt the physiological homeostasis.

09

The 6-min walk test and the 3-m backward walk test are sensitive outcome measures in Idiopathic Normal Pressure Hydrocephalus

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Introduction: While the 6-min walk test (6MWT) and 3-m backward test (3MBWT), two easy-to-use clinical tests, have been utilized in stroke research and other neurological conditions like Parkinson's disease, their application in idiopathic normal pressure hydrocephalus (iNPH) remains largely unexplored.
We aimed to evaluate the utility of the 6MWT and 3MBWT, as outcome measures after shunting and compare the rates of improvements with established outcome measures.
Methods: A total of 291 consecutively included iNPH patients underwent pre- and post-operative assessments at the Sahlgrenska University Hospital, Sweden from 2016–2022.
The 6MWT and 3MBWT were compared with the 10-m walk test (10MWT), Timed Up and Go (TUG), modified Ranking scale (mRS), and the iNPH scale. ROC analyses were conducted to evaluate the sensitivity, specificity, and AUC of the gait measures in relation to improvements observed in mRS by ≥ 1 point or iNPH scale gait domain score by ≥ 5 points.
Results: Gait improvement, defined as a 20% improvement rate in each gait measure, was observed in 58.8% of patients for 6MWT; 72.4% for 3MBWT; 50.9% for 10MWT self-selected speed; 44.0% for 10MWT max speed; and 60.0% for TUG time. AUC values for change in iNPH scale gait domain ≥ 5 points were: 6MBWT 0.802 (cut-off value: 39.5 m, sensitivity 0.78, specificity 0.67); 3MBWT 0.742 (cut-off value: -2.2 s, sensitivity: 0.80, specificity: 0.60; TUG time 0.785 (cut-off value -3.3 s, sensitivity 0.78, specificity 0.76). AUC values were lower for change in mRS ≥ 1 point in each gait measure.
Conclusions: This study shows that the 6MWT test and 3MBWT serve as additional, sensitive measures for gait improvement in a large cohort of iNPH patients. We encourage other researchers and clinicians to integrate these measures into their protocols and further explore the utility of these measures.

10

"Standard" valves vs Miethke shunt valves for paediatric hydrocephalus: the leeds experience

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Introduction: Treating paediatric hydrocephalus remains challenging. Various shunt valves are available, some of which aim to prevent over-drainage but are significantly more expensive. Valve choice in our unit is surgeon-dependent. Here we compare children with "standard" valves versus those with anti-gravitational devices ('Miethke').
Methods: From a prospectively collected operative database, all patients aged less than two years receiving a ventriculoperitoneal shunt for hydrocephalus between 2009 and 2021, with at least 3 years' follow-up and with no shunt revision, were included. Sex, hydrocephalus aetiology and age at shunt insertion were recorded for each patient, as were post-shunt Head Circumferences (HCs) and Frontal Occipital Horn Ratios (FOHRs). Patients were grouped together by valve type: "standard" (low/medium) vs Miethke (4/24 or 9/29).
Results: 86 "standard" valve and 50 Miethke valve patients were identified. Mean age at shunt insertion was 3.1 months (SD 4.8, median 1 month). Commonest aetiologies of hydrocephalus were post-haemorrhagic (38%), Spina Bifida (22%) and aqueductal stenosis (12%). No significant difference existed between valve types in age (p 0.608), sex (p 0.471) or aetiologies (p 0.584, 1.00 and 0.587). Mean post-shunt FOHRs were 0.41 and 0.43 (SDs $\pm$ 0.12–0.13) for "standard" and Miethke valves respectively (p 0.320). Mean percentage change in FOHR demonstrated no significant difference (p 0.204). Median FOHR follow-up time was 37 months. Median follow-up HC percentiles were 56 and 82 (IQRs 11–90 and 26–99) for "standard" and Miethke valves, respectively (p 0.014). Median head circumference follow-up time was 26 months (mean 27.5).
Conclusions: Our retrospective analysis shows that fixed, anti-gravitational devices do not result in significantly higher FOHRs in this cohort, although HCs were significantly larger. The use of variable pressure (opening/gravitational) valves may increase the FOHR but the question of cost and added value to the patient remains unanswered and requires dedicated investigation via a randomised trial.

11

Idiopathic Normal Pressure Hydrocephalus: pre- and postoperative performance in 6-min walk test and 3-m backward walk test

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Background: Current outcome measures for idiopathic Normal Pressure Hydrocephalus (iNPH), such as the 10-m walk test (10MWT) for gait assessment, and modified Rankin Scale (mRS) for general function, may be crude and lack sensitivity to detect e.g., subtle symptoms in the early stages of disease. We aimed to investigate the utility of two additional walking tests; the 6-min walk test (6MWT) and the 3-m backward walk test (3MBWT) and compare them with results of other clinical measures in iNPH patients before and after shunt surgery.
Methods: A total of 291 iNPH patients underwent pre- and post-operative assessments at the Hydrocephalus Research Unit, Sahlgrenska University Hospital, Sweden. Patients were evaluated using the gait- and balance tests 6MWT, 3MBWT, 10MWT, and Timed up and Go (TUG) as well as mRS, and the iNPH scale.
Results: Patients had a mean age of 73.3 (SD 6.2) years and were predominantly men (62.5%). The mean duration of symptoms was 42.8 (SD 3.2) months and postoperative follow up was 6.5 (SD 3.6) months. Preoperatively, the mean (SD) performances were: 6MWT 234 (109.3) m; 3MBWT 18.0 (15.2) s; 10MWT 6.5 (8.4) s; and TUG 24.5 (14.4) s; iNPH scale 54.5 (14.8) points; mRS 2.6 (0.8) points. The postoperative scores showed significant improvements to mean (SD): 6MWT 302 (121.7) m; 3MBWT 10.3 (7.8) s; 10MWT 12.4 (5.2) s; TUG 17.0 (10.7); iNPH scale 66.7 (17.6) points; mRS 2.2 (1.0) points; ($p < 0.001$).
Conclusions: We can demonstrate significant postoperative improvements in 6MWT and 3MBWT following shunting. According to our clinical experience, incorporating these tests into clinical protocols has demonstrated added value. Future research is warranted to determine the clinical utility and value of these measures.

12

Is it possible to accurately distinguish between LOVA and iNPH? Exploring the challenge of differential diagnosis

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Introduction: The differential diagnosis between LOVA (long-standing overt ventriculomegaly in adults) and iNPH (idiopathic normal pressure hydrocephalus) is challenging due to overlapping neuroradiological and clinical presentations. This study aimed to retrospectively analyze the preoperative neuroradiological characteristics of patients from the Pro-Hydro study to identify those with features suggestive of LOVA.
Methods: The study included 140 patients originally classified as iNPH from the Pro-Hydro study who underwent 3 T MRI and clinical evaluation at our institution from September 2015 to December 2023. After a retrospective analysis based on Oi radiological classification criteria, except aqueductal stenosis, a cohort of 113 iNPH and 27 LOVA patients was identified. Analysis was then expanded by calculating areas, volumetry, and aqueductal flow.
Results: Radscale score was significantly higher in iNPH than in LOVA patients ($p = 0.0001$). Statistically significant differences were found in Evans index ($p < 0.0001$), pontomesencephalic angle ($p = 0.0059$), midbrain and aqueduct area ($p = 0.0224$ and $p = 0.0001$), pons/midbrain ratio ($p = 0.0003$), and stroke volume ($p = 0.00002$). Stroke volume was > 18 ml/min in 22 (23.4%) iNPH and 21 (84%) LOVA patients ($p < 0.0001$). Lateral, third, and fourth ventricle volumes were greater in LOVA compared to iNPH patients ($p < 0.0001$, $p = 0.0091$, and $p = 0.0028$, respectively).
Conclusions: Significant neuroradiological differences exist between LOVA and iNPH. In addition to the parameters classically used in the study of cerebrospinal fluid pathologies, methods such as area calculations, volumetry, and aqueductal flow assessment can be useful tools for differential diagnosis.

13

Prevalence of possible iNPH in Korean population, investigated in the primary medical care/health care system

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Introduction: This is the first imaging-based study aimed to investigate the potential prevalence of idiopathic normal pressure hydrocephalus(iNPH)-specific radiologic changes in a large, over 65-year-old Korean population.
Methods: In this retrospective cross-sectional study, brain CT and MRI of patients over 65 years old were included at a single imaging center for 5 years, from 2019 to 2023. All reports of included patients were searched and sorted using keyword as NPH, hydrocephalus, and ventriculomegaly. Cases of secondary hydrocephalus were checked and iNPH specific imaging markers based on International Guidelines (IG) were evaluated by a single experienced neuroradiologist. Based on radiologic findings, patients were categorized to 3 groups: normal, Evans index (EI) > 0.3 without other iNPH-typical radiologic findings, probable iNPH according to IG.
Results: Statistically, this sample group size was proven to significantly represent the Korean population. Among a total of 7312 patients over 65 years old (2755 male, 4557 female), excluding obvious secondary hydrocephalus, 3.22% (5.66% for male, 1.73% for female) were discovered as EI > 0.3 without other iNPH-typical radiologic findings, and 1.93% (3.45% for men, 1.01% for women) were confirmed as probable iNPH according to IG. Among patients over 70 years old and 75 years old, prevalence of probable iNPH was 2.03% (2.60% for men, 1.31% for women) and 2.81% (3.74% for men, 1.67% for women), respectively. Prevalence calculated by 5-year-old interval was highest in the 65–70 years-old interval for men, over 75 years-old for women.
Conclusions: The estimated potential prevalence of probable iNPH among the elderly population over 65 years of age is approximately 2%, which increase with age, and is considerably high especially for male, with tendency to appear earlier. iNPH may be more common than assumed especially highly aging society like South Korea.

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Postoperative changes in ventricular CSF biomarkers with correlation to clinical outcome in idiopathic normal pressure hydrocephalus

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Introduction: To elucidate the pathophysiology of idiopathic normal pressure hydrocephalus (iNPH), ventricular CSF was collected peri- and postoperatively to capture the dynamics of biomarkers and its relation to clinical symptoms.
Methods: In 113 consecutive patients with iNPH, the Hellström iNPH scale was used to quantify symptom burden. Ventricular CSF was collected at shunt insertion and postoperatively by shunt reservoir puncture and analyzed for biomarkers GFAP, YKL40, MCP-1, NfL, Aβ40, Aβ42, Aβ42/40, sAPPα, sAPPβ, total tau (T-tau), phosphorylated tau (P-tau), presynaptic protein GAP43, and postsynaptic protein neurogranin.
Results: Postoperative mean concentrations increases for Aβ40 (134%), Aβ42 (106%), sAPPα (112%), sAPPβ (83%), NfL (128%), YKL40 (86%), GAP43 (124%) and MCP-1 (5%) ($p < 0.001$ for all except MCP-1 ($p = 0.03$)), while mean concentration reductions were seen in T-tau (32%), GFAP (31%), neurogranin (49%), and Aβ42/40 (10%) ($p < 0.001$ for all). A higher perioperative concentration of APPβ correlated with higher gait domain score, i.e. less pronounced gait disturbance (R_p 0.20 (0.01–0.38) (95% CI)) whereas higher levels of NfL (– 0.23 (– 0.41–(–)0.04) and MCP– 1 (– 0.21 (– 0.37–(–)0.01)) correlated with lower cognitive domain score. A higher MCP-1 correlated with lower balance domain score (– 0.20 (– 0.37–(–)0.01)). Postoperative increases in levels of Aβ40 (R_s 0.27 (0.05–0.46)), Aβ42 (R_s 0.24 (0.02–0.44)) and YKL40 (R_s 0.22 (– 0.00–0.43)) correlated with gait improvement and a postoperative increase in Aβ40 (R_s 0.36 (0.05–0.60)) was associated with improvement in urinary incontinence (p-values ranging from 0.01 to 0.05).
Conclusions: Ventricular CSF biomarker concentrations change after shunt insertion. These changes, seen as increased concentrations for some biomarkers and decreased concentrations for others, are

associated with improvement in core clinical symptoms and may illustrate reversibility of pathophysiological mechanisms in iNPH.

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New mechanism hypothesis of Maillard reaction-mediated cerebrospinal production at the choroid plexus

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Introduction: It is widely believed that cerebrospinal fluid (CSF) can be produced by choroid plexus and this concept is supported by the fact that aquaporin1 (AQP1), water channel, is abundantly present on the epithelial cell membrane of choroid plexus. Glycolysis via rich glucose transporter type-1 can be found actively in the epithelial cells and produces much water letting out the water through AQP1 to relieve cytotoxic cell swelling. The dominant existence of AQP1 on the ventricular side leads to CSF in the ventricle. Maillard reaction, which is reported as the high level of glucose is maintained chronically, in the choroid plexus is one of the most positive sites in the whole body. Maillard reaction on the choroid plexus is possibly one of the main sources of the CSF production.
Methods: Immunohistochemistry of Pentosidine and Carbomethyl lysine (advanced glycation endproducts: AGEs) for human choroid plexus and both wild type and transgenic mice choroid plexus. Brain slices of these mice were made to evaluate the ventricular size.
Results:1) AQP1, LDH, CAII, GLUT1 are abundantly expressed on the epithelial cells of CP. Pentosidine and Carbomethyllysine are also positively expressed on the epithelial cells. 2) Receptors of AGEs (RAGE) are richly present on the epithelial cells to make AGE-RAGE complex leading to tissue injury. 3) esRAGE, splicing variants of membranous RAGE, are abundantly expressed on not only the epithelial cells but also the endothelial cells to protect against tissue injury and facilitate angiogenesis. 4) On the brain slices of esRAGE transgenic mice, significant ventriculomegaly was detected when comparing to wild type.
Conclusions: Following hypothesis can be introduced that positive intake of glucose into the CP epithelial cells can lead to Maillard reaction to evoke glycolysis producing CSF and facilitating angiogenesis. In addition, the protective mechanism of the CP epithelial cells also exists.

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AI-based detection of Certas shunt valve settings in CT scans

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Introduction: Adjustable pressure valves are now widely used in hydrocephalus treatment. Shunt dysfunctions can present with diverse symptoms, and shunt diagnostics is then mandatory. Brain CTs often serve as the initial check even in hospitals without neurosurgical units. However, assessing the valve setting on a CT is often difficult due to the three-dimensional imaging, metal artefacts and low resolution. To address this, we developed an AI-based model to automatically assess the setting of valves on CTs.
Methods: 516 CTs of patients with VP shunts were collected, of which 100 images featured a Certas valve. All data was split into training, validation, and test datasets. We tested 2D as well as 3D convolutional neural network (CNN) architectures for shunt setting detection. For 2D networks, the CT images are flattened to a lateral maximum intensity projection. For 3D networks, the shunt valve is first segmented using a 3D nnUNet segmentation network, and then the setting is detected with a 3D CNN classification network.
Results: A 2D CNN model based on the YOLO framework was able to correctly identify the Certas valve and distinguish them from other shunt valves in 100% of cases but only correctly identified the shunt setting in 35% of all test cases (7 out of 20). The 3D-based nnUNet was able to identify correctly and distinguish the valve in 100% of the cases and correctly identified the shunt setting in > 82% of the cases.
Conclusion: This study shows the potential of AI-based analysis for detecting and evaluating shunt valves. Our current 2D convolutional neural network can identify Certa's valves in CT, but the detection of valve settings is still unreliable. 3D CNN models that rely on the full volumetric data provided by a CT scan led to better results, and improving these networks might be optimal for the future.

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Risk and protective factors for congenital hydrocephalus in live Births within the Brazilian Amazon rainforest

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Introduction: The Brazilian Amazon Rainforest, covering Northern Brazil, presents unique neonatal health challenges. Congenital hydrocephalus, prevalent in this area, demands in-depth exploration of its risk and protective factors.
Methods: In this retrospective cohort analysis, data of Northern Brazil from the Brazilian Live Birth Information System (SINASC) from 2018 to 2022 were utilized. Examined variables were maternal age, birth weight, maternal marital status, gravidity, quality of prenatal care, and gestational term. Cases with incomplete categorical data were excluded, while gaps in continuous variables were filled using mean values. The cohort was split into two: individuals with and without congenital hydrocephalus, excluding other anomalies. Statistical assessments involved the Chi-square test for categorical variables, the Mann–Whitney U test for continuous variables, and calculation of odds ratios with 95% confidence intervals to detect significant associations, using Python 3.11.7 for data processing. Due to the use of anonymous and secondary data, ethical committee approval was not required.
Results: Among 1,432,881 births meeting inclusion criteria, 446 cases of hydrocephalus and 1,432,435 without anomalies were identified. Marital status significantly influenced risk, with unmarried mothers showing an increased likelihood (OR 1.34, 95% CI: 1.11–1.61). Inadequate care increased the risk (OR 1.58, 95% CI: 1.31–1.91), contrasting with adequate care's protective tendency. Gestational timing was critical; premature births markedly escalated risk levels (OR 3.62, 95% CI: 2.98–4.41). Additionally, higher birth weights were associated with a reduced risk of hydrocephalus.
Conclusions: This study accentuates the vital role of quality prenatal care and carrying pregnancies to full term in reducing congenital hydrocephalus within the Brazilian Amazon. The findings advocate for intensified prenatal health services and strengthened maternal support, aiming to alleviate the incidence of hydrocephalus in this region.

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Neuropsychological profile in adults with asymptomatic, untreated congenital hydrocephalus

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Introduction: Symptomatic hydrocephalus causes a frontal-subcortical pattern of cognitive deficits. However, it remains unclear if asymptomatic adults with previously unrecognized congenital hydrocephalus (UCH) develop similar deficits, given the lower rates of comorbidities that adversely impact cognition in this population. Understanding the cognitive impact of UCH is important to guide clinical and surgical decision-making.
Methods: UCH was defined by Evans Ratio ≥ 0.3 and head circumference ≥ 97th percentile, regardless of age. Twenty asymptomatic, untreated patients with UCH (age 57.2 ± 14.6) were referred for neuropsychological evaluation.
Results: Mean Z-scores more than 0.5 SD below the mean (**in bold**) were observed on tests of executive function and verbal/contextual memory. When stratified by age, a trend for older patients (≥ 60; 67.9 ± 5.7) to perform worse than Younger patients (< 60; 46.5 ± 12.9) on Logical Memory I (p = 0.06) and Logical Memory II (p = 0.09) was seen.

Cognitive Domain/Tests	Z-Score (mean ± SD)
Working Memory	
- Digit Span	+ 0.39 ± 0.87
Language	
- Boston Naming	+ 0.29 ± 1.3
- Letter Fluency	− 0.27 ± 1.28
- Semantic Fluency	− 0.19 ± 1.25
Visuospatial Skills	
- Block Design	+ 0.08 ± 0.81
Reasoning	
- Similarities	+ 0.09 ± 0.65
- Matrix Reasoning	+ 0.36 ± 0.77
Executive Functioning	
- Trails A	**− 0.67 ± 0.95**
- Trails B	**− 0.75 ± 1.22**
Verbal/Contextual Memory	
- Logical Memory I	**− 0.70 ± 0.68**
- Logical Memory II	**− 1.1 ± 0.89**
Visual Memory	
- Visual Reproduction I	− 0.37 ± 0.85
- Visual Reproduction II	− 0.24 ± 0.73

Conclusions: Results suggest that adults with asymptomatic UCH may have mild cognitive weaknesses in areas of psychomotor processing, mental tracking/sequencing, and contextual learning/memory. It is unclear whether these deficits are developmental and longstanding, or represent a decline from previous functioning. Longitudinal studies of asymptomatic adults with UCH are needed.

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Assessment of pathological gait: arm swings and stride length with a deep learning smartphone app

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Introduction: The assessments of pathological gait, such as shuffling, short-stepped, wide-based gait, spastic gait, in Hakim's disease (iNPH), Parkinson's disease, and cervical spine disease are subjectively and inconsistent among evaluators. To quantitatively assess pathological gait, we had developed and utilized a Three-Dimensional Pose Tracker for Gait Test (TDPT-GT) iOS app which can estimate the 3D relative coordinates of 24 key points during movement without body markers using deep learning.
Methods: This study included 24 patients with Hakim's disease, 11 with Parkinson's disease, 94 with cervical spine disease, and 150 healthy individuals. Participants simply walked normally around a 1-m diameter circle twice, and TDPT-GT automatically recorded the 3D relative coordinates of 24 body points by capturing the walk from head to toe on the iPhone screen. From the 3D coordinates, 2D coordinates projected onto body axis sections were calculated. In addition, the ranges of motion angle of joints and 75% tolerance ellipses of all coordinates for each key point were also calculated. Using 1,187 measurements (average of 4.3 measurements per person), we analyzed upper and lower limb movement correlations during walking.
Results: In the 2D coordinates projected on the sagittal plane, the strongest correlation was between the ranges of motion angle of knee and elbow joints ($r = 0.48$, 95% CIs = 0.44 to 0.52). The patients with Hakim's and Parkinson's diseases exhibited smaller joint angles compared to those with cervical spine disease and healthy individuals. No strong correlations were found in the parameters of upper and lower limb movement on the coronal and axial coordinates.
Conclusions: Lower limb movements during circular walking correlate with upper limb movements. Patients with Hakim's and Parkinson's diseases demonstrate reduced back-and-forth swing of the upper and lower limbs. This study sheds light on the interplay between upper and lower limb movements in pathological gait assessment.

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Preventing distal catheter migration and subcutaneous coiling by tunnelling deep to the anterior rectus sheath: a retrospective study of a surgical technique for tunnelling a ventriculo-peritoneal shunt

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Introduction A ventriculoperitoneal shunt (VPS) forms the mainstay of surgical treatment for hydrocephalus. Despite technical advances, patients suffer frequent complications, including distal catheter migration. In this single-centre retrospective study of 1755 new VPS insertions, we assess the impact of tunnelling deep to the anterior rectus sheath (ARS) to secure the distal catheter, on the rates of distal catheter migration.
Methods: Surgical technique: The distal catheter is tunnelled from head to abdomen, in the subcutaneous plane. At the paramedian abdominal incision, the ARS is incised and tented upwards with a retractor between sheath and musculature. The tunnelling device is advanced through the ARS approximately 5 cm rostral to the incision line. The catheter is placed intra-peritoneally, a peritoneal purse-string suture is tightened around the catheter and the ARS is closed with a continuous suture.
Data collection/analysis: all patients coded as a VPS insertion between 1/1/2008 and 1/2/2024 were included and divided into traditional technique (tunnelling subcutaneously) used by all other surgeons in the department and the alternative technique. All patients coded as having a subsequent 'distal catheter maintenance' were evaluated. Medical records and imaging were reviewed to classify the cause of shunt dysfunction.
Results 1755 VPS insertions were carried out, 782 were inserted under one consultant surgeon employing the alternative technique. 973 were inserted under 27 other consultant surgeons at the same institution, using a traditional tunnelling technique. 8/973 (0.82%) migrated to the subcutaneous space requiring revision vs 0/782 (0%) using the new technique (Chi Squared: $p = 0.01$). There were 4 blocked catheters identified coiled in the pre-peritoneal space in the standard arm and none using the new technique.
Discussion Routinely tunnelling deep to the ARS during VPS insertion reduces the incidence of distal catheter migration.

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is the study of craniospinal csf dynamics predictive of headache improvement after Chiari syndrome surgery?

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Introduction: The surgical indication for Chiari syndrome (CS) can be challenging to determine. CS is linked to hydrodynamics disorders. Headaches are a common symptom, and the link with CS is sometimes difficult to establish preoperatively. No predictive factor for their improvement has been clearly identified. Phase-contrast MRI (pcMRI) is the only non-invasive technique allowing craniospinal hydrodynamic studies. Our objective was to identify potential hydrodynamic criterias able to predict favorable evolution of headaches after posterior fossa decompression surgery in patients with CS.
Methods: We included 41 adult patients with symptomatic CS headaches who underwent posterior fossa decompression after our traditional morphological and PCMRI investigations. We quantified cerebrospinal fluid (CSF) dynamic during cardiac cycle and calculated CSF stroke volumes through the Sylvius aqueduct (SV_{aqu}) and through the cervical (SV_{cerv}) subarachnoid spaces (SV_{cerv}) in micro liter per cardiac cycle. 12 months after surgery, we divided the population in two groups: G- with 12 patients who reported improvement in headaches and G + with 29 patients who continue to present headaches. We compared SV_{C2C3} and SV_{aqu} preoperatively measured in G- and G + using Student's t-test.
Results: G- had a significant smaller SV_{aqu} than G + (12 ± 11 vs 65 ± 45; $p = 0.03$). G- had a significant higher SV_{cerv} than G + (613 ± 166 vs 484 ± 163; $p = 0.03$).
Conclusions: pcMRI analysis of intraventricular and spinal CSF dynamics could present valuables criterias to prognostic headache improvements following surgical treatment of CS. This pulsatility difference between the groups does not appear to be related to the surface area of Sylvius' aqueduct or spinal canal, nor to ventricular or spinal CSF volume but could be related to different pressure gradients.

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Comparing the efficacy of LP and VP shunts in iNPH: a systematic review and meta-analysis

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Introduction: Ventriculoperitoneal (VP) and Lumboperitoneal (LP) shunts are the most common treatments for Idiopathic Normal Pressure Hydrocephalus (iNPH). Shunt procedure choice is complicated by an array of confounding factors, leading to an over-reliance on preference rather than evidence. We performed a systematic review and meta-analysis to address this gap for evidence-based shunt selection in iNPH treatment.
Methods: Publications on post-operative outcomes for LP and VP shunts in iNPH were identified in MEDLINE and EMBASE. Papers were selected based on pre-specified inclusion and exclusion criteria and meta-analysis was conducted for outcome measures after shunt procedure.
Results: 17 papers were included. LP Shunt patients showed greater cognitive improvement with an average increase of 2.00 points (95% CI: 1.08; 2.93, $p < 0.0001$) on their MMSE score post-operatively compared to VP shunt patients who improved on average by 1.30 points (95% CI: 0.81; 1.79, $p < 0.0001$). The LP group had considerable heterogeneity ($I^2 = 66.42\%$, $p = 0.0003$) whereas the VP shunt group had minimal heterogeneity ($I^2 = 0.00\%$, $p = 0.8447$) reflecting more uniformity across its included studies. For overall symptomatic improvement measured by the iNPHGS, interestingly VP shunts patients demonstrated a larger reduction in overall symptom scores with an average decrease of 2.91 points (95% CI: -3.78; -2.05, $p < 0.0001$) but with a high heterogeneity ($I^2 = 79.12\%$, $p = 0.0012$) compared to LP shunt patients with an average reduction of 1.91 points (95% CI: -2.31; -1.51, $p < 0.0001$) with no detected heterogeneity ($I^2 = 0.00\%$, $p = 0.8454$).
Conclusions: Whilst LP shunts offer superior improvements in dementia-related symptoms for iNPH, VP shunts appear to provide more overall symptomatic relief. The significant heterogeneity observed complicates direct comparisons. Future research should incorporate an approach that can accommodate confounding factors and include the numerous single-arm studies found in the literature.

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"Controls-in-common": baseline comparisons between cohorts of Normal Pressure Hydrocephalus vs. local-to-global healthy norms using the Periodic Table of DTI Elements

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*Data used in preparation of this article were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (adni.loni.usc.edu). As such, the investigators within the ADNI contributed to the design and implementation of ADNI and/or provided data but did not participate in analysis or writing of this report. A complete listing of ADNI investigators can be found at: http://adni.loni.usc.edu/wp-content/uploads/how_to_apply/ADNI_Acknowledgement_List.pdf

Introduction: In Classic Normal Pressure Hydrocephalus (*Cl*NPH), there may be variable expression of the typical triad of symptoms. In Complex NPH (*Co*NPH), overlay of neurodegenerative diseases and cardiovascular risk burden, are clinical confounders. For both cohorts, there may be imperfect responses to surgical intervention; the capacity of the brain to recover from injury may vary. Diffusion tensor imaging (DTI) can document such capacity but a barrier towards wider applicability is the lack of consistency in its interpretation. To address this, we described a novel taxonomy, the Periodic Table of DTI Elements. Here, we advance the model by establishing baseline comparisons between cohorts of *Cl*NPH vs. *Co*NPH and differing norms derived from local-to-global healthy controls.

Methods: DTI metrics were examined for cohorts with *Cl*NPH (n = 16) and *Co*NPH (n = 12) vs. 9 local, 27 regional and 47 global controls. Additional image processing pipelines were performed using the brainlife.io cloud computing platform (FSL and MRTrix3). Statistical analyses were performed for comparisons between groups. DTI profiles were mapped according to the hierarchical algorithm of the Periodic Table of DTI Elements.

Results: We found significant differences between cohorts of healthy controls (BCC; FA, MD, L1, L2and3 and PLIC; FA, MD, L1, L2and3; regional vs. global/local vs. global; $p < 0.001$, $p < 0.001$, $p < 0.001$, $p < 0.001$/ $p < 0.001$, $p < 0.001$, $p < 0.001$, $p < 0.001$ respectively). Despite such baseline differences, there was general consistency in the applicability of the Orders by categories. When differing healthy norms were used, not all Orders were equally represented. However, the hierarchical Order of reversibility of brain injury remained.

Conclusions: The Orders of the Periodic Table of DTI Elements can be replicated with differing cohorts of norms. Its utility allows for a common language for DTI interpretation towards more transparent and accurate reporting of differing NPH cohorts and specific outcomes. In this study, we establish baseline comparisons with local-to-global healthy controls.

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Coverage and data validity of the Swedish Hydrocephalus Quality Registry

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Introduction: The Swedish Hydrocephalus Quality Registry (SHQR) is one of the most extensive national quality registries for hydrocephalus in adults, aiming to cover all patients who receive surgical treatment for adult-onset hydrocephalus. SHQR contains data regarding treatment, preoperative symptoms, outcomes, and complications, as well as demographics. SHQR has been the basis for large research studies and provides public statistics regarding the clinical care of hydrocephalus. Thus, the coverage and data validity for SHQR are highly relevant. The aim of this study was to perform a structured evaluation of these factors.

Methods: Six of seven treating centers in Sweden participated in SHQR during the study. For each center, 50 patients from 2017–2020 were randomly selected for monitoring. Data in SHQR were compared to medical records, noting agreement or missing data (values were labeled N/A if they were not evaluated). Parameters were evaluated individually or as composites (e.g., preoperative symptoms). Validity was determined as agreement = N(agreeing)/N(evaluated), or absolute agreement = N(agreeing)/N(total). The degree of coverage was assessed by comparing surgical logs to patients included in SHQR.

Results: Mean agreement was 89% (absolute agreement 84%), the range was 73%-100% (absolute agreement 58%-100%) for individual parameters and 53%-97% (48%-94%) for composites. Agreement for the composites was strongly related to the number of combined parameters. 69% of patients were registered within 1 month of surgery and 98% within 12 months. The degree of coverage for the evaluated centers was 92% (range 86%-100%).

Conclusions: SHQR maintained a high overall data validity, though composite measures showed a higher degree of errors, proportional to the number of combined parameters. Coverage for evaluated centers was very high and timeliness reasonable. We conclude that SHQR can reliably be used for research and statistics if parameters and evaluation periods are well selected, supporting the utility of large national quality registries.

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Mean baseline ICP value measured during lumbar infusion test: discrepancy between theory and practice

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Introduction: In 1987 Dr A. Marmarou investigated the proportion between two different ICP components, vascular factors and CSF circulation (Resistance to CSF outflow times production of CSF), in patients after traumatic brain injury. His conclusion was: 33% for CSF circulation, and 66% for vascular factors. The vascular factor was supposed to be defined as sagittal sinus pressure. Using clinical observations and a mathematical model of cerebral blood flow and CSF circulation, we investigated this intriguing point further, in patients with hydrocephalus.

Material and methods: We used the results of 10 lumbar infusion tests with parallel monitoring of sagittal sinus pressure (Pss) in patients with idiopathic intracranial hypertension to assess all elements of Davson's equation: ICPbaseline = Routflow* production of CSF + Pss. At the same time, a mathematical model of CSF dynamics (according to Marmarou, 1983) was constructed, supplemented by elements representing branches of cerebral blood flow coupled with pathways of CSF circulation through non-linear compliances of arterial and venous bed. This model was used for simulation ICP in various conditions.

Results: In patients: baseline ICP calculated from all measured variables included in Davson's equation, were significantly lower than baseline ICP measured during the test (mean difference 7.8 ± 5 0.1 mmHg; $p < 0.01$). This difference could not be accounted for by any of measured ICP or Pss component. In model simulation: knowing CSF production Pss and CSF production rate, baseline ICP was always greater than the value resulting from Davson's equation. This value decreased to the Davson's equation target only when arterial blood pulsations were set to zero.

Conclusion: Hypothetically, Marmarou's vasogenic contribution of ICP is a sum of Pss and the component derived from pulsatile pattern of arterial blood pressure and pulsatile blood volume. Pulsations of arterial blood, detected on non-linear hemodynamic variables, add additional (above Pss) constant value to ICP.

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Clinical improvement after shunt surgery in idiopathic normal pressure hydrocephalus patients can be quantified by diffusion tensor imaging

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Introduction: White matter changes assessed by diffusion tensor imaging (DTI) typically reflect tract functionality. This study aimed to investigate DTI parameters alterations in significant regions pre- and post-shunt implantation in idiopathic normal pressure hydrocephalus (iNPH) patients, alongside assessing the relationship between DTI parameters and clinical improvement.
Methods: Patients with probable iNPH underwent prospective preoperative magnetic resonance imaging (MRI) and comprehensive clinical workup between 2017–2022. Patients with clinical symptoms of iNPH, positive result on lumbar infusion test (LIT) and/or gait improvement after 120-h lumbar drainage (LD) were diagnosed with iNPH and underwent shunt-placement surgery. Fractional anisotropy (FA) and mean diffusivity (MD) values for individual regions of interest were extracted from preoperative and postoperative MRI. These values were correlated with the clinical picture of individual patients.
Results: A total of 32 patients (73.59 ± 4.59 years) with definite iNPH were analyzed. Preoperative DTI characteristics of internal capsule and corona radiata correlated with the 1-year improvement in the Dutch Gait Scale postoperatively (all $p < 0.036$). Cognitive domain improvement after surgery in memory and psychomotor speed correlated with preoperative DTI values of cingulate gyrus ($p = 0.050$), uncinate fasciculus ($p = 0.029$), superior longitudinal fasciculus ($p = 0.020$) or corpus callosum ($p < 0.045$).
Conclusions: DTI characteristics of white matter regions reflect clinical improvement after shunt surgery in iNPH patients. They tend to improve towards physiological DTI values, thus further accentuating the benefit of shunt surgery in both clinical and radiological pictures.

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Shunt surgery and complications, the Pro-Hydro experience

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Introduction: Normal pressure hydrocephalus (iNPH) can be effectively treated with shunt surgery. However, various surgical techniques are described in the literature, without any clear superiority of one over the others in terms of complications or effectiveness. The purpose of this study is to present the surgical experience gained within the Pro Hydro study and the reported complications, comparing ventriculoperitoneal shunt (VPS) and ventriculoatrial shunt (VAS).
Methods: From September 2015 to December 2023, following an iNPH diagnosis, 154 patients underwent shunt surgery. Until May 2020 VPS was the treatment of choice (89 patients), from June 2020 VAS became the treatment of choice (65 patients). For each patient were collected surgical times, length of hospitalization and complications.
Results: The mean duration of hospitalization and surgery was respectively 3 days (IQR: 2–4.25) and 70 min (IQR: 60–80) for VPS and 1 day (IQR: 1–2) and 35 min (IQR: 30–40) for shunt VA (IQR: 1–2) (both $p < 0.001$). The most common complication in the VPS cohort was abdominal catheter migration (11 patients, 12.2% of the cohort), in the VAS was pericatheter hemorrhage (5 patients, 7.7% of the cohort). The number of complications that required a second surgery was 13 (14.6%) in VPS and 2 (3.1%) in VAS ($p = 0.025$). No statistically significant differences were found between the total number of early and late complications between the two cohorts ($p = 0.251$ and $p = 0.397$, respectively).
Conclusions: Both VPS and VAS are safe techniques for iNPH treatment. In our series, VAS allowed avoidance of general anesthesia, decreasing both length of hospitalization and surgical times. Although the complication rate was similar between the two cohorts, the need for a second operation was greater in VPS compared to VAS.

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Cortical and Hippocampal β-amyloid deposition and CSF clearance through the choroid plexus in a model of chronic hydrocephalus

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Introduction: One of the genes responsible for hydrocephalus in H-Tx rats is the deletion of Protein Tyrosine Phosphatase Non-Receptor Type 20 (PTPN20). PTPN20 is specifically highly expressed in the choroid plexus, and PTPN20 knockout (KO) mice showed ventricular enlargement, and high expression of phosphorylated Na–K-Cl cotransporter 1 (pNKCC1) was maintained in the choroid plexus epithelium for a long time, leading to excessive cerebrospinal fluid (CSF) secretion and chronic communicating hydrocephalus. In this study, we crossed PTPN20 (KO) mice with APP knock-in (KI) mice overexpressing β-amyloid and evaluated amyloid deposition in the brain parenchyma due to choroid plexus dysfunction, and discussed the pathogenesis of CSF clearance disorders.
Methods: We generated APP(KI)xPTPN20(KO) mice. The APP(KI) mice, a model of Alzheimer's disease, also known as 3rd generation APP(KI) mice, are $APP^{NL-G-F/NL-G-F}$mice. At age of 8 weeks the development of hydrocephalus was assessed using hematoxylin–eosin-stained brain sections and microscopically amyloid deposition was evaluated in the choroid plexus using amyloid antibody (82E1) staining and HQ-O RTD amyloid plaque stain reagents. Electron-microscopy was used for ultra-structural assessment of the choroid plexus epithelial cells at age of 16 weeks.
Results: Compared with the wild type and APP(KI) mice, APP(KI) xPTPN20(KO) mice demonstrated ventricular enlargement at age of 8 weeks on the hematoxylin–eosin-stained brain sections ($p < 0.001$) and bigger deposition of β-amyloid mainly in the cortex and hippocampus. On electron microscopy choroid plexus of APP(KI) demonstrated normal epithelial structures including villi and microvilli, while epithelial cells in the APP(KI)xPTPN20(KO) mice choroid plexus were collapsed and atrophic.
Conclusions: PTPN20 deficiency caused early amyloid deposition in the brain, and degeneration of epithelial cells of the choroid plexus.

PTPN20 may play an important role in β-amyloid clearance in the choroid plexus.

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Aqueduct pressure gradient decrease in Hakim hydrocephalus patients

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Introduction: Aqueduct Stroke volume of CSF (SV_{CSF}) represents the CSF volume expansion of the lateral ventricles during cardiac cycle. Aqueduct CSF flow oscillations (Q_{CSF}) are driven by the temporal evolution of pressure difference ($\Delta P_{aqueduct}$) between the third and fourth ventricles.
Q_{CSF} is also influenced by the flow resistance of the aqueduct ($R_{aqueduct}$). $\Delta P_{aqueduct} = R_{aqueduct} \cdot Q_{CSF}$.
Aqueduct morphology and Q_{CSF} are easily accessible by clinical MRI. The Aim of this work was to calculate $\Delta P_{aqueduct}$ and investigate its potential evolution in hydrocephalus patients.
Methods: We developed a dedicated software to automatically and simply quantify Q_{CSF} oscillations, SV_{CSF} and $\Delta P_{aqueduct}$. First it segments all the diameters along the length of an aqueduct to calculate $R_{aqueduct}$ using the Poiseuille equation. Viscosity of the CSF is supposed constant to water viscosity. Then it calculates Maximum and Minimum $\Delta P_{aqueduct}$, origin of the 2 CSF bidirectional Q_{CSF} peaks flow during cardiac cycle. We defined the Stress_$\Delta P_{aqueduct}$ = Maximum $\Delta P_{aqueduct}$ − Minimum $\Delta P_{aqueduct}$. We applied this new methodology to 15 Hakim hydrocephalus patients (74 ± 6 years) who underwent clinical morphological MRI included phase contrast acquisitions in the aqueduct before shunt surgery. 34 healthy volunteers (24 ± 5) underwent the same MRI protocol.
Results: SV_{CSF} (micro.l/cardiac cycle) was significantly higher in patients than in volunteers (178 ± 108 versus 39 ± 20, $p < 0.05$). $R_{aqueduct}$ ($mPa.s^{-1}.mm^{-3}$) and Stress_$\Delta P_{aqueduct}$ (Pa)were significantly smaller in patients respectively (12 ± 9 versus 78 ± 51, $p < 0.05$ and 12 ± 6 versus 21 ± 9, $p < 0.05$). In the 7 most pathological patients, SV_{CSF} negatively corelated with Stress_$\Delta P_{aqueduct}$ ($R = 0.82; p < 0.01$) whereas no correlation was found in volunteers ($R = 0.1; p > 0.7$).
Conclusion: Stress_$\Delta P_{aqueduct}$ can be calculated easily non-invasively using MRI. In Hakim hydrocephalus patients Stress_$\Delta P_{aqueduct}$ paradoxically decreases, nevertheless "Tsunami" CSF waves caused by larger aqueduct diameter continuously stress the tissues surrounding the ventricles. Reduce the aqueduct diameter to redirect CSF flow through the subarachnoid spaces could protect brain tissues.

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The effects of architectural modifications on resistance to fluid flow in ventricular catheters

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Introduction: Although various ventricular catheter designs have been implemented into routine practice, there exist few standardized studies to evaluate relative outflow resistance and the impact these design modifications have to overall shunt performance. This study aims to fill this gap by systematically investigating the impact of various architectural modifications on catheter performance, with a particular focus on bulk flow dynamics and biological outcomes.
Methods: Catheters were manufactured utilizing a novel catheter production setup with 16 variations from standard catheter including but not limited to changes in hole number, hole dimensions, hole displacement, and catheter lumen dimensions. These catheters were tested in a validated in-house ventricular catheter testing device to analyze the resistance to flow (indirectly measured as time elapsed for a set volume of fluid to pass through the catheter). A separate group of catheters, varying in lumen diameter, was tested in a fluid flow model that simulated early blood exposure following signs of blood in the ventricles.
Results: With increasing hole and lumen diameter, we found a significant decrease in catheter resistance using DIH20 ($P < 0.05$). Blood assays for varying lumen diameters showed a significant decrease in blood-particulate obstruction as the diameter increased ($P < 0.05$). Lumen obstructions showed considerable evidence increasing resistance as obstruction diameter increases ($P < 0.05$). However, row and segmental occlusion of lateral holes showed minimal difference in time elapsed ($P > 0.05$).
Conclusions: This study implemented a novel method of catheter manufacturing to systematically produce ventricular catheters with varying architecture. By testing variables independently, we found that catheters have an overall bulk relative resistance with the most significant shift being caused by shifts in lumen dimensions. In addition, blood has a higher propensity to obstruct catheters of a smaller diameter. From these experiments, we can begin to understand the fundamental effects of catheter geometry on resistance in vitro.

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APOE levels are significantly reduced in post-traumatic hydrocephalus

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Introduction: Post-traumatic hydrocephalus (PTH) is a complication of traumatic brain injury (TBI) that typically presents as failure to improve during rehabilitation. PTH can be treated with CSF diversion, but recognition of symptoms can be challenging as PTH presents at variable intervals after injury, and symptoms may be masked by the sequelae of TBI. There is therefore a need to investigate the biological mechanism of PTH and identify biomarkers. APOE is the most abundant lipoprotein in the CNS, and part of the inflammatory response and neuronal repair following TBI. The APOE4 polymorphism results in lower abundance of APOE and poor outcomes after TBI. However, APOE abundance has never been studied in PTH.
Methods: Institutional board review approval was obtained, and CSF that would have been thrown away was collected intraoperatively at the time of ventriculoperitoneal shunt placement in patients with PTH. Age-matched control CSF was collected from lumbar drains placed during endoscopic endonasal procedures. Western blot was performed, bands were detected using chemiluminescence and normalized to total protein stain.
Results: APOE is significantly reduced in post-traumatic hydrocephalus patients compared to control patients (Fig. 1). There is no difference in APOE levels between post-traumatic hydrocephalus patients and patients with hydrocephalus due to aneurysmal SAH, possibly suggesting a common mechanism of communicating hydrocephalus and a common impact on the homeostasis of APOE (Fig. 2).

Conclusions: APOE levels are significantly reduced at the time of ventriculoperitoneal shunt placement in patients with PTH. This suggests that APOE is not only part of an acute response to injury, but remains altered during the long-term sequela of TBI. This is consistent with previous work showing that the APOE4 genetic polymorphism is associated with poor outcomes after TBI and lower APOE levels. Thus, supplementing APOE levels in CSF may be a promising strategy in patients with TBI and PTH.

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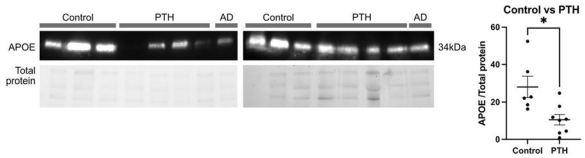

Fig. 1. APOE is reduced in PTH relative to control CSF.

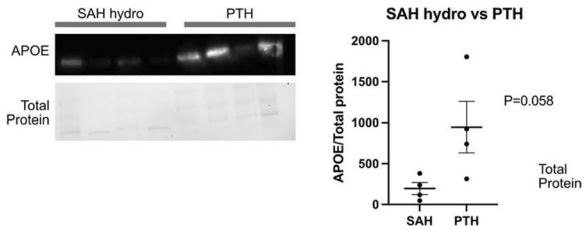

Fig. 2. No difference in APOE level in PTH relative to SAH hydro CSF.

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Pathological Choroid Plexus Proliferation May Underlie the Etiology of Hydrocephalus After Traumatic and Hemorrhagic Conditions

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Background: Although the choroid plexus (ChP) is the main structure associated with cerebrospinal fluid (CSF) production, its importance in the origin of hydrocephalus is understudied[1]. Recent studies have shown that ChP hyperactivity may underlie the origin of hydrocephalus under hemorrhagic conditions, such as traumatic brain injury (TBI) or intraventricular hemorrhage (IVH)[2,3]. Thus, we hypothesize that modulating ChP proliferation may prevent the development of posttraumatic and posthemorrhagic hydrocephalus. In this study, ChP epithelial cell cultures with traumatic CSF were investigated to understand how modulation of inflammatory pathways may attenuate ChP proliferation in posttraumatic hydrocephalus.
Methods: CSF from traumatic brain injury patients was analyzed in a 48-plex human cytokine assay. Human choroid plexus epithelial cells (HCEpiC) were cultured in (1) negative control conditions with artificial CSF, (2) experimental conditions with human TBI CSF, (3) treated conditions with TBI CSF and treated with erlotinib hydrochloride, an endothermal growth factor (EGF) inhibitor, (4) positive control conditions with artificial CSF and recombinant EGF protein. Cultures were incubated for 72 h, quantified with immunocytochemistry staining, and imaged under an immunofluorescent microscope.
Results: Elevated concentrations of EGF and vascular endothelial growth factor (VEGF) were found in TBI CSF compared to standards. Human TBI CSF induced ChP hyperproliferation compared to control CSF. TBI CSF treated with EGF inhibitor attenuated ChP proliferation compared to untreated TBI CSF.
Conclusions: ChP proliferation leading to excess CSF production may underlie the etiology of posttraumatic hydrocephalus. The initial findings of this ongoing study may lead to a comprehensive understanding of ChP proliferation after TBI and support future pharmacological treatments for posthemorrhagic hydrocephalus.
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Progressive parkinsonism due to aqueductal stenosis-induced hydrocephalus

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Purpose: In cases of hydrocephalus with aqueductal stenosis, progressive parkinsonism may develop. This study aimed to conduct a theoretical analysis of its pathophysiology, focusing on the functional anatomy of dopaminergic neuronal pathways.
Methods: We conducted a retrospective review of clinical cases involving surgical intervention for hydrocephalus presenting with progressive parkinsonism. The pathogenesis was discussed based on established functional anatomy.
Results: Cases were classified into two categories, both associated with aqueductal stenosis complicating hydrocephalus. Surgical intervention using endoscopic third ventriculostomy effectively managed parkinsonism in both categories. The first category, termed "global rostral midbrain dysfunction," displayed rapid-onset akinetic mutism (AM) attributed to shunt malfunction, likely stemming from midbrain deformation. This condition implies dysfunction of the entire dorsal midbrain, including the substantia nigra with nigrostriatal connections and midbrain reticular formation. Indirect evidence of midbrain damage was observed as hemorrhagic lesions on ventricular walls in all three cases. The second category exhibited unilateral parkinsonism and memory impairment, possibly due to dysfunction in the Cortico-striate-thalamo-cortical loop surrounding the ventricles. Notably, no physical changes were detected in the midbrain itself, including in preoperative imaging. Even in the condition known as Global rostral midbrain dysfunction, dysfunction of this loop may contribute to AM onset.
Conclusion: Hydrocephalus complicating aqueductal stenosis can lead to progressive parkinsonism with significant activity reduction and mutism. Dysfunction of the whole dorsal midbrain and Cortico-striate-thalamo-cortical loop due to ventricular enlargement causing dopaminergic neuronal pathway dysfunction form the basis of this pathophysiology.

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Endoscopic findings and clinical outcome of 'ETV' in infants under six months in Tanzania

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Introduction: It is generally believed that ETV in Infants and children under 2 years do not offer a favourable outcome. However, outcome of VP-Shunt is also not favourable in Low and Middle

Income (LMIC) setting. The Objective of this study was to determine the association between the sociodemographic, clinical and the endoscopic anatomical findings with the outcome in Infants who underwent Endoscopic Third Ventriculostomy (ETV) at Muhimbili Orthopaedic Institutute (MOI) from 2012–2020.
Methods: A retrospective analysis of a prospectively maintained ETV under 6 months hydrocephalus cohort was done. Data was collected on demographic, clinical, and anatomical characteristics with the 12 months follow up. The bivariable relationships were tested on two age groups (< 2 months vs > 2 months) using Chi-square, and Mann–Whitney U tests. Statistical significance was set at 0.05, and all analysis was done on R studio.
Results: We admitted 277 patients with a mean age of 2.67 ± 1.7 months during the study period. Most patients were male (60.3%) and two months or less (51.9%). The older patients were more likely to have an abnormal Occipital Frontal Circumference (OFC), with a mean of 51.4 ± 6.3 cm ($p < 0.001$). Younger infants had a normal cortical mantle (51 vs 29, 1.96(1.12, 3.49) $p = 0.018$). Endoscopic evidence of infection and a scarred cistern was associated with a clinical diagnosis of infection $p < 0.05$. Patients from a rural setting were more likely to have evidence of infection on endoscopy [1.7 (1.05, 2.96) $p = 0.025$]. Furthermore, patients who had an abnormal OFC had a thin cortical mantle and a not intact septum ($P < 0.001$). The ETV success rates at 4, 26, and 52 weeks were 93.1%, 76.1%, and 63.4%, respectively. No difference was seen between age groups ($p = 0.34$).
Conclusions: ETV is feasible in infants in LMIC. There is no limitation for ETV in neonates.

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Headache severity is related to increased CSF dynamics in spontaneous intracranial hypotension (SIH)

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Introduction: Spontaneous intracranial hypotension (SIH) is a disease with debilitating symptoms among which orthostatic headaches are among the most reported. Severity of imaging findings and headache severity often does not correspond. Phase-contrast MRI has been previously introduced as a reliable assessment tool to assess craniospinal CSF dynamics at the cranial cervical spine. This study aims to analyze possible correlations of craniospinal dynamics with headache intensity.
Methods: Retrospective analysis of Headache-impact test (HIT-6) and time-resolved phase-contrast MRI of craniospinal CSF velocity curves assessed at C2/C3 in 114 patients with confirmed SIH (59% ventral leak, 19% lateral leak, 20% CSF-venous-fistula, 2% sacral leak). Disease duration, Bern score according to Dobrocky et al. 2019, age and sex were analyzed.
Results: Disease duration was ≤ 3 months in 35 patients, 3–12 months in 42 patients, > 12 months 37 patients. Mean HIT-6 was 64 ± 9. Severity of headache burden was not different between these subgroups ($p = 0.869$). An elevated acceleration of the upwards CSF flow towards the cranial compartment correlated with increased headache burden ($r = 0.357$, $p < 0.001$). This was mainly observed in patients with shorter disease duration (≤ 3 months, $r = 0.397$, $p = 0.046$, 3–12 months $r = 0.408$, $p = 0.015$), while among patients with longer disease duration headache severity was independent of any dynamics assessed. Bern score and age did not correlate to headache intensity.
Conclusions: The results suggest relation a of headache severity with altered CSF dynamics in SIH that is decoupled in patients with prolonged disease duration. This poses possible implications towards risks of chronic headaches in SIH and timing of targeted treatment.

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Long-term results of surgical treatment for pediatric hydrocephalus: a comprehensive systematic review and meta-analysis

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Introduction: Pediatric hydrocephalus, particularly prevalent in low-income countries, lacks robust evidence on long-term outcomes. To attempt to alleviate this gap in the current literature, the authors conducted a systematic review and single-arm meta-analysis on this topic.
Methods: Fulfilling PRISMA guidelines, the researchers systematically explored the Embase, PubMed, and Web of Science databases to identify articles reporting cohorts of more than four patients with pediatric hydrocephalus being followed up for at least five years or more. Single proportion analysis with 95% confidence intervals (CI) under a random-effects model was utilized to pool the data. Sensitivity analysis and Baujat plots were used to explore cases of high heterogeneity, as well as funnel plot and Egger's regression test.
Results: From 4,788 studies initially found, 17 studies with 2,211 patients were included in the analysis. Myelomeningocele and post-hemorrhagic hydrocephalus accounted for 27.1% and 14.9% of cases, respectively. Treatments included ventriculoperitoneal shunts in 46.0% and ventriculoatrial shunts in 30.3%. The median follow-up period was 14.2 years (9.9–45 years). Revisions occurred in 599 patients at a rate of 76% (95% CI: 61%-91%; I2 = 98%). Infections were seen in 350 patients, resulting in a 17% (95% CI: 12%-22%; I2 = 86%) risk. A total of 240 patients died, providing a mortality rate of 12% (95% CI: 4%-21%; I2 = 94%). Procedure-related deaths were observed in 19 patients, showing a risk of 1% (95% CI: 0%-2%; I2 = 9%). In seven studies, 155 patients reported cognitive impairment with a 28% (95% CI: 17%-39%; I2 = 96%) risk.
Conclusion: Pediatric hydrocephalus represents a serious medical condition. A substantial proportion of patients will require some form of revision. The mortality rate after five years from initial treatment remains high. The outcomes display significant heterogeneity, making it challenging to draw definitive conclusions. What remains is the heavy burden that pediatric hydrocephalus places on affected individuals, particularly in low-income countries.

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Quantification of regional neural tissue strain in type I Chiari malformation pre- and post-operatively

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Introduction: Type I Chiari Malformation (CMI) is a devastating disease with limited interventions available. The primary course of action includes a decompression surgery to relieve the physical tissue compression that occurs in the cervicomedullary junction. The presented work hypothesized that tissue dynamics parameters for symptomatic CMI patients will be significantly altered after surgical intervention.
Methods: Rostral-caudal tissue motion was quantified before and after tissue decompression surgery of symptomatic CMI patients using displacement-encoding with stimulated echoes (DENSE) MRI for twenty subjects. Principal strain in four brain regions was derived from displacement: the pons, medulla, cerebellar tonsil, and upper spinal cord. Peak-to-peak displacement and mean principal compression and extension strains are reported. Baseline scans were acquired within one week of surgery and follow-up scans acquired six months post-operatively (N = 20).
Results: Tissue motion parameters were found to have no significant differences after surgical intervention ($p > 0.05$), though patient reported quality of life changed significantly ($p < 0.05$) with an average change of 16% ± 16%, wherein only two patients reporting lower quality of life post-surgery and one patient reported no change.
Conclusions: These results show that CMI decompression surgery can improve patient quality of life without altering tissue motion parameters. Due to the overall increase in post-operative patient reported quality of life, we believe these tissue motion parameters alone may not be sufficient to quantify the effects of CMI decompression surgery in regards to patient symptomatology and overall quality of life.

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Long-term gait improvement following CSF tap test in idiopathic normal pressure hydrocephalus: an analysis of clinical outcomes

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Introduction: Although the effect of the cerebrospinal fluid (CSF) tap test (TT) has been thought to be temporary in idiopathic normal pressure hydrocephalus (iNPH), some studies have suggested the possibility of a sustained effect of CSF TT. We evaluated whether gait improvement by CSF TT could be sustained 1 month after TT in patients with iNPH.
Methods: We retrospectively analyzed 150 iNPH patients from Seoul National University Bundang Hospital (SNUBH, n = 76) and Kyungpook National University Chilgok Hospital (KNUCH, n = 74) who underwent CSF TT and quantitative gait analysis. Walking speed (WS) and stride length (SL) were measured pre- and post-TT, as well as one month later. A positive response was defined as a 10% or greater improvement in gait parameters immediately or one month post-TT compared to baseline. In addition, we also evaluated which demographic factors are associated with improvement 1 month after the TT using logistic regression models with the medical institution (SNUBH, KNUCH) as a stratification variable.
Results: Immediately post-TT, 59.3% (SNUBH: 55, KNUCH: 34) and 55.3% (SNUBH: 51, KNUCH: 32) demonstrated improved WS and SL, respectively. Furthermore, 55.3% (SNUBH: 43, KNUCH: 40) and 52.0% (SNUBH: 41, KNUCH: 37) sustained improvement in WS and SL one month later. Baseline WS or SL significantly predicted sustained improvement.
Conclusions: Our preliminary findings suggest sustained gait improvement in over half of iNPH patients post-CSF TT. Potential mechanisms include prolonged CSF leakage or altered ventricular system elasticity. Future studies with more participants are needed to validate the results of this study.

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Normal cerebrospinal fluid production rate in normal pressure hydrocephalus patients post lumbar infusion test

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Introduction: Normalpressure hydrocephalus(NPH) is a complex pathology. Several diagnostic-assessments are employed to predict shunt-responsiveness. Previous work undertaken in our single-centre unit demonstrated a high cerebrospinal-fluid production rate(PRcsf) as a potential diagnostic-tool for NPH. This finding was contradicted by studies using lumbar-infusion test(LIT). Therefore, we reproduced both assessments in same patients and studied the impact of the LIT on the PRcsf of NPH patients.
Methods: A prospective-observational study was performed on suitable suspected NPH patients in our single-centre unit from February-2024 onwards. Patients underwent lumbar drain(LD) insertion which was connected to the Liquoguard7-pump. PRcsf was calculated in the patients using the flow-rate data of the Liquoguard7-pump. LIT was then performed through the constant infusion of Hartman's solution via the LD using the LIT-programme of the LiquoGuard7-pump. Rout was calculated. Cerebrospinal-fluid was removed to equal the infused volume of Hartman's solution, and PRcsf was re-calculated. PRcsf was further calculated after time intervals of 24 h and 48 h and the results were compared.
Results: Following exclusion of unsuitable patients, LIT was performed on 6 patients (6 M:0F, 77.5Yrs). PRcsf before the infusion test was calculated to be 76-100 ml/hour. Rout was calculated to be average 12.3 mmHg/ml/min. PRcsf immediately following infusion study was calculated to be 24-36 ml/hour, and returned to 76-100 ml/hour at 24 h and 48 h post-infusion study. Rout was observed to decrease with progressive external lumbar drainage. The patients experienced good subjective and objective improvement post external lumbar drainage and so all met the criteria for probable NPH.
Conclusions: Cerebrospinal fluid production rate appears to be within the 'normal' range immediately following lumbar infusion study, but thereafter returns to a high 'pathological baseline'. It seems either infusing fluid reduces CSF production, or draining fluid increases it, or a combination of both. These preliminary results need to be validated in larger patient cohorts.

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"One shunt fits all?": The difference between the various antibiotic impregnated shunt catheters

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Introduction: Traditionally the various antibiotic impregnated shunt catheters have been marketed as generically identical products with equivalent biochemical and physical characteristics. This raises the questions, are they truly coequal? Does one shunt fit all? And if so then which shunt? In the National Hospital for Neurology and Neurosurgery a prospective comparative study was performed evaluating the different commercial antibiotic impregnated peritoneal shunt catheters.
Methods: A uniform length of Ares, Bactiseal and Xabo antibiotic impregnated peritoneal shunt catheters were connected to sterile drainage systems, running normal saline continuously at 20 ml/hour. Samples were collected from the catheters at 1 week, 3 weeks, 5 weeks and 8 weeks and tested at the Bristol antimicrobial reference laboratory for antibiotic concentrations to discern elution rate. The antibiotic load and degradation products over time were tested using HPLC-chromatograms. Antimicrobial activity over time was tested through the zone of inhibition test. The catheters were examined by UCL mechanical engineering team, exploring the rigidity, elasticity and surface microstructure of each catheter using nano-indentation for elastic modulus, 3-dimentional computerised tomography scan and GeminiSEM scanning electron microscope.
Results: The antibiotic elution rates for the various shunt catheters at 1 week, 3 weeks, 5 weeks and 8 weeks, respectively, are as follows: Ares (rifampicin level: 0.00392 mg/l, 0.0041 mg/l, < 0.002 mg/l, < 0.002 mg/l; clindamycin level 0.182 mg/l, 0.665 mg/l, 0.0706 mg/l, 0.106 mg/l); Bactiseal (rifampicin level: 0.00259 mg/l, 0.00263 mg/l, < 0.002 mg/l, < 0.002 mg/l; clindamycin level 0.0190 mg/l, 0.571 mg/l, 0.0390 mg/l, 0.0544 mg/l); Xabo(rifampicin level: < 0.002 mg/l, 0.0146 mg/l, < 0.002 mg/l, < 0.002 mg/l; clindamycin level 0.0478 mg/l, 0.195 mg/l, 0.0265 mg/l, 0.0324 mg/l. All the catheters differed in internal & external diameter, elasticity, degree of antibiotic impregnation and degree of surface adhesion over time. The antibiotic load, degradation products over time and antimicrobial activity were different for the 3 catheters.
Conclusions: Although previously considered generically equivalent, the different tubing types have different elution rates, biochemical and physical characteristics. Further prospective observational studies are required to explore the patient impact of each shunt-catheter.

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Optimizing EVD Management in Aneurysmal Subarachnoid Hemorrhage: Long-term Placement Strategy and Implications for Shunting Surgery

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Introduction: Patients diagnosed with aneurysmal subarachnoid hemorrhage (aSAH) are susceptible to developing shunt-dependent hydrocephalus. External ventricular drainage (EVD) is employed for the transient diversion of cerebrospinal fluid, and an EVD weaning protocol is utilized to determine the necessity of ventriculoperitoneal shunt placement. Controversy surrounds the optimal approach for managing EVD due to its association with reduced hospitalization duration. In this case series, our objective was to investigate the strategy of long-term EVD placement in aSAH patients and evaluate its potential contribution to informed decision-making regarding shunting surgery.
Methods: This study comprises ten patients with aSAH, all of whom underwent clipping or endovascular intervention for the ruptured aneurysms. Following an initial short-tract EVD placement lasting approximately one week, patients subsequently received long-tract EVD placement for about three weeks. Decisions regarding shunting surgery or EVD removal were made based on parameters such as drainage volume and repeated imaging scans. Patients were followed up at three- and six-months post-hemorrhage.
Results: Within the series, five patients ultimately underwent ventriculoperitoneal shunt placement. The average durations of short-tract and long-tract EVD placements were 7.4 and 17.2 days, respectively. On the final day prior to EVD revision, VP shunt insertion, and EVD removal in the shunt-free group, the average daily drainage volumes were 195.7, 141.2, and 21.8 ml, respectively. Analysis of the daily drainage volume curve suggests that a post-operative 20th day cerebrospinal fluid volume-to-initial volume ratio exceeding 0.5 may indicate the necessity for shunting surgery.
Conclusions: Long-term EVD placement in patients with aSAH may yield valuable insights for identifying individuals who require ventriculoperitoneal shunt. Despite the extended hospitalization duration associated with this observation, no EVD-related complications or infections was observed. In our study, cerebrospinal fluid drainage of 20th day exceeding 50% of the initial volume indicates the necessity of the shunt.

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Beyond the volume in prediction of idiopathic normal-pressure hydrocephalus patients' shunt surgery response

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Introduction: While many endeavours assessing idiopathic normal-pressure hydrocephalus (iNPH) have often focused on volumetric measurements within the ventricular system, this study takes a broader approach. Exploring the potential of global geometric features derived from the lateral ventricle as diagnostic markers for predicting iNPH shunt surgery response, we aimed to reveal further insights into iNPH morphometry that can improve patient selection for surgical intervention.
Methods: Our study contained 132 patients (76 shunt responders and 56 non-responders) from the Kuopio NPH registry. Our inclusion criteria required pre-surgery and one-year post-surgery symptom assessments alongside preoperative anatomical MRI (Magnetic Resonance Imaging). Volumetric brain segmentations were performed using SynthSeg 2.0 software on T1-MRI images, and then 3D lateral ventricle meshes were generated for geometric feature extraction. This analysis incorporated six geometric features derived from ventricle meshes: convexity (Cx), global Gaussian curvature (GGC), global mean curvature (GMC), surface area (SA), surface-to-volume ratio (SAVR), and volume (V). The classification task utilized CatBoost, LightGBM, and XGBoost machine learning models. Model performance evaluation employed repeated (10 rounds) nested cross-validation with 5 inner folds of the Bayesian search for hyperparameter tuning and 5 outer folds. Additionally, we conducted a SHAP feature importance analysis to identify noteworthy features.
Results: Our analysis revealed that LightGBM (AUC = 0.63, SD = 0.11) was the best-performing model in predicting the shunt surgery response. The top three features contributing the most to the model's prediction were GGC, SA, and Cx. Similarly, SHAP analysis suggested GMC, SA, and Cx as the main predictors.
Conclusions: Global geometric features, such as GGC, GMC, SA, and Cx, showed promising results in quantifying lateral ventricle shape for iNPH shunt surgery response prediction. However, their modest differentiation lacked robust standalone discrimination. Hence, we suggest that future research explore their significance in a multimodal setting.

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Cognitive impairment in iNPH and PD: a comparative analysis of linguistic, acoustic, and gaze features

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Introduction: One of the defining characteristics of Idiopathic Normal Pressure Hydrocephalus (iNPH) is cognitive impairment. To accurately differentiate preoperative iNPH from other types of dementia, it is crucial to characterize cognitive impairment in detail. This study analyzes linguistic, acoustic and gaze features from our reading task conducted by patients with iNPH, Parkinson's disease (PD), and the healthy elderly (HE). The aim of this study is to use these features to clearly distinguish between iNPH and PD, which is essential for the correct understanding and management of these conditions, as they present similar symptoms but have different pathological mechanisms and treatment possibilities.
Methods: The study included individuals aged 60+from iNPH, PD, and HE, all native Korean speakers (n=90). Neurospecialists diagnosed iNPH and PD, excluding other neurological disorders. The HE was assessed using the K-MMSE-2 to confirm normality. A reading task for Korean patients with degenerative diseases was conducted with software to collect gaze and voice data. Calibration of the eye-tracking devices was performed prior to data collection to verify the angle range. The analysis focused on linguistic, acoustic, and gaze features.
Results: The study found that both iNPH and PD had significantly longer gaze duration compared to the control group, indicating that more time was required to integrate visual information during language processing. Acoustic also showed significant differences for iNPH and PD compared to the control group, with significant differences also observed between these two groups. Linguistic such as utterance length and overall speech speed rate also showed significant differences compared to the control group, as well as between iNPH and PD.
Conclusions: The results suggest the potential for the development of new biomarkers to differentiate these conditions for early diagnosis. In addition, these findings are expected to provide essential data for improving diagnostic and treatment strategies for these diseases.

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Step by Step: a detailed gait analysis in patients with idiopathic normal pressure hydrocephalus using 3D motion capture

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Introduction: Few studies have used advanced gait analysis techniques for identification and monitoring of people with idiopathic Normal Pressure Hydrocephalus (iNPH)—those that have only report simple outcome measures that could be obtained through more rudimentary techniques. While visual inspection/video-recorded gait performance is often used to aid diagnosis of iNPH, it is typically a subjective measure and there is currently no research working towards an objective rating system. Therefore, this study aimed to provide detailed characterization of gait of individuals with suspected iNPH as compared to age-matched healthy controls.
Methods: Detailed 3D gait analysis was conducted using a 13-camera motion analysis system. Body motion (Kinematics) and kinetics (force plates) were collected at 100 and 1000 Hz, respectively. Standard spatiotemporal gait parameters (gait speed, step length and width, cadence) and kinetics and kinematics of the ankle, knee, and hip joints were obtained through Visual3D.
Results: Preliminary results from 13 patients with suspected iNPH and 11 healthy age-matched controls (76.3±6 and 72.8±5 years, respectively) indicate all spatiotemporal gait parameters were significantly different between groups ($p<0.05$); patients with iNPH exhibited 63% slower gait speeds, 64% shorter step lengths, 418% larger step widths, and 29% lower cadence. Patients with iNPH also displayed reduced peak angles and ranges of motion during both stance and swing phases for all three joints in all three planes of rotation ($p<0.05$).
Conclusions: Patients with suspected iNPH exhibit clear gait deficiencies when compared to healthy controls. Ground reaction forces and joint kinetics could not be evaluated due to the patients' short step lengths resulting in multiple foot strikes across the force plates. Future work will aim to evaluate these characteristics following cerebrospinal fluid tap-test and include modelling techniques to potentially predict responders to invasive procedures. The results of this body of work will therefore inform future clinical care guidelines.

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Considering iNPH in the New Era of Dementia ~ Society, Policy, and Institution

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Japan is a super-aging society, with approximately 30% of the total population aged 65 and over, and 16% aged 75 and over. This demographic trend is further exacerbated by the increasing number of elderlies residing in single-person households or old-age households, due to the shift towards nuclear families and the weakening of community ties. Consequently, there is an urgent need to address the growing shortage of caregivers for the elderly, with the rapid aging of the population. Dementia is the leading cause of elderlies requiring long-term care, and falls and fall-related fractures are rapidly increasing. Idiopathic normal pressure hydrocephalus (iNPH) presents itself as a condition where therapeutic intervention can help prevent dementia and falls. Therefore, raising awareness of iNPH, along with ensuring early diagnosis and intervention, becomes paramount. Health and Global Policy Institute (HGPI), of which the speakers are members, is a non-profit, independent health policy think-tank. It has been developing dementia policy projects for over a decade and has been involved in recent dementia policy through research, policy recommendations, and advocacy. In recent times, the project has focused on iNPH and has held discussion forums with academia, government, patients, and industry to examine the future of policy surrounding iNPH. In this presentation, we would like to introduce these initiatives and discuss some of the recent developments in dementia policy. These include the enactment of the Dementia Basic Law to promote a symbiotic society and the emergence of new drugs for Alzheimer's disease. We will also consider their impact on the policy of iNPH and the diagnosis and treatment of iNPH.

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Transcallosal microscopic excision of posterior third ventricular

epidermoid and ventriculostomy: a unique surgical video and literature review

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Introduction: Epidermoid cysts are rare, benign tumors of brain arising from ectodermal cells and are rarely found in ventricular system. Posterior third ventricle is a rare location for these tumors and can cause obstructive hydrocephalus.
Methods: This presentation shall include a microsurgical video of a 60-year-old male who presented with symptoms of raised intracranial pressure along with left hemiparesis due to the mass effect and obstructive hydrocephalus caused by the posterior third ventricular epidermoid cyst (size 3.1 × 2.9 × 2.4 cm). He underwent transcallosal microscopic decompression of the tumor followed by fenestration of the third ventricular floor through the same approach to address obstructive hydrocephalus and raised intracranial pressure. The microscopic third ventriculostomy was performed as a prophylactic measure to avoid recurrence of obstructive hydrocephalus in case there is residual tumor or recurrence of tumor.
Results: Following the surgery, patient made an excellent recovery with resolution of headache and vomiting. The left hemiparesis improved completely and was able to walk on his own. Follow up scans at regular intervals for the last 3 years show a stable residual tumor and no recurrence of hydrocephalus.
Conclusions: Posterior third ventricular epidermoid cysts are rare. Both microscopic and endoscopic approaches are safe ways to address tumor decompression and third ventriculostomy. This video and review highlight the microscopic decompression and third ventriculostomy through transcallosal approach which has been reported less than 15 times in the literature till now.

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Efficacy of endoscopic cerebrospinal fluid diversion training using translucent ventricle model

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Introduction: Although neuroendoscopic surgeries for hydrocephalus are minimally invasive and effective, complications have also been reported. One factor is that intraventricular manipulation by the endoscope itself cannot be visualized during surgery. In this study, we developed a translucent ventricular model and directly visualized endoscopic manipulation to evaluate compression of the brain parenchyma and the reach range of the devices.
Methods: This translucent model made by urethane resin was co-developed by Japan Medical Company. Choroid plexus, veins, fornix, and mammillary bodies are painted as indicators. Puncture sites are two, via the right anterior horn and the parietal lobe. Via the anterior horn, we perform ETV (endoscopic third ventriculostomy), biopsy, aqueduct plasty, septostomy, bilateral CPC (choroid plexus cauterization). Via the parietal lobe, we performed wide ipsilateral CPC. The movement of endoscope and devices were evaluated.
Results: It has been confirmed that considerable stress is placed on the fornix and choroid plexus during third ventricle manipulation (ETV, biopsy, etc.) and endoscope removal, and on the foramen of Monro and massa intermedia when approaching the aqueduct. During CPC, the sheath was pushing the brain parenchyma considerably. Although it was possible to reach a wide range via the parietal lobe, it was confirmed that the endoscope and coagulation device could not enter deeper than the trigone on both sides via the anterior horn.
Conclusions: In training using the world's first translucent ventricle model, we were able to see things that had not been possible to visualize before, such as the compression of the brain by the endoscope and sheath itself, and the reach range of the devices. It is thought that it will be quite useful in education, and validation during the development of devices. Furthermore, it may be possible to contribute to the development of new endoscopic approaches in the future.

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Cardiac 123I-MIBG scintigraphy for Parkinson's disease and idiopathic normal pressure hydrocephalus

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Parkinson's disease (PD) is an important differential diagnosis for Idiopathic normal pressure hydrocephalus (iNPH), but its diagnosis is sometimes not easy because the two conditions can coexist. We previously reported that at least 5% of iNPH patients had abnormal cardiac 123I-MIBG scintigraphy, which indicated the presence of comorbid PD in iNPH. However epidemiological data on the comorbidity of PD and iNPH are still limited, and further studies are needed. Disease-specific imaging biomarkers are one solution to this problem, and we believe that cardiac 123I-MIBG scintigraphy is one of the most promising candidates. Cardiac 123I-MIBG scintigraphy can visualize cardiac sympathetic denervation associated with Lewy pathology in PD and DLB. This nuclear imaging is incorporated into the current PD diagnostic criteria. In addition, it may be useful for subtype classification of PD. In this talk, I would like to discuss the comorbidity of PD and iNPH from the view point of cardiac 123I-MIBG scintigraphy.

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A new Lumbo-Peritoneal Shunt System for the treatment of Communicating Hydrocephalus: First Experiences and Clinical Perspectives

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Introduction: Recently, a new system, specifically designed for lumboperitoneal shunts (LPS) was introduced. This modular system offers the integration of differential pressure units as well as fixed- or adjustable gravitational units and/or control reservoirs. Here, the efficacy and safety of this novel LPS system in managing different forms of communicating hydrocephalus were assessed.
Methods: Twenty one consecutive patients, who underwent LPS implantation between March 2023 and April 2024 were retrospectively analyzed. Data encompassing demographics, surgical specifics, complications and outcomes were collected and evaluated.
Results: The median age of the cohort was 58.1 ± 17 years, with a f/m ratio of 11:10, representing a wide spectrum of etiologies: idiopathic normal pressure hydrocephalus (iNPH, n = 9), posthemorrhagic hydrocephalus (PHH, n = 7), idiopathic intracranial hypertension (IIH, n = 3) and hydrocephalus following tumor resection (n = 2). Surgical time was 70.9 ± 17.9 min. Overall, we found rapid postoperative recovery. Relevant complications requiring surgical revision were found in 4 patients (19.1%). In 3 (14.3%) of these, revision was done due to dislocation of the peritoneal catheter. In only one patient (4.8%) the LPS system had to be removed. While initial overdrainage was found in 23.8%, which resolved after valve adjustment, no overdrainage with subsequent hygroma or subdural hematoma requiring borehole evacuation was found. Follow-up assessments up to one year highlighted improvements in gait and visual function, particularly evident in

iNPH and IIH patients. Furthermore in 3 patients with complex cranial wound conditions the LPS was successfully applied as rescue solution.
Conclusions: Here we present the first study applying the novel LPS system. Our findings suggest favorable outcomes associated with this LPS system in managing various etiologies of communicating hydrocephalus. Rapid postoperative recovery and promising amelioration of symptoms were observed, while no overdrainage requiring borehole evacuation was found. Further investigations involving larger, prospective cohorts are imperative to validate these outcomes and optimize treatment strategies.

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Investigating Hyperlipidemia and Coverage of Lipid Lowering Treatment in INPH

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Introduction: Hyperlipidemia and atherosclerotic disease have been shown to be overrepresented vascular risk factors in iNPH. One of the leading causes of death in treated iNPH is cardiovascular disease. The prevalence of hyperlipidemia is partly described in iNPH, however there is an additional need to investigate the current treatment status of hyperlipidemia. The aim was to investigate lipid lowering treatment coverage and how many that reach LDL (low-density lipoprotein) target values in iNPH.
Methods: All patients referred for NPH-investigations to a neurological clinic in Northern Sweden during 2007–2019 were reviewed for participation in this study. Of these, 281 patients diagnosed with iNPH were included. INPH diagnosis was confirmed by an experienced neurologist based on MRI, clinical examination, gait assessment, CSF-dynamics and tap-test. During investigation for NPH, lipid measurements and cardiovascular risk factors were assessed in a standardized manner. SCORE2-OP is an assessment tool for evaluating risk of cardiovascular events developed by European Society of Cardiology (ESC). SCORE2-OP is based on individual cardiovascular risk factors and was assessed in each participant. Individual LDL-target value was based on ESC guidelines for cardiovascular prevention.
Results: Mean age for participants was 74($\pm$6.2) years and 35.3% were women. A large majority of the participants (99.3%) should have had ongoing statin treatment according to their SCORE2-OP risk group assessment. However, only 39.4% of those had. Regarding LDL-target values based on SCORE2-OP, only 10.2% of all iNPH had reached target. Coverage of statin treatment was 35.4% in those who did not meet LDL target, compared to 89.3% in those who did ($p < 0.001$).
Conclusions: This cohort study illustrates the clinical reality and highlights that iNPH has high prevalence of hyperlipidemia. Furthermore, iNPH patients are commonly undertreated for their hyperlipidemia according to treatment guidelines. Treating hyperlipidemia systematically could be a simple way to reduce cardiovascular burden and mortality in iNPH.

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Effect of cerebrospinal fluid removal on standing balance in patients with idiopathic normal pressure hydrocephalus

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Introduction: Balance is another problem that is often found in patients with idiopathic normal pressure hydrocephalus (iNPH). This study aimed to investigate the effect of cerebrospinal fluid (CSF) removal using the tap test on standing balance in patients with iNPH. Additionally, to compare standing balance between eyes open and eyes closed conditions for each time of assessment.
Methods: Patients with iNPH were recruited from the outpatient clinic, Siriraj Hospital, Thailand. Standing balance was assessed at pre- and 24 h after the tap test using the force distribution measurement (FDM) platform. The ability to stand still with eyes open and closed was tested on the platform for 20 s per condition with a physical therapist standing behind the patients to prevent adverse event. Standing balance variables included 95% confidence ellipse area (mm^2), center of pressure (COP) path length (mm), COP velocity (mm/s), length of minor axis (mm), length of major axis (mm), and angle between Y and major axis (deg). It was found that the data were not normally distributed, so, the Wilcoxon signed ranks test was used to compare data between pre- and post-tap tests and between visual conditions.
Results: Thirty-seven patients with iNPH, including 20 males and 17 females with an average age of 79.1 $\pm$ 5.9 years participated in this study. No statistically significant differences ($p > 0.05$) were found in all standing balance variables after tap test. Statistically significant differences ($p < 0.05$) were found in COP path length, COP velocity, length of minor axis, and angle between Y and major axis between eyes open and closed conditions when testing at post-tap, but no difference at the pre-tap time.
Conclusion: Overall, the tap test did not improve standing balance ability in patients with iNPH and this ability was reduced when vision was disturbed.

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A comprehensive analysis of the chronic burden of hydrocephalus in a paediatric population; revisions, false alarms, and scans

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Introduction: Effective management of hydrocephalus is critically dependent on the reliability of cerebrospinal fluid (CSF) shunt systems. Yet, the complexity of diagnosing shunt failures leads to a significant, enduring burden for paediatric patients and healthcare systems. Our study presents a novel approach to quantify this chronic burden, offering the first in-depth analysis of the long-term consequences for children with shunts. This research provides a comprehensive longitudinal retrospective analysis of all clinical events associated with the patients' shunt over time, starting from the initial placement.
Methods: At Starship Children's Hospital in Auckland, New Zealand, we conducted a retrospective analysis of clinical events associated with patients' CSF shunts. Our study tracked 73 patients over a period ranging from four to 18 years following their first shunt surgery.
Results: Our study reveals a stark reality for paediatric patients with CSF shunts. Within three months following shunt placement, there is a 56% likelihood of rehospitalisation for shunt-related concerns, potentially requiring shunt revision. By six months, this risk increases to 63%, and by the first year, it reaches 78%. Alarmingly, 70% of hospital visits prompted by suspected shunt malfunctions are later ruled out and

determined to be false alarms. Within the initial year, 59% of patients experienced at least one false alarm, while 36% had two, and 16% encountered at least three. Over four years, the average patient spent 39 days in hospital for shunt-related issues—nearly half (49%) of their total hospital stays—and underwent an average of 7.4 brain MRIs, 4.1 CT head scans, and 3.3 shunt series radiographs.
Conclusions: This study highlights the significant impact of diagnostic uncertainty in shunt failure and the need for ongoing shunt monitoring, evidenced by the high readmission rates, numerous diagnostic scans and hospital admission days.

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Screening for idiopathic normal pressure hydrocephalus in patients with minor ischemic stroke

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Introduction: Patients with idiopathic normal pressure hydrocephalus (iNPH) often have multiple vascular risk factors and may suffer from cerebrovascular disease. However, the prevalence of iNPH among patients with ischemic stroke hasn't been reported, possibly leading to underdiagnosis. This study aims to estimate the prevalence of iNPH in patients admitted with an ischemic stroke.
Methods: We retrospectively reviewed the medical records of the patients admitted to our hospital for an ischemic stroke between January and December 2023. We excluded the patients of the following features: younger than 60 years, admitted with cardiogenic or dissecting cerebral infarction, or discharged with an mRS score of 4 or more. During the period if the MRI on admission demonstrated either ventricular enlargement (Evans' index over 0.3) or DESH, we examined the patient for classic iNPH symptoms. A tap test was conducted for those who met the criteria of iNPH, with positive results indicating shunt surgery. Improvement after the surgery was evaluated utilizing the iNPH Grading Scale.
Results: Of the 163 patients included, 44 (26.9%) had ventricular enlargement (Evans' index > 0.3), while 14 (8.5%) had DESH on the initial MRI. Among these, 12 patients (7.3%) showed any of the iNPH symptoms and underwent a tap test, and 10 patients (6.1%: 2 with only ventricular enlargement, 2 with only DESH, and 6 with both) subsequently underwent shunt surgery. All the 10 patients experienced improvement of the iNPH symptoms three months after the shunt surgery, with the average total score on the iNPH Grading Scale changed from 6.3 (SD = 2.05) to 4.3 (SD = 2.21) ($P < 0.01$).
Conclusions: Elderly patients with minor ischemic stroke may also have iNPH at a higher prevalence than the general population. It may be beneficial to carefully evaluate stroke patients for radiographical findings or symptoms of iNPH.

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Manual and automatic quantification of ventricular volume before and after shunt surgery in idiopathic normal pressure hydrocephalus

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Introduction: Neuroimaging is essential in the work-up of idiopathic normal pressure hydrocephalus (iNPH). CT is commonly used both pre- and postoperatively. This study aims to compare manual segmentations with fully automated quantifications of lateral ventricular volume on CT images. Both preoperative and follow-up scans (6 weeks postop) were analyzed, and results were compared to clinical response.
Methods: Forty-nine iNPH patients were included. CT brain images were analyzed pre and post shunt surgery using manual segmentations and ScanDx, an AI-driven brain CT quantification pipeline. It uses trained deep-learning models to segment and quantify various brain tissue classes, including ventricles from brain CT images. Clinical assessment was performed before and 3 months after shunt insertion using a modified iNPH symptom scale (Hellström), including 10 m gait, balance and incontinence evaluation, and a mini mental state examination (MMSE). Forty-two patients were dichotomized into responders or non-responders. Responders were predefined as having either ≥ 3 points improvement on MMSE, ≥ 5 points on iNPH scale, or both.
Results: Manual and automatic volumetry of lateral ventricles were strongly correlated (Pearson's $r = 0.96$ for preoperative and $r = 0.91$ for postoperative volumes. Median volume reduction at 6 weeks post-operatively was 21.5 ml (15.2%) for automatic measurements and 13.5 ml (12.4%) for manual. Clinical response was seen in 30 of 42 (71%) patients but there was no correlation between clinical improvement and degree of ventricular reduction.
COnclusion: Our study demonstrates the potential of acquiring quantitative volumetric data from CT images, using a fully automated AI tool, even with the presence of an intraventricular shunt. Robust correlations were seen between automatic and manual methods. However, a systematic bias was observed where the automatic model tends to overestimate certain anatomic regions. Volume reduction postop was 15.2% with automatic and 12.4% with manual measurements.

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Dynamic balance dysfunction and falls as early signs of idiopathic normal pressure hydrocephalus

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Introduction: Recognizing the importance of early diagnosis and intervention in idiopathic normal pressure hydrocephalus (iNPH) due to its progressive symptoms is crucial for optimizing outcomes. This study focused on very mild cases, and investigated the characteristics of dynamic balance and its correlation with falls.
Methods: Among 165 patients diagnosed with probable iNPH according to national guidelines, 62 patients (age: 75.8 ± 5.4 years [39 males, 23 females]) with very mild iNPH, as evidenced by meeting the criteria of iNPH grading scale gait domain ≤ 1 (i.e., "normal" to "complaints of dizziness and postural instability, but no objective gait disturbance") and Timed-up and Go (TUG) ≤ 13.5 s, were enrolled. Patients were assessed using the TUG, Functional Gait

Assessment (FGA) (each-item, 0 to 3 points; total 30 points) for dynamic balance function during gait, and falls history in the past 6 months, before the tap-test. Unpaired t-tests were conducted to test for differences in the TUG and FGA between fallers and non-fallers. Multivariate stepwise logistic regression analysis was conducted to identify the sub-item factors of FGA associated with fall status. Statistical significance was defined as $p < 0.05$.
Results: Overall fall-rate was 45.2%. Fallers had significantly worse FGA scores than non-fallers (fallers: 16.0 ± 3.1, non-fallers: 21.4 ± 3.4, $p < 0.001$), whereas there was no difference in TUG (fallers: 11.6 ± 1.2 s, non-fallers: 11.4 ± 1.5 s, $p = 0.512$). Fall-related independent factors in FGA were extracted for item 5 (gait and pivot turn, logit value:2.818, $p = 0.002$), item 7 (gait with narrow base of support, logit value:2.716, $p = 0.002$), item 2 (change in gait speed, logit value:2.5, $p = 0.003$), item 4 (gait with vertical head turns, logit value:1.871, $p = 0.013$), and item 6 (step over obstacle, logit value:1.577, $p = 0.026$).
Conclusions: Our results highlight the importance of dynamic balance dysfunction and falls as early signs of iNPH. The FGA sub-items associated with falls may serve as an indicator for the early detection of iNPH.

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Measurement and visualization of water molecule movements in brain parenchyma using MRI Q-space imaging

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Introduction: Cerebrospinal fluid (CSF), Interstitial fluid (ISF), and blood in the brain are collectively called as neurofluids, the movements of which may be related to neurodegenerative diseases such as hydrocephalus. The movement of ISF in the brain parenchyma is difficult to observe because of various reasons such as very slow (~ μm/s) neighbor on capillary blood flow (~ mm/s). The current study presented the feasibility to measure and visualize movements of water molecules in the brain parenchyma based on q-space imaging (QSI) technique of magnetic resonance imaging (MRI).
Methods: The QSI technique measured diffusion MRI signal in various q-values. The signals in q-values were inversely Fourier transformed to obtain probability density function of water proton displacement called as "propagator". The propagator represents average of the water proton displacement as the peak location, which the displacement divided by the diffusion time is the velocity. Bloch-Torrey simulation was conducted to evaluate the movements of the ISF and blood mixed in a voxel. The blood flow velocity was set to 2 ± 0.5 mm/s higher than the ISF velocity set to 10 ± 10 μm/s. After the simulation, diffusion-weighted stimulated echo EPI at 9.4 T-MRI was applied to the mouse brain to measure the water molecule movements. The velocity bandwidth was set to ± 160 μm/s in both the simulation and the experiments.
Results: The simulation results demonstrated that the average velocity of ISF movements can be extracted by the QSI technique in spite of the presence of the blood flow. The water molecule movements in the mouse brain appeared to have some flow patterns.
Conclusions: The Bloch-Torrey simulation represented the feasibility to measure and visualize ISF movements in the brain by QSI. The movements of the water molecules in the mouse brain were recorded, although the interpretation related to the clearance system was still not sufficient.

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Forefront treatment of post-hemorrhagic ventricular dilatation in extremely low birth weight infants to avoid permanent ventriculo peritoneal shunt and improve neurodevelopmental outcome

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Introduction: The treatment of post-intraventricular hemorrhagic hydrocephalus (PIVHH) in extremely low birth weight infants (ELBWIs) is especially difficult and often results in severe neurological sequelae. We have devised "Fibrinolytic Ventricular Lavage (FVL) therapy," in which low dose urokinase (UK) is repeatedly administered intraventricularly with ventricular drainage management (EVD) from early onset of PIVHH. The effectiveness of FVL therapy will be discussed.
Methods: Forty-eight patients with PIVHH (IVH Grade3: 20 cases, Grade4: 28 cases) are involved. The early intervention group (within 3 weeks of onset of IVH) received EVD by PI catheter and FVL therapy, while the late intervention group (after 3 weeks of onset of IVH) received EVD alone or VPS after waiting until weight reached 1800 g.
Results: 30 infants were treated with EVD early, and 26 of them also received FVL therapy. 23/26 (88%) treated with FVL therapy were cured of PIVHH without requiring permanent ventriculo peritoneal shunt (VPS). On the other hand, 3/4 infants treated with EVD alone required VPS, and all 5 infants managed with EVD in the late phase required VPS. Of the 13 infants for whom conservative treatment was preferred, 7 underwent VPS and 6 had arrested hydrocephalus. The good outcome at the adjusted 36-month follow-up was 21/26 in the early intervention group, in which the majority of patients had the severe IVH Grade 4, and 6/16 in the late intervention group, with significantly better outcome in the early intervention group. Shunt-related complications were frequent in patients who underwent VPS, which also had a significant impact on poor outcome.
Conclusions: Periventricular white matter injury is caused not only by compression and ischemia due to ventricular enlargement, but also by hematoma and inflammatory cytokines induced by the hematoma and its lysate. FVL treatment concept for PIVHH in ELBWIs is safe, advanced, and very promising.

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Zwitterionic-Coating for Mitigating Cellular Occlusion on a Ventricular Catheter for the Treatment of Hydrocephalus

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Introduction: Current hydrocephalus treatments involve the insertion of ventricular shunt catheters with mechanical valves to regulate cerebrospinal fluid (CSF) flow. However, approximately 40% of these shunts fail within two years due to catheter occlusion by cellular debris. Despite efforts to enhance shunt performance, such as using catheters coated with polyvinylpyrrolidone (PVP) to reduce bacterial adhesion, these strategies have not effectively reduced catheter occlusion rates in clinical practice. In this study, we aimed to develop a zwitterionic coating for catheters to prevent cellular occlusion, thus improving the longevity and reliability of shunt systems.
Methods: Commercial silicone catheters (Barium stripe, Medtronic) underwent zwitterionic coating using an electrospinning technique. Human astrocytes and choroid plexus (ChP) cells were cultured to assess cell adhesion on uncoated versus zwitterionic-coated catheters. The catheters were visualized for cellular quantification by

immunostaining against CD68 (microglial marker) and against GFAP (astrocyte marker) DAPI was used to quantify nuclei.
Results: In vitro cellular experiments demonstrated a significant reduction in cellular attachment on zwitterionic-coated catheters compared to uncoated catheters. The uncoated control catheters exhibited notable astrocyte and choroid plexus attachment, whereas zwitterionic-coated silicone catheters showed minimal cellular attachment. Graphical quantification further confirmed a significant decrease in astrocyte attachment on zwitterionic-coated catheters (the normalized density (number of cells per unit area): $p = 0.0329$, mean = 24.39 ± 16.68 (SD)) comparing to the control catheters (the normalized density: mean = 37.10 ± 18.44 (SD)).
Conclusions: This study underscores the potential of zwitterionic coatings in mitigating cellular adhesion on catheters. In vitro testing of these coatings provided critical insights into their efficacy in preventing cellular attachment, highlighting their promise for enhancing device tolerance and reducing inflammatory responses associated with shunt failure.

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Exploring voice acoustic features and cognitive metrics in Hakim's disease: a machine learning approach to differentiating Hakim's disease from other neurodegenerative disorders

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Introduction: Several studies have indicated that patients with cognitive impairment, including those with Hakim's disease (HD), Alzheimer's disease (AD), and Parkinson's disease (PD), exhibit impairments in speech and cognition. However, no studies have been conducted that analyze the differences in voice and cognition between specific diseases. This study aims to investigate the possibility of identifying voice acoustic features and cognitive availability that can differentiate HD from other neurodegenerative diseases. This is achieved by analyzing the voice and Korean Mini-Mental State Examination (K-MMSE) scores of patients with HD using machine learning (ML).
Methods: We enrolled 54 patients with HD from a total of 196 patients with cognitive impairment who scored 24 or less on the K-MMSE. We plan to analyze the acoustic voice features such as voice quality, voice variability, and speech rate extracted from specific speech tasks (alternative motion rate tasks, AMRs), and sub-scores of K-MMSE such as memory, intention, and drawing using ML algorithms.
Results: In our previous study, we demonstrated that acoustic features extracted from AMRs can differentiate HD from other neurodegenerative brain diseases. The results of this study, which utilizes K-MMSE partial scores and voice features, will confirm whether there are differences in speech and cognitive abilities between HD and other brain diseases.
Conclusions: The unique pathophysiological characteristics of each condition can be discovered.

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Exploring the relationship between global gray matter and the idiopathic normal pressure hydrocephalus triad

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Introduction: The idiopathic normal pressure hydrocephalus (INPH) triad includes cognitive impairment, gait disorders, and urinary incontinence. Limited imaging studies have investigated the relationship between global gray matter (GM) alterations and the INPH triad. This study aims to explore this relationship in patients with INPH through structural image analysis.
Methods: 42 patients diagnosed with INPH and 24 healthy control (HC) subjects were included in this study. The INPH patients received a cerebrospinal fluid tap test (CSF TT), followed by assessments of gait parameters, cognitive function, and urinary frequency using the 3-meter timed up and go test (3-mTUG), the 10-meter walking test (10-MWT), the Mini-Mental State Examination (MMSE), and the Montreal Cognitive Assessment (MoCA). All participants underwent a 3D T1-weighted MRI. Statistical parametric mapping 12 was used for preprocessing images, statistical analysis, and voxel-based morphometry for gray matter volume analyses. Pearson's correlation analysis and Bonferroni's statistic-corrected one-way ANOVA were used to determine the relationship among demographic variables.
Results: INPH patients demonstrated considerable deficits in cognitive impairment and gait disorders, and increased urinary frequency compared to HCs ($p < 0.001$). Relative to HCs, INPH patients demonstrated markedly reduced GM volumes in the bilateral hippocampus, bilateral calcarine gyrus, right caudate nucleus, and left superior parietal lobule ($p < 0.001$). Conversely, significantly increased GM volumes were observed in the bilateral precentral gyrus and the right inferior and middle occipital gyrus among the INPH group ($p < 0.001$). Furthermore, INPH patients had worse MMSE and MoCA scores, which were significantly correlated with bilateral Hippocampus ($p < 0.05$). As well as urinary frequency, which were significantly correlated with alterations in the left Superior Parietal Lobule ($p = 0.012$).
Conclusion: Compared to HCs, the INPH patients' cognitive impairment and urinary incontinence were significantly associated with global gray matter alterations.

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New bioreactor system to test the mechanisms that underlay catheter malfunction under hydrocephalic conditions

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Introduction: Pediatric Hydrocephalus is characterized by excessive cerebrospinal fluid (CSF) accumulation within the brain's ventricles, which, if not treated, leads to increased intracranial pressure, abnormal head enlargement, and death. Currently, it is the most common neurological disorder treated by pediatric neurosurgeons, and CSF shunting is the main procedure. Unfortunately, despite advances in neonatal and neurosurgical care, CSF shunts malfunction frequently, with failure rates of about 30 – 40% during the first year and approximately 50% within the first two years after implantation. The primary cause of shunt failure is tissue-dependent ventricular catheter obstruction. Thus, our lab developed a new Bioreactor that allows ventricular and subventricular zone (VZSVZ) cell culture to test ventricular catheters. We aimed to use the Bioreactor to recapitulate the interactions between brain parenchymal cells and functional catheters to understand the mechanisms associated with ventricular catheter failure.

Methods: We have meticulously designed and 3D-printed a physiological system that includes a catheter assessment area adjacent to a flow control area. The catheters are introduced into transwell inserts cultured with neural stem cells (NSC) from P3-5 C57BL/6 J mice into a 3D hydrogel exposed to proliferative media. Thus, the cells proliferate and migrate radially in the hydrogel (5 mm deep), precisely recapitulating the physiological conditions of periventricular areas treated with ventricular catheters.
Results: The NSC differentiated into Astrocytes (GFAP positive cells) and neuroblasts (β-tubulin III positive cells) in the hydrogel. Our results confirmed that only astrocytes migrated toward catheter holes with a preference for attachment on the edges.
Conclusions: To our knowledge, this is the first time that periventricular cells have been cultured to replicate the parenchymal cortex. These findings provide a deeper understanding of astrocyte differentiation and migration associated with the foreign body reaction caused by silicon-based catheters, thereby paving the way for a better understanding of treatment failure in pediatric hydrocephalus.

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The resistance to CSF outflow is not associated with tightness over the high convexities in patients investigated for Normal Pressure Hydrocephalus

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Introduction: Our investigation explores the correlation between CSF volume in the high convexities and resistance to CSF outflow (Rout). Rout and disproportionately enlarged subarachnoid space hydrocephalus (DESH) have been described as diagnostic and prognostic indicators in iNPH. Despite extensive research performed separately on radiological descriptors and CSF circulation, the interplay between CSF reabsorption and high convexity tightness in NPH is not well-defined. It is possible that tight high convexities could result in increased Rout through obstruction of CSF flow to the arachnoid granulations. We aim to elucidate these physiological relationships in NPH patients and controls, postulating that tighter high convexities correlate with increased Rout.
Methods: We randomly selected subjects from a retrospective cohort of patients with ventriculomegaly (VM) investigated for NPH and a healthy control group for preliminary analysis. The cohort consisted of unique infusion tests (CELDA™ infusion device) paired with T1-weighted 3 T MRI scans. We measured the high convexity volume using a standardised segmentation and thresholding method. Rout was calculated as the ratio between the mean pressure increase to mean inflow of artificial CSF.
Results: 219 patients (VM) and 24 Controls were analysed. Rout [mmHg/(ml/min)] was 12.6 ± 6.4 and 10.37 ± 4.52 $p = 0.027$ with high convexity volumes [mL] of 6.04 ± 2.99 and 12.26 ± 3.13; $p < 0.001$ (VM vs Controls). There was no correlation between high convexity volume and Rout in either VM: $R = -0.024$; $p = 0.7815$ or Controls $R = -0.26$; $p = 0.2236$. For VM with Rout ≥ 12 ($N = 79$) & ≥ 15 ($N = 37$), R was -0.1014; $p = 0.3741$ and $R = 0.0987$; $p = 0.5611$, respectively.
Conclusions: The absence of a link between Rout and high convexity volume could have several physiological interpretations. Primarily, it is indicative that tight high convexities do not obstruct CSF reabsorption pathways. Alternatively, should arachnoid granulations become obstructed in the areas investigated, they do not result in increased Rout, potentially indicating the presence of alternative circulatory routes.

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A patient with clinical presentation of Richardson's syndrome but pathologically confirmed secondary hydrocephalus without neurodegenerative disease

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Introduction: Recent reports suggest a link between progressive supranuclear palsy (PSP) and normal pressure hydrocephalus. We present a case of a patient who initially presented with symptoms consistent with Richardson's syndrome, but an autopsy revealed only secondary hydrocephalus.
Clinical summary: The patient had dizziness and left-sided deafness diagnosed as an acoustic tumor. At the age of 62, he underwent gamma knife radiosurgery. One year and five months later, he developed an unstable gait, and imaging confirmed secondary hydrocephalus. Following ventriculoperitoneal (VP) shunting, his gait normalized, and he returned to work. However, four months later, he developed new symptoms including akinesia, dysphagia, postural instability, supranuclear vertical gaze palsy, cognitive decline (scoring 8 on the Mini Mental State Examination), frontal signs, urinary incontinence, and eyelid apraxia. Furthermore, magnetic resonance imaging (MRI) revealed marked ventricular dilatation, with atrophy of midbrain tegmentum. Based on these features, he was diagnosed with PSP and hydrocephalus. Thereafter, the patient showed no worsening of mobility. At the age of 73, mild progression of atrophy was observed on MRI. SPECT showed mild dopamine transporter reduction predominantly in the putamen. He died at 74 years of age from colon cancer.
Neuropathological findings: Brain weight was 1,430 g. His brain showed pathological findings, such as loss of ependymal cells in the cerebral ventricle, subependymal gliosis, and arteriosclerosis in the brain parenchyma, compatible with hydrocephalus. Atrophy in the globus pallidus, subthalamic nuclei, and substantia nigra, globose-type neurofibrillary tangle, and tufted astrocyte were not noted, clinical diagnosis of PSP was denied pathologically. He also had a mild cerebral amyloid angiopathy, but the other aging pathology such as Alzheimer's disease, argyrophilic grain accumulation, or Lewy body disease was not seen.
Conclusions: This autopsy case demonstrates Richardson's syndrome presenting due to secondary hydrocephalus. It highlights that Richardson's syndrome can be a clinical manifestation of hydrocephalus.
Note: Consent to publish has been obtained by the patient.

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Changes in telemetric intracranial pressure after implantation of shunt for Idiopathic Intracranial Hypertension

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Introduction: Implantation of a ventriculoperitoneal (VP) shunt is standard practice in people with fulminant Idiopathic Intracranial Hypertension (IIH). In our unit, we integrate the M.scio telesensor

(B.Braun – Miethke) to the shunt and this study evaluates the changes in ICP within 1 year from surgery.
Methods: We performed a single centre study of people with fulminant IIH who underwent VP shunt insertion between February 2021 and April 2023. They all had frontal VP shunt with proGAV 2.0 (B.Braun – Miethke) set at 10. Baseline telemetric ICP recordings within 1 month from surgery were compared to recordings for up to 1 year after surgery to determine if there was any change. Those recordings included the mean ICP and amplitude (AMP) in the sitting and supine position. The change in Body Mass Index (BMI) was also assessed.
Results: Fourteen people were included in the study (13F:1 M) with mean age 26 years. The baseline mean sitting ICP was -3.7 mmHg and within the 1st year (mean 6 months, range 3–12 months), it measured – 5.6 mmHg ($p = 0.38$). The mean sitting AMP was 5 mmHg at baseline and at the 2nd measurement. The mean supine ICP was 13.2 mmHg at baseline and 14.7 mmHg at the 2nd recording ($p = 0.47$), and the mean supine AMP measured 4.5 mmHg and 5.6 mmHg respectively ($p = 0.5$). The baseline mean BMI around the time of surgery was 34 kg/m^2 and around the second measurement was 35 kg/m^2 ($p = 0.7$).
Conclusions: In this series, the telemetric ICP recordings did not change significantly between the baseline measurement soon after shunt insertion and up to 1 year afterwards. This is the first study to provide telemetric ICP measurements in a longitudinal fashion and will help the interpretation of telemetric recording in case of shunt malfunction. More research is required to assess factors that may affect ICP over longer periods.
Keywords: Idiopathic Intracranial Hypertension, Intracranial Pressure, Telemetric measurements, Ventriculoperitoneal shunt.

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Cerebrospinal fluid diversion for vision-threatening papilledema secondary to cerebral venous sinus thrombosis

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Introduction: Cerebral venous sinus thrombosis (CVST) often leads to elevated intracranial pressure and vision-threatening papilledema, requiring complex management with anticoagulation and cerebrospinal fluid (CSF) diversion. However, guidance on preserving vision through CSF diversion remains limited. This study evaluates the outcomes of CSF diversion to better inform clinical decision-making in CVST management.
Methods: The methods included a retrospective observational study of patients with CVST that underwent CSF diversion from October 2016 to April 2023. Inclusion criteria were adults with vision-threatening papilledema due to spontaneous CVST. Data on demographics, aetiology, grade of papilledema, surgery, anticoagulation, visual outcomes, sinus recanalization, and complications were gathered and analysed.
Results: A total of 15 patients (5 women, 10 men; mean age 35) with vision-threatening papilledema (Frisen grade ≥ 3) due to CVST were included. The cause of thrombosis in 2/3 were oral contraceptives, infection, tumours, and hypercoagulable states, whereas in 1/3 it was not identified. Eleven patients had a shunt as primary CSF diversion procedure (9 ventriculoperitoneal or VP and 2 lumboperitoneal or LP shunt) and 4 patients underwent shunting (3 VP and 1 LP) after a period of temporary lumbar drainage. Four patients underwent shunt revisions, which eventually led to shunt removal and all 4 remained shunt independent. Anticoagulation duration varied (2 months to lifelong) and 12 patients had confirmed recanalization within 6 months, whereas no repeat venous imaging was performed in 3. Thirteen patients had good visual outcomes and two remained visually impaired.
Conclusion: Permanent CSF diversion resolved vision threatening papilledema secondary to CVST, whereas temporary lumbar drainage did not resolve papilloedema in the long term and permanent shunt was required. VP shunt is preferred in our practice to LP shunt. Most patients had favourable visual outcome. More research is needed to standardise management of papilledema secondary to CVST.
Keywords: Cerebral venous sinus thrombosis, cerebrospinal fluid.

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The evolution of a multidisciplinary Normal Pressure Hydrocephalus service: continuous quality improvement

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Introduction: The management of Normal Pressure Hydrocephalus (NPH) requires a multidisciplinary approach with an efficient and responsive service. We initiated a project to redesign our service, reduce variation and establish a culture of continuous quality improvement through evaluation of clinical and service delivery outcomes.
Methods: Using Lean Six Sigma principles a new multidisciplinary service involving neurosurgeons, neuropsychologists, advanced clinical practitioner and physiotherapists was developed and piloted in 2019 before being fully established in 2021. Retrospective audit data were compared with prospective data collected as part of continuous service evaluation. Further refinements to pathways were made in response to the changing healthcare environment, increased demand and our evolving experience.
Results: Between 2014–2019, 117 patients were investigated or treated for NPH, with an average of 14 shunts undertaken per year. Following redesign of the service a total of 194 new patients have been assessed up to end of 2023. 124 (64%) were offered a trial of CSF drainage (tap test or extended lumbar drain) with 56% of those who proceeded demonstrating a positive response. In 2023 69 new patients were assessed and 30 shunts were undertaken. Median length of stay reduced from 6.5 to 3.5 days ($p < 0.001$) for extended lumbar drain test and from 3 to 2 days ($p < 0.001$) for ventriculoperitoneal shunt (VPS) insertion. At 6 months following VPS, 37 of 43 (86%) consecutive patients had an improvement of at least one point on the iNPH Grading Scale, with the median (interquartile range) score improving from 6 (5–8) to 3 (2–4.5) ($p < 0.0001$).
Conclusions: This paper describes the evolution of our service through cycles of continuous improvement. The haphazard treatment of NPH has been transformed into a highly-organised, data-driven and rapidly expanding multidisciplinary regional service with an increasing focus on evidence-based and patient-centred care.

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Hippocampal shape abnormalities in idiopathic normal-pressure hydrocephalus

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Introduction: We utilized 3-dimensional, surface-based, morphometric analysis to investigate hippocampus shape between 2 groups: (1) idiopathic normal-pressure hydrocephalus (INPH) patients with a positive cerebrospinal fluid tap test response and (2) healthy controls. The aims were (1) to evaluate INPH-related structural abnormalities of the hippocampi and (2) to investigate relationships between hippocampal shape changes and gait disturbance in INPH patients.
Methods: Forty-eight INPH patients and 25 healthy controls were imaged with MRI for vertex-based 3-dimensional hippocampal shape analysis. All participants also underwent ^{18}F-florbetaben PET imaging. To be included as a control, participants had to be β-amyloid negative by ^{18}F-florbetaben.
Results: Vertex-wise shape analysis revealed significant bilateral deformation in patients with INPH compared with healthy controls after FDR correction. Both the left and right hippocampi were more elongated and narrowed in INPH patients. In both hemispheres, INPH patients demonstrated an upward bending of the middle and posterior hippocampus reflecting a bilateral vertical displacement from body to tail. Within the INPH group, after adjusting for age and gender, there was no significant difference in hippocampal shape between amyloid-positive and amyloid-negative individuals. Significant correlations were found between local shape deformity and the timed up and go and 10 m walking tests (to a greater degree on the right than on the left). Bilateral inward deformations at the superomedial hippocampal tail and inferior hippocampal body were consistently associated with inferior performance across tests. Inward deformations at the right medial and lateral hippocampal head and right superior hippocampal body were also consistently associated with worse performance across tests.
Conclusions: Our results suggest that patients with INPH have unique patterns of hippocampal shape changes. Our findings encourage future studies to elucidate the underlying mechanism of hippocampal morphometric abnormalities in INPH patients. Changes in overall shape may contribute to the distinctive gait abnormalities associated with INPH.

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First use study of wireless, wearable, continuous thermal shunt flow monitors at home by ten shunted hydrocephalus subjects

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Introduction: Hydrocephalus shunt management lacks an objective method to assess shunt function outside of clinical settings. Wireless, wearable thermal flow sensing, recently validated in a 9-centre clinical study in the United States via FlowSense®, an investigational device, offers a potential solution. The longitudinal tracking of shunt flow outside of clinical settings, throughout the activities of daily living (ADL), is an important potential application of the technology. Here, we present first-in-human results of wearable shunt flow monitoring deployed for remote and home-use.
Methods: 10 shunted hydrocephalus subjects (age 7–60, 3 female 7 male) were provided a modified FlowSense device and iPhone with mobile application for home use. Devices recorded relative flow rate changes, motion, and orientation during wear. Subjects were trained on use and asked to obtain at least 5 measurements each lasting a period of 8–24 h (a minimum total of 400 h across all subjects) across a 30-day period. Subjects were supplied with replaceable adhesive patches for removal and reapplication of the device units in their homes. Subjects completed usability surveys following completion of the enrollment period.
Results: 885 h of data were collected in addition to qualitative user data. 94.2% of measurement segments indicated good skin contact of the sensors. Thermal flow data correlated significantly with subject activity. All subjects described acceptable comfort levels during ADL while wearing device units.
Conclusions: The data in this study support the use of wireless, wearable flow sensing technologies for monitoring shunt flow outside of a clinical setting with high patient satisfaction and usability. Advancements to sensor design will target improved accuracy of flow measurements in the presence of varied user activity. Ongoing and future studies are designed to assess correlations of measured thermal flow signal values to patient symptoms and standard of care assessments of shunt function.

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The pathology underlying hydrocephalus due to ciliary dysfunction

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Introduction: We have previously reported the DNAH14−/− mouse model of a chronic hydrocephalus harboring ciliary dysfunction, that demonstrated chronic progression of ventriculomegaly followed by cognitive decline. We have also reported chronic decrease of dopamine receptor function in DNAH14−/− mice as a cause of cognitive decline in this model. In the present study, we did further investigation on the pathological changes underlying the hydrocephalus due to ciliary dysfunction.
Methods: To evaluate disturbance of CREB phosphorylation in the neurotransmission pathway in DNAH14−/− mice, we performed immunohistochemistry (CREB and phosphorylated CREB; pCREB) and western blotting using hippocampus obtained from 24 week old mice. To evaluate CSF clearance from the ventricular system to cisterns, we injected fluorescent dye (0.7 kDa) into the lateral ventricle of 8 week old mice, and collected CSF via cisterna magna 1, 3, and 5 min after injection.
Results: In immunohistochemistry, immunoreaction against pCREB was diminished in DNAH14−/− mice compared with wild type (WT), while there was no obvious difference compared to CREB. In western blotting, the ratio of pCREB to CREB (pCREB/CREB) was significantly decreased in DNAH14−/− mice compared with WT. In the evaluation of ventricular clearance, the amount of dye eliminated from the lateral ventricle to the cistern was significantly decreased in DNAH14−/− at 5 min after injection, without significant changes at 1 and 3 min.
Conclusions: We evaluated the phosphorylation of CREB in DNAH14−/− in the present study. It implies that mis-phosphorylation of CREB in hippocampus can be the cause of cognitive decline in DNAH14−/− mice. We also evaluated impaired ventricular clearance that preceded morphologic, pathologic, and neurologic changes in DNAH14−/− mice. These results indicate that ependymal ciliary beating can contribute to brain clearance, and its impairment relates to chronic hydrocephalus.

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Predicting good outcomes one year after shunt surgery in iNPH patients with mild gait disturbance: the role of instrumented timed-up go test score

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Introduction: The Instrumented Timed-Up Go test (iTUG) score, assessed using a smartphone app, has been reported as an effective way to evaluate the improvement in gait in idiopathic normal pressure hydrocephalus (iNPH) patients with mild gait disturbance. In this

study, we examined to what extent improvement in iTUG score after the tap test predicts improvement in gait one year after shunt surgery in iNPH patients with mild gait disturbance.
Methods: Patients who underwent tap test between May 2020 and March 2023 and subsequently underwent shunt surgery, with a pre-tap TUG time of less than 20 s, were included. For these patients, TUG, iTUG score, MMSE, FAB, iNPH grading scale, and presence of DESH were recorded before and after the tap test, as well as one year post-operatively. Improvement in gait was defined as an increase of 1 or more in the score for gait in iNPH grading scale after tap test and one year postoperatively. By calculating the Area Under the Curve (AUC), we determined the cutoff value for improvement in iTUG score, predicting gait improvement one year later.
Results: A total of 76 patients were included. Among them, 54 individuals (median [IQR] age 77.5 years old [74–81], 33 men (61.1%), TUG time 14.2 s [12.4–17.1]) showed improvement in gait one year post-operatively, while 22 individuals (age 78 years old [74.5–80], 13 men (59.1%), TUG time 13.6 s [10.6–15.1]) did not. The maximum AUC was observed when iTUG score improved by 7 (AUC 0.72, 95% confidence interval 0.58—0.87).
Conclusions: A cutoff value of 7 in iTUG score may effectively predict gait improvement one year after shunt surgery in iNPH patients with mild gait disturbance.

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Estimating osmotic pressure of the CSF in iNPH patients using T2 analysis

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Introduction: Although the cause of iNPH is still unknown, there is a hypothesis that it may caused by increased CSF osmotic pressure. As a result, water is drawn from the brain tissue into sub-arachnoid space, increasing the average pressure of the CSF. We have been using T2 analysis for investigation of clearance pathway of the brain, and we applied similar technique to estimate osmotic pressure of the CSF.
Methods: Multiple spin-echo images were acquired using a CPMG (Curr-Purcell-Meiboom-Gill) imaging sequence. T2 components within each voxel was identified using NNLS (non-negative least squares)(1). Of the T2 components, one with longer than 500 ms T2 were identified as CSF components, and avera was calculated. Since it is known that in a protein solution R2 (= 1/T2) is proportional to the concentration of protein, R2 values were calculated. Also, a color map indicating the R2 values for each pixel was also generated for visual inspection.
Results: In iNPH patients, regions of CSF with short T2 were observed. Most common location was near sagittal sinus, but locations near the vein of Galen, or locations further down in the spinal canal were also seen. The actual T2 value of these regions was in the range of 500—1500 ms, where normal value is about 2000 ms. T2 value in the lateral ventricle was always close to 2000 ms.
Conclusions: A method to estimate osmotic pressure of the CSF was developed. It was possible to observe the increase of osmotic pressure in iNPH patients. T2 analysis can be a useful diagnostic tool for iNPH.

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Personalized computational modeling on ventricular cerebrospinal fluid flow dynamics

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Introduction: Hyperdynamic CSF flow characteristics in patients with Hakim's disease are well known, while these fluid dynamic characteristics and their physiological effects in the intracranial system are still unclear. Although 4D flow MRI is a powerful tool to obtain personalized CSF flow velocity fields, MRI has severe resolution limitations and intrinsic artifacts. Therefore, our study aims to develop an MRI flow data assimilation framework that combines between flow MRI data and computational fluid dynamics (CFD) simulation.
Methods: The CSF flow region (ventricular region) was extracted from T2-weighted MRI images and implicitly represented in a uniform Cartesian grid using a volume-of-fluids function. MRI flow velocity fields were extracted from 4D flow MRI with elimination of eddy-current offsets. The CSF flow was assumed to be a Newtonian fluid flow expressed by the incompressible Navier–Stokes equation. The flow data assimilation was formulated to minimize the error between MRI and CFD velocity fields by optimizing CFD inlet/outlet boundary conditions and computed by variational optimal boundary control approach.
Results: Numerical examples showed the convergence of the error function and provided high-resolution CSF flow velocity fields in the aqueduct of Hakim's disease patients with satisfying flow governing equations. Whereas non-negligible errors remained due to MRI artifacts expressed as discontinuous velocity profiles.
Conclusions: A flow data assimilation framework can provide high-resolution CSF flow velocity fields, allowing us to perform CSF flow dynamics and mass transport analyses in the ventricular region associated with physiological homeostasis. Nevertheless, assimilated velocity profiles are influenced by MRI artifacts and biases, this approach leaves several challenging tasks to tackle, such as MRI data denoising and bias filtering, and more appropriate formulation of the error functions.

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Quantitative gait analysis using deep learning algorithms on monocular videos and Timed Up and Go test in idiopathic normal pressure hydrocephalus

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Introduction: A vision-based gait analysis system using deep learning algorithms for simple monocular videos was validated to estimate temporo-spatial gait parameters in idiopathic normal pressure hydrocephalus (INPH) patients. The Timed Up and Go (TUG) test is widely used as a clinical performance-based measure for assessing general mobility in INPH patients. The TUG test has also been used to reflect risk of falling in INPH patients. The aims of the study were (1) to investigate relationships between gait parameters measured by vision-based

gait analysis and TUG scores and (2) to determine whether the automated machine learning model based on gait parameters measured by vision-based gait analysis could predict the risk of falling in INPH patients.
Methods: Gait data from 51 patients were collected from the vision-based system. All patients were also evaluated with TUG. A TUG time of ≥ 13.5 s was used as a cut-off to identify potential fallers.
Results: TUG scores were negatively correlated with gait velocity, cadence, stride length, and swing phase. TUG scores were positively correlated with step width, stride time, stance phase, double-limb support phase, stride time variability, and stride length variability. The area under the curve for predicting falling risk using the automated machine learning-based model was 0.938. We found that velocity was the most important factor in predicting falling risk with the interpretable method called SHapley Additive exPlanations.
Conclusions: This study identified important associations between gait parameters measured by vision-based gait analysis and TUG scores in INPH patients. An automated machine learning model based on gait parameters measured by vision-based gait analysis can predict falling risk with excellent performance in INPH patients. We suggest that our vision-based gait analysis method using monocular videos has the potential to bridge the gap between laboratory testing and clinical assessment of gait and balance in INPH patients.

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Spectral diffusion analysis in patients with idiopathic normal pressure hydrocephalus

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Introduction: A spectral diffusion analysis provides a parameter representing interstitial fluid (ISF) volume (F_{int}). This study aims to compare F_{int} values between healthy controls (HCs) and patients with idiopathic normal pressure hydrocephalus (iNPH).
Methods: This study included 36 HCs aged over 60 years and 34 iNPH patients. F_{int} maps were calculated from diffusion-weighted images with six b-values (0, 50, 100, 250, 500, and 1000 s/mm^2) using the non-negative least squares method. For semi-automatic measurement, a region-of-interest (ROI) template was created using spatially normalized b0 images and tissue probability labels, and was slightly modified for each individual. The ROIs included the following: medulla oblongata, pons, bilateral cerebellum white matter (WM), bilateral cerebral crus, bilateral thalamus, bilateral lenticular nucleus, bilateral frontal WM (FWM), bilateral corona radiata, and bilateral centrum semiovale. When the ROIs in iNPH patients included periventricular hyperintensity (PVH), these ROIs were categorized into an iNPH$_{PVH}$ group.
Results: Some ROIs of FWM, corona radiata, and centrum semiovale included PVH regions. Consequently, the ROIs in these regions were divided into iNPH and iNPH$_{PVH}$ groups. In the lenticular nucleus, iNPH's F_{int} was significantly larger than HC's. Moreover, in the FWM and centrum semiovale, the F_{int} of iNPH$_{PVH}$ was significantly larger than that of iNPH and HC. In all other regions, there were no significant differences in F_{int} between the groups.
Conclusions: The spectral diffusion analysis provides insights into the ISF dynamics in patients with iNPH. Our findings may reflect an iNPH pathological condition where cerebrospinal fluid permeates into the brain tissue without passing through the perivascular space due to the disruption of the ependymal cells on the ventricular surface. However, the ISF dynamics in iNPH patients may not significantly differ from those in HCs in regions other than the PVH and basal ganglia.

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High diagnostic performance of stateviewer AI for normal pressure hydrocephalus using brain FDG-PET imaging

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Introduction: Diagnosing neurodegenerative dementia (NDD) and normal pressure hydrocephalus (NPH) is challenging due to their overlapping clinical and imaging features. Fluorodeoxyglucose (FDG) positron emission tomography (PET) reveals distinct patterns for NDD and can also identify structural brain changes in NPH. We developed StateViewer, an AI algorithm that utilizes FDG-PET to diagnose normal aging, all major NDD types, and NPH (12 classes total).
Methods: We developed a latent space model from FDG-PET scans of 1,000 patients using matrix decomposition. This model was applied to another cohort of 1,676 individuals, 157 diagnosed with definite NPH, employing a modified k-nearest neighbors classifier designed for class imbalances and overlapping labels. Classifier performance was evaluated by the area under the precision-recall curve (PR-AUC) and ROC-AUC via leave-one-out cross-validation, using clinical diagnosis as the gold standard.
Results: The AI demonstrated robust diagnostic capability for the NPH-positive group (n = 157) and all negative groups (n = 1519), achieving PR-AUC of 0.91 (95% CI: 0.88–0.95) and ROC-AUC of 0.99 (95% CI: 0.98–0.99).
Conclusions: FDG-PET can differentiate between normal aging, NDD, and NPH effectively. The StateViewer algorithm quantifies these distinctions, offering sensitive and specific predictions to improve clinical decision-making for NPH. The retrospective nature of the study and potential biases from the clinical interpretation of FDG-PET scans may influence outcomes. Despite these limitations, the strong negative predictive value in distinguishing NDD and normal aging suggests that the results are reliable. Prospective validation in clinical settings is recommended to confirm these findings.

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Correlation between GLCM-based texture features of the lateral pterygoid muscle and cognitive function in patients with idiopathic normal pressure hydrocephalus: a preliminary report

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Introduction: The potential relationship between mastication ability and cognitive function in idiopathic normal pressure hydrocephalus (iNPH) patients is unclear. This report investigated the association between mastication and cognitive function in iNPH patients using the gray level of the co-occurrence matrix on the lateral pterygoid muscle.
Methods: We analyzed data from 96 unoperated iNPH patients who underwent magnetic resonance imaging (MRI) between December 2016 and February 2023. Radiomic features were extracted from T2 MRI scans of the lateral pterygoid muscle, and muscle texture parameters were correlated with the iNPH grading scale. Subgroup analysis compared the texture parameters of patients with normal cognitive function with those of patients with cognitive impairment.

Results: The mini-mental state examination score correlated positively with the angular second moment ($P < 0.05$) and negatively with entropy ($P < 0.05$). The dementia scale (Eide's classification) correlated negatively with gray values ($P < 0.05$). Gray values were higher in the cognitive impairment group (64.7 ± 16.6) when compared with the non-cognitive impairment group (57.4 ± 13.3) ($P = 0.005$). Entropy was higher in the cognitive impairment group (8.2 ± 0.3) than in the non-cognitive impairment group (8.0 ± 0.3) ($P < 0.001$). The area under the receiver operating characteristic curve was 0.681 ($P = 0.003$) and 0.701 ($P < 0.001$) for gray value and entropy, respectively.
Conclusions: Our findings suggest an association between heterogeneity of mastication and impaired cognitive function in iNPH patients and highlight muscle texture analysis as a potential tool for predicting cognitive impairment in these patients.

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A randomized double-blinded study of early volumetric changes after shunt surgery; is Certas Plus "virtual off" really off?

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Introduction: Traditional radiological 2D-measures often lack sensitivity to detect changes in ventricular volume after shunting in iNPH. Automated ventricular volumetry using a novel 3D quantitative MRI (qMRI) protocol offers a fast and reliable alternative in assessing volume of the whole ventricular system. The Codman Certas Plus valve setting 8 (a k a "virtual off") offers a very high (> 400 mm H20) resistance, in theory limiting shunting of CSF to a minimum. The aim of this study was to evaluate early changes in ventricular volume after shunting in relation to shunt setting and compare with 2D-measures.
Methods: Fifty consecutive recruited iNPH-patients underwent a baseline qMRI ventricular volumetry the day before surgery. Acquisition time was 6 min. Patients were randomised to have Certas Plus valves set to either 4 (110 mm H20) or 8. Valve setting was blinded to surgeons, patient and the study group. Another qMRI volumetry was done 24–48 h after surgery and radiologists assessed changes in ventricular width in standard MRI sequences.
Results: Forty patients completed both qMRI scans, on average 36 h postoperatively. In total, 18 patients had setting 4, 22 patients setting 8. Groups were equal in gender and age. Baseline ventricular volume of setting 4-group was larger than in setting 8 (146 ± 29 (mean $\pm$ SD) vs 138 ± 39 ml, $p = 0.03$) but groups were equal post-operatively (126 ± 29 vs 131 ± 36 ml, $P = 0.08$). Mean reduction of ventricles in setting 4 was 21 ± 13 ml and setting 8 was 6 ± 5 ml ($P = 0.014$), reducing ventricles by 14% and 4% compared to baseline, respectively. All 40 patients had smaller ventricles according to volumetry but only 10 had measurable 2D-width reduction.
Conclusions: Reduction of ventricular volume is easily detectable using qMRI-volumetry early after shunting also when traditional measures fail to show it. Patients with setting 8 still had a minor reduction of ventricular volume early after surgery.

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Ventricular volumetry in relation to clinical outcome and overdrainage in iNPH at 3 and 12 months after surgery

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Introduction: Knowledge of long term changes in ventricular volume after shunting in idiopathic normal pressure hydrocephalus (iNPH) is poor. Overdrainage symptoms are frequently underreported. We performed a prospective longitudinal cohort study investigating ventricular volumetry in relation to clinical outcome and overdrainage symptoms.
Methods: Fifty iNPH-patients were consecutively recruited and assessed for baseline clinical status according to the Hellstrom iNPH-scale and quantitative MRI (qMRI) automated ventricular volumetry the day before surgery. Codman Certas Plus valves were implanted and set to 4 (110 mm H20) on discharge from the hospital. Clinical assessment and qMRI volumetry were repeated at three and twelve months after surgery. Adverse events and valve adjustments were registered with special care taken to overdrainage symptoms such as headaches, tinnitus and hygromas. Patients who improved ≥ 5 points in iNPH-scale were considered responders.
Results: Forty-nine patients (25 female/24 male) completed baseline assessment, 43 at three months and 44 at twelve months. Age was 77 ± 0.75 years (mean $\pm$ SD). Ventricular volumes were 137 ± 5 ml (100%) at baseline, 112 ± 5 ml (82%) at three months and 108 ± 5 ml (77%) at twelve months ($p < 0.001$). Baseline mean Hellstrom iNPH-scale score was 51 ± 2 and after 3 months 67 ± 2 ($p < 0.001$). Gait domain iNPH-scale score was 40 ± 2 at baseline, 63 ± 4 at three months ($p < 0.001$) and 65 ± 4 at twelve months. 36 out of 44 (84%) patients were shunt responders. There was no difference in preoperative parameters nor postoperative reduction of ventricular volume between responders/nonresponders. A total of 12 patients (28%) experienced overdrainage and four (8%) patients needed an additional antisiphoning device.
Conclusions: Ventricular volume becomes progressively smaller at 3 and 12 months after shunting for iNPH. Shunt responders were similar to non-responders in degree of ventricular reduction and preoperative clinical and radiological parameters. Overdrainage after shunting for iNPH is common and an antisiphoning device for all iNPH-patients should be considered.

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Early results of CSF and plasma cytokines and chemokines 3 and 12 months after shunting in idiopathic normal pressure hydrocephalus; a prospective controlled study

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Introduction: Biomarkers have been associated with outcome in idiopathic normal pressure hydrocephalus (iNPH). A characteristic cerebral spinal fluid (CSF) pattern in iNPH has been described. Few studies report on correlation between lumbar (L-CSF), ventricular CSF (V-CSF) and plasma concentrations. Neuroinflammatory biomarkers have hardly been studied in iNPH. Our aim was to make a well-designed prospective clinical study with long term follow up of biomarkers in relation to clinical outcome.
Methods: iNPH-patients were consecutively included and assessed for baseline clinical status. During shunt surgery 10 ml of L-CSF, 10 ml of V-CSF and 6 ml blood was sampled. Patients were clinically

assessed at three and twelve months after surgery. Also, blood was drawn and shunts tapped for 10 ml of V-CSF. Eighteen age-matched healthy individuals were sampled for L-CSF and plasma. All sampling was conducted according to a strict standardized protocol. All samples were analyzed using an antibody-based immunoassay of 71 cyto- and chemokines along with traditional biomarkers for absolute concentrations. Multivariate data analysis was used to find statistical differences in the biomarker concentrations.
Results: Fifty five patients (mean age 77 ± 5, 29 M/26F) completed assessment and sampling at baseline, 49 completed three and twelve months. Mean Hellstrom iNPH-scale score at baseline was 49 ± 12 and 64 ± 16 at 3 months. In plasma 24 biomarkers expressed differently at baseline compared to three and twelve months follow up. In V-CSF 31 biomarkers were significantly altered at three months follow up compared to baseline. Especially MIF and Fractalkine showed great changes over time. Data analysis is ongoing.
Conclusions: Preliminary results show clear differences in inflammatory biomarkers between baseline and three and twelve months. Also, clear differences between V-CSF and L-CSF were noted for most biomarkers. Analyzing a panel of intercorrelated biomarkers could be a way to identify novel biomarkers in iNPH and assess outcome after shunt surgery.

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The customized tissue probability map and gray and white matter templates can improve the accuracy of brain segmentation in patients with idiopathic normal pressure hydrocephalus

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Introduction: The deformation of brain structures in patients with idiopathic normal pressure hydrocephalus (iNPH) is very severe. The aim of the study was to develop an accurate segmentation of brain images in patients with iNPH.
Methods: First, we collected the anatomical cranial MRI images of 274 patients with probable iNPH for creating a customized tissue probability map (TPM) and gray and white matter templates. These images were obtained via three-dimensional (3D) spoiled gradient-recalled echo or 3D-magnetization-prepared rapid gradient echo (MPRAGE) sequence. We excluded the images of 79 patients with brain lesions and of 26 patients because of artefacts. Second, the remaining images of 169 patients were segmented into air, bone, gray and white matter, CSF, and other soft tissue images using a Computational Anatomy Toolbox (CAT) for SPM. Then, we created a customized TPM, which has softer probability distribution in and around the lateral ventricles and Sylvian fissures than in the other brain structures, and gray and white matter templates. Finally, we collected cranial 3D-MPRAGE images of other 38 patients with probable iNPH and compared the accuracies of brain segmentation images between two methods (Method A: applying CAT with the standard TPM and templates; and Method B: applying both CAT with the customized TPM and templates) using the Chi-Square test.
Results: The proportions of misidentifying the dura and/or extradural structures as brain structures were 44.7% in Method A and 10.5% in Method B ($p < 0.001$). In addition, the failure rates of detecting the periventricular white matter T1-hypointensities were 42.1% in Method A and 18.4% in Method B ($p = 0.024$).
Conclusions: The customized TPM and gray and white matter templates for iNPH can more accurately extract and segment brain structures from cranial images in patients with iNPH than the conventional method when using CAT.

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Impact of third ventricle morphology on long-term memory in LOVA hydrocephalus

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Introduction: LOVA (Long-standing overt ventriculomegaly in adults) is defined as a type of chronic hydrocephalus which remains asymptomatic or with few symptoms until becoming decompensated in adults, leading to cognitive deficits. In a previous study, we demonstrated how ETV intervention can lead to immediate improvement of LTM (Long-Term memory) in patients with LOVA hydrocephalus. Now, in this study, our aim is to demonstrate the existence of an association between cognitive outcomes and neuroradiographic parameters of LOVA before and after ETV.
Methods: Twenty-one consecutive patients with LOVA hydrocephalus underwent multiple measurements of ventricular morphology based on MRI scans before and after ETV surgery. Their cognitive status was assessed before surgery, immediately after surgery and at four-month follow-up, using a neuropsychological battery that measured six cognitive domains: general cognitive status, attention/executive function, language, visuospatial ability, short-term memory, and long-term memory (LTM).
Results: Deformation of the third ventricle, measured as TVMI (Third Ventricle Morphology Index), was the only value that showed significant correlation with LTM in patients with LOVA hydrocephalus before surgery. TVMI was negatively correlated with patients' memory efficiency before surgery. TVMI was also directly correlated with immediate postoperative improvement in LTM. The latter variable, moreover, was significantly correlated with Evans index and pre-morbid intelligence.
Conclusions: Literature regarding specific cognitive alterations in patients with LOVA is scarce, and thus far, no study has been presented correlating specific cognitive domain alterations with morphometric changes in the ventricles. With this study, we demonstrate that the greater the degree of deformation of the third ventricle, the lower the mnestic efficiency assessed in the preoperative phase. This can be explained by considering that the third ventricle has close anatomical relations with limbic structures associated with memory circuits, such as the fimbria-fornix system and the Anterior Thalamic Nucleus, which are part of the Papez circuit.

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The dead canary in the coal mine

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Introduction: A Retained Foreign Object (RFO) is an object retained after skin closure following an invasive procedure. It is classified as a "never event". After falls, it is the second most common sentinel event (SE) reported to The Joint Commission.
Methods: Review of the current literature on Operating Room Safety.
Results: Several factors are known to increase the risk of RFO: intraoperative blood loss, longer duration of operation, more sub-procedures, lack of (or incorrect) surgical counts, more than one surgical team, and

unexpected intraoperative factors. Other important contributing factors include lack of clear policies regarding the counting responsibility, the handling of surgical specimen, the involvement of two surgical teams, and the proper shift hand-off of the surgical technician. Surprisingly, the extremely high percentage (> 80%) of falsely "correct counts" reported by the Joint Commission points to another very important contributing factor. Someone may report an incorrect count as "correct" because they fear being the lone voice causing a delay in the case.

Conclusions: While RFOs seem exceedingly unlikely to occur in shunting, they represent an important warning sign ("the dead canary in the coal mine") for any team using the OR, including Neurosurgery. We are not immune from unsafe communication. Eliminating RFO and more importantly restoring the integrity of safety culture requires a multipronged strategy. Effective communication is key to safety in this situation as well as in preventing other mishaps such as infection in the case of neurosurgical shunting. OR staff need to be constantly reminded that failure can and will happen and they need to remain vigilant and vocal. Whenever a policy is ignored or violated, OR staff should be involved in reviewing and approving the policy revision. Every team member is responsible to preempt the compounding of errors. Commitment to safety starts from the top by leadership providing appropriate resources and role modeling.

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Insights neurofluid dynamics in Chiari syndromes?

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Introduction: The origin of the presence of symptoms in Chiari syndromes (CS) is unknown. CS is related with alteration of neurofluids (blood and cerebrospinal fluid (CSF)) dynamics. Phase-contrast MRI (pcMRI) is the only non-invasive technique for studying craniospinal dynamic of neurofluids during one cardiac cycle. There is an alteration in neurofluid dynamics in CS potentially related to the symptomatology. The aim was to compare hemohydrodynamic alterations between symptomatic and asymptomatic CS patients, and control.

Methods: We included retrospectively 17 symptomatic CS patients (symptomatic group (G+)), 13 asymptomatic CS patients (asymptomatic group (G-)) and 28 controls (Gc) who underwent pcMRI at the diagnosis phase. We measured vascular stroke volume (SVvasc) measured at this intracranial level upstream of the Willis circle and CSF cervical stroke volume (SVcerv). We assessed venous drainage pathways. This evaluation was carried out by measuring an α factor. When α is equal to 1, venous drainage is exclusively via the lateral sinuses. When α is equal to 2, venous drainage is performed 50% by lateral sinuses and 50% by accessory venous drainage.

Results: SVcerv is higher in G- (658.77 ± 131.35µL/CC) than G + (518.2 ± 185 µL/CC) ($p = 0.02$). SVcerv correlated with SVvasc showing the adapted response of CSF to intracranial vascular volume variation constraints in Gc ($R^2 = 0.37$, $p < 0.05$) and G + CS ($R^2 = 0.53$, $p < 0.05$). This correlation was not present in G- CS ($R^2 = 0.24$, $p = 0.12$). In G-, a positive correlation was objectified between SVvasc and α factor ($R^2 = 0.45$, $p < 0.05$). This correlation was not present in G + ($R^2 = 0.001$, $p = 0.91$) and in Gc ($R^2 = 0.09$, $p = 0.15$).

Conclusions: This study demonstrated existence of different hydrodynamic alterations between symptomatics and asymptomatics CS. These various hemohydrodynamic changes may help to understand the pathophysiological adaptation of neurofluids to CS and potentially the genesis of a symptomatic context linked to it.

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Idiopathic normal pressure hydrocephalus concomitant with progressive supranuclear palsy

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Introduction: Recent studies have unveiled a frequent coexistence of idiopathic normal pressure hydrocephalus (iNPH) with neurodegenerative movement disorders, including progressive supranuclear palsy (PSP). This study delves into the clinical and radiological traits of patients with iNPH who also had comorbid with PSP, referred to as iNPHc + PSP.

Methods: We conducted a retrospective analysis of the clinical and radiological features of patients with iNPH hospitalized in our department between 2009 and 2019. The diagnosis of iNPH was made when patients met the established clinical criteria and positive response to the tap test, while PSP diagnosis required: 1) Movement Disorder Society (MDS)-PSP criteria for probable or possible PSP, 2) a reduced or diminished response to levodopa administration, 3) a significant decrease in dopamine transporter activity, and 4) negative results from α-synuclein real-time quaking-induced conversion-based assay.

Results: Out of 85 iNPH patients, 18 (21.2%) were identified as having iNPHc + PSP. Clinically, comorbid PSP causes the impairment of vertical eye movement, axial-dominant parkinsonism, and a propensity to fall backward in iNPH ($p = 0.022$, $p = 0.002$, and $p < 0.005$, respectively). Radiologically, a shortened mesencephalic tegmentum length on MRI and altered specific binding ratios (SBR) in DaTscan were indicative of PSP in iNPH patients ($p = 0.0016$, $p = 0.026$, respectively). Lumboperitoneal shunt (LPS) surgery notably improved short-term outcomes, including the modified Rankin scale ($p = 0.038$) and the total score on the iNPH grading scale ($p = 0.003$) one year post-surgery, although it did not affect survival outcomes.

Conclusions: PSP frequently coexists with iNPH. The combination of MDS-PSP criteria, brain MRI, and DaTscan is crucial for detecting PSP in iNPH patients. While LPS surgery enhances short-term clinical outcomes, it does not improve long-term survival rates.

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Shunt study for the patients with Hakim's disease comorbid with PD/PDD

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Introduction: Hakim's disease, also known as idiopathic normal pressure hydrocephalus (iNPH), can coexist with Parkinson's disease (PD) or PD dementia (PDD). We aim to analyze the impact of concurrent PD/PDD on the disease progression of Hakim's disease and the outcomes of shunt surgery.

We retrospectively analysed iNPH patients without accompanying disorders (iNPHa) and those with iNPH concurrent with PD/PDD (iNPHc + **Methods:**PD/PDD) over the past decade. The diagnosis of iNPH and concomitant PD/PDD was based on established diagnostic criteria. The effect of the shunt surgery on clinical symptoms and striatum volumes was assessed.

Results: Thirty-three patients with iNPHa and 21 patients with iNPHc + PD/PDD were identified. Comorbid PD/PDD significantly exacerbated clinical outcomes, as evidenced by worsened scores on the NPH grading scale, modified Rankin Scale (mRS), and Hoehn and Yahr (H&Y) score. LPS surgery improved various NPH grading scales, including gait disturbance ($p < 0.01$), cognitive impairment ($p = 0.02$), and urinary disturbance ($p < 0.01$) in iNPHa, and gait disturbance ($p = 0.01$) and urinary disturbance ($p = 0.03$) in iNPHc + PD/PDD over a one-year period. Comorbid synucleinopathies were associated with persistently worse mRS and H&Y scores over three years, but shunt surgery extended overall survival ($p < 0.01$) and the duration of sustained mRS ($p < 0.05$) and H&Y score ($p < 0.01$) in iNPHc + PD/PDD. Both caudate and putamen volumes were reduced in iNPHa ($p < 0.01$) compared to controls and in iNPHc + PD/PDD ($p < 0.01$) compared to PD, and shunt surgery restored caudate volumes in both groups.
Conclusions: Comorbid PD/PDD significantly deteriorated clinical symptoms and course of iNPH, but shunt surgery restored the reduced striatal volume and improved the disease course even in the presence of comorbid PD/PDD. A randomized controlled trial is currently underway to validate these findings.

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The Preliminary Study of vertical shift index of corpus callosum: A novel diagnostic tool for normal pressure hydrocephalus

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Introduction: Imaging diagnosis of idiopathic normal pressure hydrocephalus (iNPH) relies on identifying ventricular enlargement and altered cerebrospinal fluid distribution patterns. Studies on long-term microgravity effects on astronauts revealed vertical brain shifts, suggesting impaired cerebrospinal fluid circulation. We applied this phenomenon to develop a method to quantify corpus callosum vertical shift and its usefulness for iNPH diagnosis.
Methods: We studied 20 iNPH patients (80.7 ± 5.5 years), 54 Alzheimer's/mild cognitive impairment patients (AD/MCI, 81.3 ± 5.7 years), and 159 normal patients (60.7 ± 10.7 years). Using MRI or CT, we measured vertical corpus callosum shifts. The vertical shift of the corpus callosum was measured using the midline of the sagittal section. A line connecting the upper edge of the confluence of sinuses and the midpoint of the anterior skull base was drawn. From point A at the level of the posterior clinoid process, a perpendicular line was drawn. Point B was defined as the intersection of this line with the skull, and point C was defined as the intersection of this line with the upper edge of the corpus callosum. The vertical shift index (VS-index) was calculated as A-C distance/A-B distance.
Results: The iNPH group had significantly higher VS-index values compared to AD/MCI and normal groups (iNPH = 0.606 ± 0.03; AD/MCI = 0.541 ± 0.03; normal = 0.494 ± 0.04; $p < 0.001$). A VS-index cutoff of 0.56 between iNPH and normal groups showed 97% accuracy (sensitivity 97.5%, specificity 95.0%), with an AUC of 0.99. A cutoff of 0.57 between iNPH and AD/MCI groups yielded 84% accuracy (sensitivity 95.0%, specificity 80%), with an AUC of 0.93.
Conclusions: The VS-index effectively distinguishes iNPH from normal, AD, and MCI cases.

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Exploring next-generation hydrocephalus imaging: modeling cerebrospinal fluid dynamics and artificial intelligence

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Introduction: Recent advancements in artificial intelligence (AI) have greatly enhanced our ability to anatomically extract complex structures of brain and CSF, surpassing human capabilities. Additionally, current MRI technology enables the observation of complex pulsatile CSF movements. Utilizing these technologies, our study aims to deepen our understanding of hydrocephalus pathophysiology.
Methods: This study included 44 patients with Hakim's disease and 127 healthy adults aged 20 to 80 years. MRI sequences included 3D T1- and T2-weighted MRI, 4D flow MRI for CSF (venc: 5 cm/s) and for the circle of Willis (venc: 120 cm/s), IVIM MRI and 3D time-of-flight MRA. Using AI, we automatically segmented three regions of interest which are critical for DESH assessments, from the 3D T1- and T2-weighted MRI: the lateral ventricles and the high convexity-subarachnoid space, the Sylvian fissure, and the basal cisterns.
Results: Our AI facilitated instant, quantitative assessment of DESH severity. Furthermore, by integrating flow velocity parameters from 4D Flow MRI and perfusion components from IVIM, we developed the Fluid Oscillation Index (FOI), providing a novel metric for evaluating CSF pulsatility across the entire intracranial space. Furthermore, we integrated these two techniques to determine the relationship between CSF oscillation (FOI) and DESH severity. OIs at the cerebral aqueduct and bilateral foramina of Luschka were elevated in both Hakim's disease and healthy controls aged ≥ 60 years.
Conclusions: Social implementation of AI-based automated DESH determination will contribute to the detection of many patients with Hakim's disease. The computational simulation by estimating CSF motion across the entire intracranial CSF space on both 4D flow MRI and IVIM MRI could help explore the underlying mechanisms of disproportionate expansion of the ventricles and subarachnoid spaces in Hakim's disease.

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The efficacy of gait and balance measures in identifying probable Idiopathic Normal Pressure Hydrocephalus following a High-Volume Cerebrospinal Fluid Tap Test

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Introduction: Performance Orientated Mobility Assessment (Tinetti) is a reliable and valid clinical test to measure gait and balance in the older population. The aim of this study was to identify whether the Tinetti assessment is clinically useful in detecting a positive response to high-volume cerebrospinal fluid (CSF) tap test (TT) in patients with possible normal pressure hydrocephalus (iNPH).
Methods: A prospective observational study of patients undergoing CSF TT between May 2021 and March 2024. Patients were assessed

immediately prior to, and between 1 and 2 h after CSF TT using the Tinetti assessment and a 10-m gait assessment. Differences between pre and post CSF TT scores were used as part of a multidisciplinary assessment to classify patients as responders or non-responders. Patients deemed to improve were offered a VPS.
Results: Forty-two patients (28 male, 14 female) underwent high-volume CSF TT. The mean age was 77 (range 66–88) years. There were 33 responders, of whom 18(55%) had an increase in gait velocity of at least 10% and 28(85%) had an improvement in Tinetti balance or gait score of at least 2 points. Mean (SD) gait velocity increased from 0.60(±0.25)m/s to 0.67(±0.24)m/s (p = ns) in the responders and from 0.81(±0.27)m/s to 0.84(±0.17)m/s (p = ns) in the non-responders. Mean (SD) total Tinetti score increased from 8.78(±6.25) to 14.82(±5.85) (p < 0.05) in the responders and from 12.11(±6.43) to 14.44(±5.75) (p = ns) in the non-responders.
Conclusions: Due to the impracticalities of undertaking serial assessments, measurable improvement may not be observed following CSF TT. In this study, gait velocity alone was unreliable as a marker of response to CSF drainage when measured within 2 h of CSF TT but Tinetti scores did significantly improve within this time window. Tinetti is a reliable and valid tool which, in this small cohort, supported the identification of patients with probable iNPH.

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Comparison of lumboperitoneal shunt under local anesthesia and ventriculoperitoneal shunt under general anesthesia for hydrocephalus related to leptomeningeal metastasis

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Introduction: Hydrocephalus associated with leptomeningeal metastasis significantly impairs the quality of life in patients with end-stage cancer by increasing intracranial pressure (ICP) and exacerbating symptoms such as headaches and mental changes. Although ventriculoperitoneal shunts (VPS) are commonly used in palliative care due to their effectiveness in reducing ICP, they are often declined by patients due to potential brain complications and the risks associated with general anesthesia. This study compares the outcomes of palliative lumboperitoneal shunts (LPS) performed under local anesthesia with traditional VPS under general anesthesia.
Methods: From 2017 to 2024, a cohort of 76 patients with leptomeningeal metastasis-related hydrocephalus underwent surgical intervention. These patients were evenly divided into two groups, with 38 undergoing LPS under local anesthesia and 38 undergoing VPS under general anesthesia. We evaluated patient demographics, primary cancer types, clinical outcomes, and survival times post-surgery.
Results: The rates of symptom improvement were comparably high in both groups (92.1%) with no statistically significant difference in effectiveness. The average survival times post-surgery were 4.9 months for LPS and 3.8 months for VPS, which were not statistically significant (P = 0.442). Age and gender distributions were similar between the groups. Notably, the operation time for LPS (94.7 min) was significantly shorter than that for VPS (123.6 min), which was statistically significant (P = 0.001).
Conclusions: Despite the small sample size and the lack of statistical significance in survival times, the use of LPS under local anesthesia was well-received due to the shorter operation time and avoidance of brain complication and general anesthesia, making it a viable alternative for patients reluctant to undergo VPS. Further research is needed to establish the long-term benefits and potential broader application of LPS in palliative care for end-stage cancer patients with hydrocephalus related to leptomeningeal metastasis.

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Reliability of the iNPH Radscale in a multicentre clinical setting

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Introduction: The iNPH Radscale includes seven imaging features for the diagnostic work up of idiopathic Normal Pressure Hydrocephalus (iNPH). However, the scale has not been validated in a broad clinical setting. The purpose of this study was to assess the interrater agreement between four hydrocephalus centres and an expert double reader.
Methods: These are the first results to be presented from the international multicentre iNPH ClinRad scale study, where the focus of this abstract is radiological evaluation alone. The full study includes four Hydrocephalus centres with the primary aim to determine the reliability, validity and feasibility of the clinical iNPH scale (Hellstrom Scale) and the radiological iNPH Radscale in the diagnostic evaluation of patients with iNPH. The participating centres included iNPH patients eligible for shunt surgery according to their local protocol. Preoperative MRI included as a minimum 3DT1 and FLAIR sequences. Radiological assessment was made according to the iNPH Radscale at each site, including Evans' index, temporal horn width, callosal angle, narrowing of sulci, focally enlarged sulci, widening of the Sylvian fissures and white matter lesions. All images were further assessed by an expert reader as a reference standard. All double readings were blinded to clinical data and local radiological assessments.
Results: A total of 131 cases have yet completed the imaging investigation and assessment by local and reference radiologist. The interrater agreement for iNPH Radscale assessed by weighted kappa was 0,76 (95% CI 0,67 – 0,84) for the total sample, ranging from 0,69 to 0,8 for the different centres. Agreement for individual features will be analysed separately when inclusion is completed.
Conclusions: The interrater agreement was good to excellent at different hydrocephalus centres. The iNPH Radscale is therefore suggested for radiological assessment in the investigation of iNPH in a clinical setting and allows comparison of data between different centres.

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Intracranial pressure in prone position

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Introduction: Patients undergoing neurosurgical procedures often need to be positioned prone. It is unknown what, if any, effect this

positioning has on the intracranial pressure (ICP) though there have been reports of ophthalmological adverse outcomes. There are implications for any subsequent effects on brain autoregulation or perfusion which could affect post-operative outcomes. Patients with M.scios incorporated into their shunt systems undergo routine non-invasive ICP monitoring during follow-up clinics at the National Hospital for Neurology and Neurosurgery. Here we investigate ICP in prone versus supine position in these patients.
Methods: Single-centre prospective observational study. Patients were recruited from routine outpatient follow-up clinics. ICP readings were taken from the M.scio at 10 s, 1 min and 5 min in supine and prone positions. A paired t-test compared ICP values in the two groups (prone versus supine).
Results: Eleven patients were recruited. ICP was significantly lower in prone compared to supine position. The average ICP during prone position was 5.58 ± 7.65 mmHg, versus supine position 10.05 ± 8.276 mmHg, with the average difference between prone and supine positions being 4.47 ± 6.78 mmHg. All values are mean $\pm$ SD. The difference between the groups was statistically significant ($p = 0.0009$).
Conclusions: ICP is lower, in general, during prone position compared to supine position. The suggestion is that intra-operative prone positioning does not adversely affect the majority of patients. This study would benefit from recruiting more patients in order to be more robust.

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Can we reduce clinic times for patients with M.scios?

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Introduction: Patients with M.scios incorporated into their shunt systems undergo routine intracranial pressure (ICP) monitoring during follow-up clinics at the National Hospital for Neurology and Neurosurgery. Patients typically have their ICP measured during sitting, standing and lying positions due to the knowledge that ICP varies based on the body's position. The length of time taken for ICP to stabilise after positional change is not known. M.scios are a relatively new technology. Here we investigate how long ICP takes to stabilise after a change in body position when measured from the M.scio.
Methods: Single-centre prospective observational study. Patients were recruited from routine outpatient follow-up clinics. ICP readings were taken at 10 s, 20 s, 30 s,45 s, 1 min, 1.5 min, 2 min, 3 min, 4 min and 5 min in each of the following positions: sitting, supine, standing and prone. Repeated-measures ANOVAs were performed on data in each position to assess whether ICP values differed significantly over the total 5-min time period.
Results: Thirteen patients were recruited. There were no significant differences in ICP values over the 5-min period in sitting, standing or prone positions. There was a significant difference ($p = 0.0073$) in supine values over the 5-min period. Post-hoc comparisons (corrected) showed that these differences were significant in 20 s versus 4 min, and 1 min versus 4 min.
Conclusions: In sitting, standing and prone positions, there were no significant differences in ICP over the time period. This suggests that ICP readings taken at 10 s could be adequate and that patients do not need to wait in these positions for ICP to 'stabilise' in order to achieve accurate readings. This has the potential to reduce total clinic times for these patients. In supine position, there was significant variability over the 5-min period. This is likely due to individual patient factors in addition to low patient numbers thus far.

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Non-invasive MRI of blood-CSF-barrier function: a novel tool for assessment of pharmacological management of intracranial pressure and in an experimental model of hydrocephalus

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Introduction: Raised intracranial pressure (ICP) is a defining feature of idiopathic intracranial hypertension (IIH) as well as common forms of hydrocephalus. Hypersecretion of cerebrospinal fluid (CSF) at the blood-CSF-barrier (BCSFB) in the choroid plexus has been implicated in the development of these neurologic conditions. There is currently an absence of non-invasive means of measuring BCSFB-function, preventing effective monitoring of CSF-production targeted therapy. In this study, we demonstrate how a novel and non-invasive MRI method can capture changes in BCSFB-function that underlie pharmacological modulation of ICP and pathological development in a preclinical model of hydrocephalus.
Methods: ICP was measured from the lateral ventricle using a fluid-filled pressure sensor (Digitimer) in isoflurane-anaesthetized male C57BL6J mice. Hydrocephalus was induced by bilateral intracerebroventricular injection of 2 mM $FeCl_3$. A novel MRI has recently been developed to assess BCSFB-function which measures the rate of flux of labelled blood-water into CSF [Evans et al., 2020]. BCSFB-function and ventricular volume were acquired at 9.4 T (Bruker) using BCSFB-ASL (arterial spin labelling) and high resolution T2-weighted imaging. In order to try to reduce ICP and hydrocephalus pathology, aminophylline was administered following baseline recordings or surgery.
Results: Aminophylline administration resulted in a dose dependent decrease in ICP with a concomitant decrease in non-invasive MRI measures of BCSFB-function. In the hydrocephalus model, defined by ventriculomegaly, BCSFB-function was increased relative to baseline, but this was prevented with aminophylline treatment.
Conclusions: Here we demonstrate that we are now able to measure the action of drugs to decrease ICP by targeted downregulation of BCSFB-function using non-invasive and translational MRI methods. Our data suggests that the MRI method can capture upregulation of BCSFB-function in an experimental model of hydrocephalus together with modulation by aminophylline treatment. As such, this translational method may therefore have potential to inform therapy for IIH and hydrocephalus.

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The super learner algorithm: enhancing idiopathic normal pressure hydrocephalus diagnosis with ai-enhanced cortical analysis

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Introduction: The diagnostic landscape for idiopathic normal-pressure hydrocephalus (NPH) is intricate, with a pressing need for accurate and cost-effective methods. Because of the lack of accurate

diagnostic and prognostic quantitative biomarkers, frequent presence of comorbidities, and limited understanding of the pathophysiology of the disorder, only a minority of patients receive disease-specific treatment.
While traditional neuroimaging offers insights, its isolated diagnostic precision can be enhanced. Emerging quantitative methods analyzing cortical thickness based on standard T1-weighted brain MR images offer new diagnostic possibilities.
Methods: We analyzed 294 patients referred to our clinic from January 2015 until December 2022. After the exclusion criteria, the final sample consisted of 100 possible NPH patients. Of these, 71 underwent ventriculoperitoneal shunt (VPS) surgery, while 29 did not qualify post-evaluation. Cortical thickness was assessed using an advanced deep-learning neuroimaging pipeline. For predictive modeling, we employed a comprehensive set of Machine Learning algorithms, including Distributed Random Forest (DRF), Extremely Randomized Trees (XRT), Generalized Linear Model with Regularization, Gradient Boosting Machines (GBM), Extreme Gradient Boosting machines (XGB), and a Fully-connected Multi-layer Artificial Neural Network (Deep Learning machine). These algorithms were strategically combined into a Super Learner ensemble approach to harness their collective predictive power.
Results: Among patients with negative CSFTT outcomes or subpar VPS surgery responses, distinct cortical variations emerged, particularly in the caudal middle frontal, rostral middle frontal, superior frontal, and superior parietal regions. Our Super Learner model, integrating CSF dynamics and cortical thickness data, achieved a 90% positive predictive value, signifying a tangible advancement over traditional measures.
Conclusions: Analyzing preoperative cortical thickness emerges as a viable strategy for streamlining therapeutic decisions for potential NPH patients. Future endeavors should focus on large-scale multicentric studies to further delineate specific cortical thickness patterns, potentially enhancing the prediction accuracy for VPS surgery outcomes.

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Cerebral perfusion SPECT may help predict shunting effectiveness in patients with PSP and Hakim's disease

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Introduction: Some patients with progressive supranuclear palsy (PSP) also exhibit Hakim's disease. We aimed to clarify the effect of shunt surgery and the predictors of shunting effectiveness in patients clinically diagnosed with PSP and Hakim's disease.
Methods: We conducted a retrospective case series study. Patients satisfied with both possible/probable PSP based on MDS-PSP criteria and probable/definite iNPH according to the Japanese guidelines for iNPH (Third Edition) were included. We statistically compared patients responding to a shunt surgery with those who did not. Shunt surgery was considered effective if any of the following criteria were met: improvement of Timed Up and Go test by > 4 s or MMSE by > 2 points; reduction of urinary symptoms; a physician's clinical judgment if these indicators were unknown.
Results: Of the 83 patients meeting the PSP criteria, thirteen (15.7%) met the iNPH criteria (average age: 75.6 ± 3.7 years; five (38.5%) women; average disease durations: 3.1 ± 2.2 years). All satisfied the criteria of probable PSP-Richardson syndrome. Ten of the 13 patients had an effective trial of CSF drainage by a lumbar puncture. Of these 10 patients, eight who had consented underwent shunt surgery, which was effective in five. Therefore, except for the two patients who had undergone an effective trial but refused the surgery, five of the 11 (45.5%) had effective shunting (Group A), while the remaining six did not (Group B). Comparing Groups A and B, Group A had a significantly lower frequency of frontal hypoperfusion in cerebral perfusion SPECT (0/3 vs. 5/5; $p = 0.018$).
Conclusions: We have shown that shunt surgery is effective in about half of the patients with a clinical diagnosis of PSP and Hakim's disease and that cerebral perfusion SPECT may be useful for estimating the effectiveness of shunt surgery. We are currently planning a multi-center prospective study to confirm these findings.

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Lumboperitoneal shunt surgery via lateral abdominal laparotomy

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Introduction: One of the technical problems encountered in performing lumboperitoneal shunt (LPS) surgery involves operative positioning. To insert the spinal catheter into the subarachnoid lumbar space, LPS is usually carried out with the patient in the lateral decubitus position. However, laparotomy around the periumbilical region, especially in obese patients in the lateral decubitus position, can be quite difficult. We thus added a simple modification to the laparotomy for LPS, altering the laparotomy site to the lateral side of the patient's trunk. We aimed to analyze our method regarding technical features and outcomes.
Methods: We compared two LPS procedures: routine periumbilical anterior abdominal laparotomy and our modified method with lateral abdominal laparotomy. The first 11 consecutive cases underwent routine anterior abdominal laparotomy with position changes or tilting of the operative bed. In contrast, the following 17 successive cases underwent lateral abdominal laparotomy, which did not require position changes.
Results: The mean operative time in the anterior abdominal laparotomy group was 72.36 minutes. One patient had a spinal tube tear, which required revision of the LPS 2 years postoperatively. The mean operative time in the lateral abdominal laparotomy group was 38.82 minutes. One patient experienced a postoperative headache and exhibited a thin chronic subdural hematoma on imaging studies, which disappeared after adjustment of the valve pressure.
Conclusions: In the current series, the operative time was shorter in the lateral abdominal than in the anterior abdominal group, with no difference in the complication rates. Lateral abdominal laparotomy simplifies LPS.

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Enhancing differentiation accuracy of idiopathic normal pressure hydrocephalus by simultaneously assessing GM and WM using a multi-input CNN in MRI

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) and progressive supranuclear palsy (PSP) exhibit common symptoms in part but differ significantly in treatment responsiveness, emphasizing the need for precise differential diagnosis. Traditional diagnostic methods for brain MRI rely heavily on visual assessment, leading to considerable observer variability. This study proposes an innovative automated approach using a Multi-Input Convolutional Neural Network (MI-CNN), augmented by GradCAM visualizations, to enhance diagnostic accuracy and explainability.
Methods: Initially, gray matter (GM) and white matter (WM) are identified with SPM12, followed by normalization in MNI space. This study utilized an MI-CNN, and investigated the optimal input configuration—either GM, WM, or a combination of both—to maximize

classification accuracy. The decision-making process of the MI-CNN is elucidated using GradCAM, which highlights crucial regions, thus improving the model's transparency. The evaluation involved 39 iNPH and 39 PSP subjects.
Results: The combination of GM and WM inputs significantly enhanced model performance, achieving high accuracy of 0.859 and an AUC of 0.945, surpassing the GM-only model (accuracy 0.822, AUC 0.936) and WM-only model (accuracy 0.796, AUC 0.874). Notably, the GradCAM visualizations identified critical regions such as the ventricles, high convexity, and Sylvian fissure as key diagnostic areas, aligning closely with established neuroimaging markers for iNPH.
Conclusions: The new findings from this study reveal that the simultaneous assessment of both GM and WM significantly enhances the differentiation of iNPH from PSP. Moreover, it not only boosts diagnostic accuracy but also provides essential insights into image interpretation. These insights are consistent with established MRI findings for iNPH, substantially enhancing the transparency of deep learning applications in medical diagnostics.

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Cerebrospinal fluid biomarkers of neurodegeneration in idiopathic normal pressure hydrocephalus

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is treated with cerebrospinal fluid (CSF) shunt surgery that alleviates symptoms for most patients. CSF-based biomarkers can potentially improve diagnostics and prognostics of iNPH. Here we explored the longitudinal and ventriculo-lumbar composition together with predictive value in relation to symptom alleviation of selected CSF biomarkers.
Methods: Altogether, 285 possible iNPH patients received ventriculoperitoneal shunts between 2009–2021. All participants had their lumbar-CSF collected preoperatively. Subsets of the participants had additional intraoperative ventricular- (n = 97) and postoperative lumbar- and ventricular-CSF (n = 41) samples obtained. CSF biomarkers representing the amyloid-β cascade (Aβ38, -40, -42, sAPPα, -β), tau pathology (P-tau181, T-tau), inflammation (MCP1), axonal damage (NfL) and synaptic function (Ng) were analyzed from the selected samples. Participants were *APOE*-genotyped, and a subset of the participants (n = 41) had a brain biopsy analyzed for tissue Aβ- and tau-pathology.
Results: CSF P-tau181, T-tau, NfL, and Ng concentrations increased (2.5–3, 2–2.5, 1.5–2, 6.5–eightfold) postoperatively and stabilized thereafter ($p < 0.01$). CSF Aβ42 increased in Aβ pathology-negative participants, while participants with an Aβ-positive biopsy had a slight decrease. Preoperative lumbar-CSF Aβ42, T-tau, and P-tau181 concentrations correlated with intraoperative ventricular-CSF biomarker concentrations ($\rho = 0.34–0.55$, $p < 0.001$). Similarly, postoperative lumbar- and ventricular-CSF Aβ42, T-tau, P-tau181, NfL, and Ng concentrations correlated between the compartments ($\rho = 0.77–0.96$, $p < 0.0001$) but expressed lower levels (median 15–30%) in ventricular-CSF. Low preoperative lumbar-CSF T-tau (< 206 ng/l) and the absence of *APOE ε4* predicted (ORs 3.1 and 3.9) over 20% gait velocity improvement ($p < 0.05$) and low T-tau (< 213.5 ng/l) and NfL (< 1045 ng/l) predicted (ORs 13.6 and 2.4) normal cognition by the MMSE postoperatively ($p < 0.05$).
Conclusions: CSF shunt surgery changes the biomarker composition of CSF, which tends to stabilize postoperatively. The selected biomarkers present a rostro-caudal gradient. Preoperative lumbar-CSF P-tau181, T-tau, and NfL concentrations have predictive value for postoperative gait improvement and cognitive capabilities in iNPH.

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Analysis of amyloid oligomer concentrations in CSF and plasma before and after CSF shunting

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:99

Purpose: Amyloid beta oligomers (AβO) are amyloid polymeric compounds consisting of 10–20 monomers and are known to have strong neurotoxicity. In addition to the fact that AβO concentration in CSF has been shown to correlate with the severity of Alzheimer's disease, we have also reported that in iNPH, AβO concentration is increased by impaired CSF clearance and decreased by CSF shunting. However, due to the invasive nature of specimen collection in CSF biomarkers, the development of blood biomarkers is desired. In this study, we investigated whether plasma AβO could be a marker reflecting Alzheimer's disease pathology and CSF clearance disorders,
Methods: We measured AβO concentration in CSF and plasma and Aβ42/40 ratio in CSF by ELISA before and after shunting in patients with suspected iNPH who were operated CSF shunting from January 2022 to August 2023 at medical institutions affiliated with the research group. We analyzed the correlation between CSF and plasma AβO concentrations and CSF Aβ42/40 levels, comparing changes before and after shunting. The correlation between AβO levels in CSF and plasma and Aβ42/40 in CSF, and changes before and after shunting were analyzed.
Results: The data of 70 patients' (median age 77 years) were analyzed. The median AβO concentration was within 10–15 pM in CSF and 2–3 pM in plasma before surgery, showing a significant correlation between these two concentrations. Similarly, AβO in plasma and Aβ42/40 in CSF also showed a significant correlation. Postoperatively, the AβO concentration was significantly decreased in both CSF and plasma. Aβ42/40 in CSF was found reduced after shunting.
Conclusion: In patients with iNPH, plasma AβO correlated with CSF AβO and Aβ42/40, reflecting concomitant Alzheimer's pathology, and the decreases after shunting reflected CSF clearance and dynamics. Plasma AβO can be an applicable marker of Alzheimer's pathology in iNPH.

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Differentiating iNPH from other dementias: preliminary results on glymphatic function using the ALPS index

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Introduction: Diffusion tensor imaging along the perivascular space (DTI-ALPS) is a novel neuroimaging technique that quantifies glymphatic function via the ALPS index, highlighting water diffusion characteristics in perivascular spaces. Prior research indicates a significantly decreased ALPS index in iNPH patients compared to healthy controls; this study is the first, to the best of our knowledge, to investigate ALPS index differences between definitive iNPH patients and patients with ventriculomegaly secondary to other forms of dementia.
Methods: 31 patients divided into 23 diagnosed with definitive iNPH and 8 diagnosed with other forms of dementia associated with ventriculomegaly (NEG group) were submitted to a diagnostic MR examination to quantify the ALPS index in both cerebral hemispheres. Statistical analyses included Welch Two Sample t-tests to assess ALPS index differences between groups, and Cohen's D to estimate effect sizes.
Results: The overall mean ALPS index was 0.75 (SD = 0.19) for the entire cohort. The NEG group demonstrated a mean ALPS index of 0.68 (SD = 0.09), which was lower than the iNPH group's mean of 0.78 (SD = 0.22). This difference reached statistical significance (Cohen's D = -0.53; p = 0.046), suggesting a reduced perivascular water diffusion in non-iNPH dementia patients compared to those with true iNPH. Results for individual hemispheres showed similar trends, though not reaching statistical significance.
Conclusions: Contrary to previous studies that found a lower ALPS index in iNPH patients versus healthy controls, our findings indicate that iNPH patients may exhibit higher ALPS indices than patients with ventriculomegaly due to other dementias. This suggests a possible differential diagnostic utility of the ALPS index in distinguishing between iNPH and other types of dementia associated with ventriculomegaly. Further research is needed to confirm these preliminary findings and explore their implications for clinical practice.

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Ventricular endoscopy 2D video can be used for 3D reconstruction of anatomy – a novel technique for neuro-navigation

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Introduction: Ventricular endoscopy is a common minimally invasive technique in neurosurgery, with critical uses in hydrocephalus and CSF disorders. Traditional neuro-navigation techniques require pre-operative registration and do not account for deformation and shift due to cerebrospinal fluid loss intra-operatively. Artificial intelligence-based interpretation of the video feed serves as a tool to account for deformation, and even provide 3D video reconstruction for adaptive neuro-navigation without conventional tracking. This technology further serves as a foundation for additional capabilities such as augmented reality overlay in the endoscopic scene.
Methods: Thirty patients were enrolled who underwent endoscopic third ventriculostomy and had available brain CT or MR imaging. Segmentation of ventricular and deep brain structures was performed on the preoperative imaging to serve as ground truth. High resolution intraoperative video was collected, and adapted Neural Radiance Fields (NeRF) methods were applied to the endoscopic video post-operatively. The resulting 3D video reconstruction was registered to preoperative imaging, and segmented structures were overlaid as semi-transparent visual cues in the registered video stream. Geometric accuracy was evaluated in terms of Projected Error (PE).
Results: The NeRF-based volumetric 3D reconstructions aligned well with ground truth pre-operative MR (or CT) imaging, with a PE of 0.43 mm (inter-quartile range 0.46 mm), giving an augmented video overlay with submillimeter accuracy. The methods demonstrated a fast, one-time optimization runtime (< 120 s for evaluated scenarios) followed by real-time rendering, which is promising for the initial research prototype and can be accelerated as an online method for eventual clinical use.
Conclusions: Volumetric 3D reconstruction based on real-time 2D video during ventricular endoscopy provides a feasible platform for advanced functions during these cases. This study demonstrates proof of concept that real-time endoscopic video can be used to create accurate 3D reconstructions of ventricular and brain anatomy, allowing for deformation correction, a novel basis for neuro-navigation, and augmented reality overlay.

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Combined control of ICP and assessment of CSF dynamics with active shunt systems

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Introduction: Shunt systems to regulate intracranial pressure (ICP) and infusion studies to assess cerebrospinal fluid (CSF) dynamics are essential tools in the management of hydrocephalus. While these tools have traditionally been used separately, shunt systems with active valves or micropumps offer the unique potential to combine the benefits of both.
Methods: We developed a dual controller for active shunt systems that simultaneously addresses two objectives. First, the ICP is controlled to a range of safe pressures rather than a specific reference value as intended by classical shunt controllers. This approach aims to provide a more physiological therapy, given that there is no scientific consensus that a single constant optimum ICP reference value exists. Second, the CSF drainage is optimized in a way that maximizes the information gained about the patient's condition. The drainage rate is actively altered to perform a safe exploration of the CSF system that is similar to targeted excitation of the CSF system during infusion studies.
Results: We evaluated the proposed dual controller in an in-silico patient study based on the Marmarou CSF dynamics model with time-varying parameters and analyzed the obtained closed-loop data with a least-squares parameter estimator. During the simulation, the dual controller actively alters the CSF drainage rate to excite the CSF system while simultaneously ensuring that the ICP remains in the pre-defined range of safe pressures. The obtained closed-loop data allowed for successful tracking of the time-varying parameters for the outflow resistance and cerebral elastance.
Conclusions: This study demonstrates how the regulation of ICP and the assessment of CSF dynamics can be combined into a single framework when active shunt systems are used. The implementation of this approach in future smart shunts could make CSF drainage more physiological and allow for improved monitoring of patients with hydrocephalus.

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In-vivo measurement and analysis of intraventricular bioimpedance

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Introduction: Intraventricular bioimpedance (BI) measurements have been proposed as a technology for continuously assessing ventricular cerebrospinal fluid (CSF) volume to improve monitoring of hydrocephalus patients. Although the technology's potential could be demonstrated in simulations and in-vitro experiments, the in-vivo validation is limited to small animal models thus far. This work aims to expand on the current research by providing in-vivo validation in a large animal model.
Methods: A pilot study (n = 1) was conducted using an acute ovine model. A catheter with integrated electrodes was implanted in the left lateral ventricle and connected to a custom-built BI measurement system. Medical pressure transducers were used to measure intracranial pressure (ICP), intrathecal pressure (ITP), arterial blood pressure (ABP), and central venous pressure (CVP). All measurements were taken at a 1 kHz sampling rate. Following a 10 min baseline period, three intrathecal bolus infusions of 2 mL saline solution were administered in intervals of approximately 7.5 min to increase the CSF volume.
Results: During the baseline period, physiological waveform effects of the cardiac cycle (at 1.4 Hz) and respiration (at 0.3 Hz) were clearly visible in the BI and all pressure measurements. The computation of signal cross-correlations showed a strongly positive correlation of r = 0.93 between ABP and ICP with a 59 ms delay, and a mildly negative correlation of r = -0.45 between ICP and BI with a 182 ms delay. In response to the bolus infusions, BI decreased by 0.34 ± 0.12 Ohm, ICP increased by 51.7 ± 12.0 mmHg, ITP increased by 49.2 ± 12.5 mmHg, ABP increased by 43.1 ± 13.5 mmHg, and CVP increased by 2.5 ± 2.0 mmHg.
Conclusions: This pilot study demonstrates that physiological effects and changes in the CSF volume can be observed through intraventricular BI measurements. Future shunt systems could be augmented by this measurement technology to improve hydrocephalus patient monitoring, CSF drainage control and thus therapeutic results.

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Quantification of brain and CSF 3D center of mass shift in astronauts and ground-based controls

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Introduction: Brain MRI of astronauts after long-duration spaceflight (LDSF) have demonstrated an upward shift of the brain toward the vertex, and a concurrent downward shift in extra-axial CSF (eaCSF) as estimated by visual alignment of pre-/post-flight images. Using a novel technique, we quantified the degree of shift as measured by change in center of mass for brain and CSF compartments.
Methods: MRIs were obtained in 36 astronauts and 10 controls. Astronauts were imaged pre- and post-flight, with flight duration of ~ 6 months. Control subjects were imaged at baseline and 12 months. Each tissue or fluid compartment within the skull, including gray matter, white matter, eaCSF, ventricle CSF, bone, and intracranial blood, was segmented with SimNibs Charm. Baseline and follow-up skull segmentations were registered to each other for each subject. The registration was used to move all tissues into the baseline space. FSL was used to calculate volume and center of mass for each tissue. Change from baseline was calculated for each variable and compared between groups.
Results: After spaceflight, astronauts had a significant upward brain shift compared to controls at 12 months ($p = 1 \times 10^{-6}$). Astronauts had a concurrent inferior and anterior eaCSF shift compared to no CSF movement in controls (inferior $p = 1.2 \times 10^{-7}$, anterior p = 0.023). Superior shift of ventricles was not different in astronauts after spaceflight compared to controls, but posterior movement was observed (inferior p = 0.12, anterior p = 0.015).
Conclusions: LDSF is consistently associated with a superior brain shift and subsequent eaCSF redistribution. That exceeded the variable changes observed in Control participants over the course of 1 year. The clinical significance of these brain structural changes remains unknown and require further investigation.

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Impact of ventricular dilation and ventricular catheter placement on obstructive catheter failure in pediatric hydrocephalus patients: insights from a multicenter shunt biobank study

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Introduction: We assessed the impact of ventricular dilation and the proximity of ventricular catheters (VCs) to the ventricular wall on the pattern of cerebrospinal fluid (CSF) flow and the occurrence of tissue blockage within VC holes.
Methods: 343 failed VCs and pertinent clinical data were collected from six centers. Each VC drainage hole was categorized based on the degree of tissue obstruction. For a subgroup of patients, Evan's Index (EI), Frontal-occipital Horn Ratio (FOHR), and distance of the shunt from the ventricular wall were collected from pre-operative scans. These scans were also used to generate computational fluid dynamics (CFD) simulations of flow patterns through VCs which were then mapped onto patterns of tissue obstruction in explanted VCs.
Results: Pre-revision scans revealed that 82% of VCs were either embedded in tissue outside the ventricles or were in contact with the ventricular wall. The number of VC holes contacting the ventricular wall had a negative correlation with the number of unobstructed VC holes (p = 0.0375). VC holes contacting the ventricular wall were more likely to have tissue obstructions as compared to those that did not (p = 0.014). EI and FOHR were lower in patients with VCs embedded in tissue compared to patients whose VCs were completely inside the ventricles (p = 0.04, 0.01). The flow-obstruction mapping revealed patterns of VC hole obstruction that do not match our steady-state CFD flow simulations.
Conclusions: VC holes contacting the ventricular wall or cortical tissue are prone to obstruction. The observed patterns of VC hole obstruction do not align with CSF flow patterns in our steady-state model, suggesting that flow may not be the primary driver of obstruction. Placement of VCs with all holes inside the ventricles and redesigning of VCs to account for the almost inexorable tissue contact may prolong their patency.

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ICP is more than a number in hydrocephalus

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Introduction: ICP variability and waveform composition are more frequently considered in acute neurological diseases than in hydrocephalus. However those cases where both the LP value and overnight ICP monitoring is clinically required, more sophisticated interpretation of the recorded signal is necessary.
Materials and methods: This is a retrospective observational study. Over 400 cases of overnight ICP monitoring were reanalysed.

(2003–2020). An Intraparenchymal Codman microtransducer was used in all patients. Signal from the overnight period (sleep- confirmed by patient or nurses' notes) was considered. Computer recordings of raw signal and real time waveform analysis were performed using ICM + software. Variability of the ICP signal is derived from volumetric changes of four components, listed by the Monro-Kelly doctrine: arterial blood, venous blood, CSF volume, and volumetric changes in brain tissue (including contusions).
Results: Changes in arterial blood volume are responsible for the appearance of B waves (20 s to 3 min period, average frequency 1/min, average magnitude 0.5 to 2 mmHg;), and occasionally plateau waves (up to 60 mmHg, occurring episodically rather than in cyclic pattern, lasting from 2 to 20 min). Disturbances of venous blood outflow produce either an increase in mean ICP level or sometimes a reverberating ICP pattern, associated with the dynamical interaction between ICP and the resistance of transverse venous sinus. Changes in ICP secondary to depleted CSF circulation are associated with either an increase in resistance to CSF outflow or production of CSF. They are responsible for elevation of baseline ICP level (normal values between 5 to 17 mm Hg).
Discussion: Variability of ICP should be classified accurately, as different forms of management should be applied. Arterial blood inflow-breaking the vasodilatatory cascade or increase in brain compliance. Increase in venous sinus outflow- stenting. Increase of resistance to CSF circulation- shunting or ETV.

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A phase IV placebo-controlled single center trial for tirzepatide in idiopathic intracranial hypertension trial (TIIHT)

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Introduction: Approximately 85% of IIH patients have a body mass index (BMI) greater than or equal to 30, however, weight loss in the range of 3–24% can lead to disease remission. Glucagon-like peptide-1 (GLP-1) agonists such as Tirzepatide can easily produce similar reductions in body weight. GLP-1 agonists may therefore represent a novel therapeutic avenue for IIH treatment, potentially obviating the need to resort to invasive surgical measures and significantly improving quality of life (QOL) while preserving vision.
Methods: A randomized, double blinded placebo-controlled phase IV clinical trial. The trial will enroll patients aged 18–60 years with confirmed IIH based on modified Dandy criteria, BMI ≥ 30 and unilateral or bilateral papilledema. All patients will be enrolled in an intensive weight management program with a total study trial length of 12 months.
Results: The primary outcome measure will be change in intracranial pressure (ICP) between study enrollment and at 12 months. Sample size to detect a clinically significant difference was determined to be 50 patients (90% power; 5% significance threshold; 25% dropout). Secondary objectives include vision (i.e. perimetric mean deviation [PMD], retinal nerve fiber layer [RNFL] thickness, Frisen grade, visual acuity, visual function questionnaire [VFQ]-25) and headache parameters (e.g. number of monthly headache days (MHDs), number of moderate to severe MHDs, mean number of analgesic MHDs, change in headache impact test (HIT-6 score)) at enrollment and 12 months.
Conclusions: Limited non-invasive options exist for the treatment of IIH. Acetazolamide is the current standard of care, but it is estimated that 19–48% of patients will not tolerate the medication due to adverse effects. GLP-1 agonists are FDA approved drugs with the potential to reduce ICP both directly and indirectly through weight loss, and present a promising medical alternative for the treatment of IIH.

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Influence of ventricular catheter design on CSF flow dynamics

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Objective: Ventricular catheter (VC) failure is mainly attributed to mechanical obstructions within drainage holes. We employed computational methods to analyze cerebrospinal fluid (CSF) behavior inside VCs. Specifically, we investigated CSF mass flow patterns and shear stress distribution across commercial VC models. We aim to evaluate the efficacy of dimensional variations and design alterations in mitigating VC failure risk.
Methods: Commercial catheters from a patient biobank were scanned under confocal microscopy to create 3D renders of the catheters. Deidentified patient MRI scans were used to create 3D ventricular renders. Catheters were inserted into the lateral ventricles using Kocher's Point. Cerebrospinal fluid secretion from the choroid plexus and cardiac-driven ventricular pulsations were assigned to the ventricular domain. A constant pressure outlet was placed at the VC exit. Flow parameters, including mass flow rate, shear stresses, and velocity streamlines, were quantified in the catheter drainage holes and lumen.
Results: Simulation results reveal that fluid mass distribution varies across the catheter's drainage holes during different phases of the cardiac cycle. There is a variance in flow distribution, with certain phases showing a higher concentration of mass flow toward the drainage holes near the catheter tip. In contrast, other phases exhibit a significant shift in mass flow toward the holes further from the tip. Additionally, the intermediary sections of the drainage holes experience varying flow rates ranging from 20 to 60% throughout the cycle.
Conclusion: Similar trends in mass flow rate and shear stress distribution were noted across the drainage segments regardless of catheter manufacturer, hole number, and segment spatial arrangement. Despite modifications in hole geometry and varied segment spatial arrangement, no discernible enhancement in (CSF) flow distribution was observed across catheter variants. The overall flow distribution remained consistent, suggesting that these alterations did not confer additional benefits in CSF drainage efficiency.

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Maintaining momentum: sustaining symptom improvement in Hakim's disease (iNPH) patients through ventriculoperitoneal shunt valve adjustments

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Introduction: Ventriculoperitoneal (VP) shunt is the main treatment modality of Hakim's disease (idiopathic NPH). While VP shunt insertion normally yields symptomatic improvement, it could be challenging to achieve long-term improved outcomes with minimal over-drainage. This study aims to explore whether VP shunt adjustments, particularly valve pressure reduction, would sustain outcome improvement without risking over-drainage.
Methods: A single-centre retrospective observational study was conducted on Hakim's disease patients who had the Miethke M. blue plus VP shunt inserted between May 2020 and July 2023, following a

positive trial of lumbar drain. Objective outcome measures were 10-m walking speed and over-drainage-associated complications as confirmed by CT brain.
Results: Between July 2020 and September 2023, 90 patients underwent M. Blue plus VP shunt insertion, of whom 38 were females (42.2%) and 52 were males (57.8%). Mean age was 77.7 ± 7.10. Sixty-three patients (70%) had a total of 111 shunt adjustments: 37.8% (n = 34) had one, 13.3% (n = 12) had two, 16.7% (n = 15) had three and 2.22% (n = 2) had four adjustments. Of patients with documented walking speeds at the post-shunt insertion and post-valve pressure reduction stages (n = 50; 55.6%), the Wilcoxon Sign-Rank test indicated that the improvement in median walking speed was statistically significant post-shunt adjustment (Z = -2.84, p < 0.00452). The initial mean valve pressures were 5.75 ± 1.90 mmHg and 30.3 ± 3.61 mmHg, whereas the mean reduced valve pressures were 4.92 ± 2.59 mmHg and 26.5 ± 3.75 mmHg. Fourteen patients (15.6%) incurred over-drainage-associated complications at a mean valve pressure of 5.07 ± 2.6 mmHg (proGAV 2) and 25.3 ± 3.86 mmHg (M. blue). Four patients (4.44%) had over-drainage at proGAV2 setting < 3 mmHg while 11 patients (12.2%) had over-drainage at M. Blue setting < 30 mmHg.
Conclusions: Our findings support the hypothesis that reducing valve pressures in shunt adjustments produces objective improvement in long-term mobility albeit an accompanying risk of over-drainage.

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Deciphering congenital hydrocephalus genes using xenopus

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Introduction: Congenital hydrocephalus (CH), characterized by abnormal ventricle expansion, affects approximately 1 in 770 births. While genetic factors contribute to around 40% of cases, many remain undefined, hindering our understanding of the pathogenesis and genetic counseling efforts. Here, we report on a patient with non-communicating CH, where whole exome sequencing revealed a novel variant in a gene linked to aqueductal stenosis. To study its role in hydrocephalus, we employed a novel approach using the genetically tractable *Xenopus* frog model. Leveraging the semi-transparent tadpole brain, we utilized Optical Coherence Tomography (OCT) imaging for real-time, 3D visualization of the embryonic central nervous system (CNS) and the entire cerebrospinal fluid circulation. Combining CRISPR-CAS9 system gene depletion with *Xenopus's* efficiency and affordability, we have transformed our investigation of CH candidate genes and their mechanisms in hydrocephalus.
Methods: We generated G0-*Xenopus* mutants using CRISPR/Cas9, targeting two non-overlapping exons. We analyzed the tadpole CNS and CSF circulation using OCT imaging and particle tracking. Additionally, we examined the impact on neurodevelopment using in situ hybridization and immunofluorescence.
Results: Mutant tadpoles exhibited aqueductal stenosis when two non-overlapping exons were targeted—21% (Exon1) and 19% (Exon 15). Both results phenocopied the core brain pathology of the proband with aqueductal stenosis. Particle tracking analysis revealed intact CSF circulation throughout the ventricular system, indicating normal ependymal cilia formation and normal CSF physiology. Further analysis revealed abnormal expansion of the neuroprogenitors shaping the aqueduct, leading to aqueductal stenosis in *Xenopus*.
Conclusions: Our research demonstrates the effectiveness of integrating whole exome sequencing for identifying candidate genes, followed by functional analysis using the *Xenopus* model system, providing a robust platform for analyzing variants in congenital hydrocephalus. This patient-driven gene discovery approach emphasizes collaboration between patients and researchers, accelerating the identification of genetic disease causes and enhancing clinical outcomes for affected individuals.

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Accumulation of reactive oxidative species leads to the development of acquired hydrocephalus

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Introduction: Oxidative phosphorylation pathways hyperactivate during sickness or injury, leading to elevated concentrations of mitochondrial reactive oxidative species (mtROS). However, under high-stress conditions, maintaining a healthy balance of mtROS becomes challenging. Heightened levels of mtROS trigger downstream activation of matrix metalloproteases (MMPs). These MMPs can disrupt cell junctions, potentially increasing the permeability of the cerebrospinal fluid-blood brain barrier (CSF-BBB) and ventricular lining. This disruption may impact CSF homeostasis, contributing to the development of hydrocephalus. Our hypothesis proposes that the accumulation of mtROS is a fundamental step in the pathophysiology of inflammatory-dependent hydrocephalus.
Methods: In a preliminary in vivo experiment, hydrophobic rotenone, a mitochondrial inhibitor of complex I, was intraventricularly administered to C57BL/6 mice on P3. After 14 days, MRI quantified ventricular volumes, and immunocytochemistry assessed cell junction integrity. In vitro experimentation utilized a commercial mixture of hydrophilic rotenone and antimycin A (RAA) on murine ventricular zone cells harvested on P4. Antimycin A is a mitochondrial inhibitor of complex III. The effects of RAA and the ability of the antioxidant epicatechin to reverse these effects on apoptosis and cell junction integrity were assessed using LIVE/DEAD assay and Western Blot, respectively.
Results: Intraventricular administration of rotenone induced ventriculomegaly in mice compared to controls, as confirmed by MRI images. Elevated MMP-9 expression was observed near rotenone-exposed areas of the ventricular lining and adjacent blood vessels. The results from the in vitro experiment are currently being interpreted to discern their potential implications.
Conclusions: This preliminary research establishes a correlation between mtROS and the development of hydrocephalus. Ongoing research will determine if elevated mtROS can be effectively targeted with pharmacologic interventions. Future experiments will evaluate cell permeability and compare the efficacy of other commercially available antioxidants.

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Use of the lumbar infusion test in paediatric populations with idiopathic intracranial hypertension: a systematic review of the literature and institutional experience

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Introduction: The lumbar infusion test (LIT) is a routine part of the diagnostic process of various CSF dynamics disorders in adults. However, it is rarely used in the paediatric population due to a lack of evidence substantiating its efficacy and overall guidelines on when and in which patients to use it. This study aims to evaluate the LIT regarding the indication criteria along with the efficacy of its usage.

Methods: PubMed, Science Direct, Scopus and additional sources were searched to identify articles utilizing the LIT in a paediatric cohort. The PRISMA guidelines were followed with the risk of bias assessment by the Newcastle–Ottawa Scale. Moreover, case reports from a monocentric experience in children who underwent LIT between 2022 and 2024 were discussed.
Results: A total of 14 studies yielding 442 patients were included in the review along with seven cases (8.86 ± 4.75 years) from a single institution who underwent LIT. The most common indications to perform LIT were shunt responsiveness prediction for hydrocephalus, and idiopathic intracranial hypertension (IIH). All analyzed studies demonstrated a high positive predictive value of LIT to select patients for shunt surgery. In patients with posterior fossa arachnoid cysts, pathological LIT results were present. In the institutional experience, all patients underwent LIT due to suspicion of IIH. One patient underwent dural venous stenting, four patients underwent shunt implantation and the remaining two were conservatively treated. All invasively treated patients improved in terms of vision impairment, headaches and/or papilledema.
Conclusions: LIT represents a useful part of the diagnostic battery for hydrocephalus, IIH or arachnoid cysts. Most of the published series are outdated, and the potential of LIT in the diagnostic process of CSF disorders in children has not been extensively studied. This gives a future perspective on the research of LIT usage in clinical practice.

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Ventriculoatrial shunt with intra-operative venography, a non-inferior alternative to the ventriculoperitoneal shunt: case series & technique description

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Introduction: The mainstay treatment for hydrocephalus is diversion of cerebrospinal fluid, typically through a ventriculoperitoneal shunt.[1,2] Alternatively, ventriculoatrial shunt (VAS) placement may be a viable and effective alternative to the VP shunting method.[1,2] Confirmation of the distal access placement can be difficult with plain x-rays intra-operatively. Here, we detail a surgical technique using digital subtraction venography to confirm distal catheter placement.
Methods: Retrospective review was completed for 46 adult VAS patients at a singular site between 7/2021–5/2024. EMR and imaging were reviewed. Intra-operatively, the internal jugular vein was accessed with ultrasound guidance using Seldinger technique. Distal catheter placement was confirmed through use of intraoperative digital subtraction venography with iodinated contrast. The atrial portion of the catheter was then connected to the proximal ventricular catheter and valve.
Results: Kaplan–Meier analysis demonstrated overall VAS failure-free survival was 93.5% with follow-up between 1–21 months after initial surgery. Two distal failures occurred due to shearing of the distal catheter at the neck in-line connector and suboptimal distal placement. One proximal failure occurred due to suboptimal placement. There were no instances of cardiac or infectious complications.
Conclusions: We demonstrate evidence supporting the use of VAS as a non-inferior alternative with comparable outcomes to VPS in adults (VPS failure rates at 1 year of approximately 11–25%).[3,4,5,6] Intraoperative digital subtraction venography may serve as an effective method to ensure optimal distal catheter placement, potentially preventing returns to the OR for revision. Limitations for our study include sample size and limited follow-up period, which will assist in elucidating risk factors for VAS failure and overall long-term outcomes after VAS placed with intra-operative venography.

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Expert opinions for standardization of post-shunt management of patients with idiopathic normal pressure hydrocephalus

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Introduction: In order for patients to maximize benefit from idiopathic normal pressure hydrocephalus (iNPH) treatment, post-shunt management is extremely important. There are no high-level evidence reports on postoperative shunt management methods, and information is often not shared among healthcare professionals who manage patients. Therefore, we prepared a clinical questionnaire regarding the postoperative management of iNPH patients, and missing evidence was completed with the analyzed collected expert opinions.
Methods: The questionnaire was answered by seven high volume iNPH treatment centers (managing 100 + patients/year), and we discussed all questions in a face-to-face meeting. Sample questions were: 1) The rules to obtain optimal pressure settings, 2) Protocols for suspected CSF under-drainage, 3) Protocols for suspected CSF over-drainage, 4) Expected duration of follow-up, outpatient visits frequency, and when to discontinue, 5) Rules for shunt valve pressure setting in coexistent neurodegenerative disease, 6) Collaboration with other departments, etc. We also collected and summarized expert opinions.
Results: Summarized replies from the experts indicated: 1. Postoperative shunt pressure should be adjusted from high to low at least every two months, and imaging studies (MRI and CT) are followed up for the corpus callosum angle, expected to correlate with cognitive and gait disturbance improvement. 2. Valve puncture is performed periodically to confirm shunt flow, and obtained biomarkers may serve as indicators to determine the appropriate shunt pressure. For a year after shunt placement, frequent pressure changes are necessary to improve symptoms, but after that the focus shifts to checking for complications.
Conclusions: Shunt management should monitor brain imaging changes and neurological condition over time to adjust adequate CSF drainage, with CSF biomarkers a needed adjunct. Patients should be followed for as long as possible, emphasizing the importance of documenting changes to decide on future management.

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First in human trial of a new telemetry system for the remote chronic monitoring of intracranial pressure in hydrocephalus patients

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Introduction: The detection of shunt failure relies on non-specific symptom assessment and imaging. False alarms are extremely prevalent. There is an unmet clinical need to provide an accurate means of directly monitoring intracranial pressure (ICP) as a means to detect shunt failure or false alarms. We report the first human trial of a novel implantable monitoring technology that allows remote/home based regular ICP measurements.
Methods: The sensor is the first discrete microimplant to be implanted within the brain. Measuring 2 × 3 × 20 mm (0.3 gm) it contains no battery. It is placed directly into the cortex alongside, but separate to the shunt and during the same shunt procedure. An external wand is placed within 8 cm of the implanted sensor. Wireless power provided to the sensor to allow a direct pressure measurement within the cortex to be made. ICP data is transferred wirelessly back to the wand and displayed to the patient.
Results: A group of adult hydrocephalus patients were implanted with sensors during a procedure to replace their shunts. ICP was measured while patients were in hospital and subsequently every two days for 3 months when they were at home. Measurements were made under quite resting conditions and subjects made the measurements on themselves. There were no adverse safety related events. ICP was able to be measured 100% of the occasions a measurement was attempted. A diary of ICP values along with patient reported symptoms were tracked on a dedicated app and hospital based neurosurgical team was able to remotely review data via a clinical portal.
Conclusions: The Kitea system is well tolerated by patients with no adverse events. The trial is continuing with the enrolment of children and assessment of clinical efficacy.

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Pioneering the biomechanical efficacy and safety of the m. blue® device in treating adult post-hemorrhagic hydrocephalus following aneurysmal rupture: an in-depth study

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Background: Ventricular shunt devices with gravitational units significantly reduce over-draining risks in adult post-hemorrhagic communicating hydrocephalus (APHCH) management. The M.BLUE® system, originally for pediatric use, has only been tested in one trial for idiopathic normal pressure, hydrocephalus. This study aims to fill the scientific gaps regarding the M.BLUE® device's use in APHCH and evaluate potential complications, assessing device safety.
Method: We performed a retrospective analysis of 17 adults diagnosed with APHCH and treated with the M.BLUE® device, focusing on the Evans' index (EI) and the callosal-marginal angle (CMA). We also assessed improvements in gait, urinary, and cognitive functions, and monitored post-operative adjustments to the anti-gravitational system to evaluate effectiveness and complications.
Results: Significant reductions in EI by 14.9 ± 12.2% ($P < 0.001$) and increases in CMA by 27.3 ± 21% ($P < 0.001$) were observed. A case of headaches indicating over-draining without subdural hematoma and three instances of under-draining required post-operative adjustments. Additionally, three mechanical complications unrelated to the M.BLUE® device were reported: a ventricular catheter malposition, an extra-peritoneal migration of the distal catheter in an obese patient, and an infection. Improvements were noted in cognitive (14/15, $P < 0.001$), urinary (12/13, $P < 0.001$), and gait functions (15/15).
Conclusion: This preliminary study highlights the M.BLUE® device's potential as an effective and safe option for managing APHCH. The significant reduction in ventricular volume and minimal post-operative adjustments emphasize its utility. The observed improvements in gait, urinary, and cognitive functions further support its clinical benefits.

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Rare incident of migrating spinal arachnoid cyst: case report of a female patient

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Introduction: Spinal arachnoid cyst by itself is a rare but not unique phenomenon that requires scientific attention regarding its origins, ways of diagnosis, or treatments. And yet, no literature source describes their apparent ability to migrate along the axis of the spinal column. We present one such patient, a 30-year-old female, who demonstrates an unexplained phenomenon of a "migrating" intradural extramedullary cyst: an arachnoid cyst that moves from C7-Th1 of the spinal column level to Th4.
Methods: We retrospectively examined one female patient with a diagnosed spinal arachnoid cyst. At our disposal are all available MRI images, which clearly show the cyst's ability to "jump" from C7-Th1 to Th4 level in the span of dozens of hours. Utilizing all the available data at our disposal, we were able to carefully monitor the progress of the patient's condition.
Results: The MRI scan on the day of surgery showcased the cyst at the level of Th4, and the decision was made to start the intervention at this level only. The neurosurgeon reported that a fluid resembling cerebral spinal fluid was evacuated and the tension on the spinal cord had decreased. The treatment was deemed a success, but a control image of the MRI scan showed that the cyst had returned to the C7-Th1 level (Fig. 1).
Conclusions: Although the patient outcome was satisfactory, the simple fact that this growth was able to "migrate" is still puzzling. It would be very simple to sweep this case under the rug, lest we forget that aside from healing, our obligation to medicine is to understand, no matter how unclear the situation is.
Note: Consent to publish has been obtained by the patient.

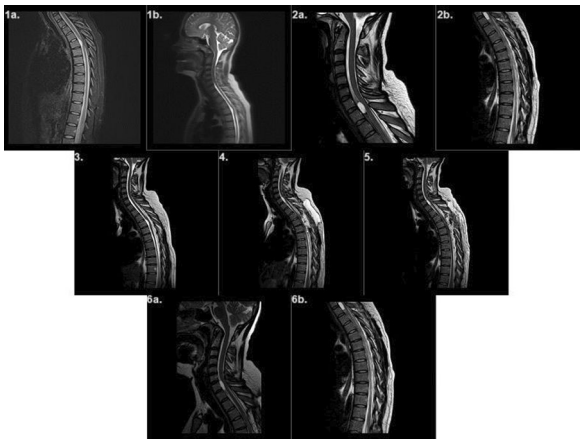

Fig. 1 The MRI imaging in T2 sequence: 1a, 1b: Before hospitalization. 2a, 2b: After hospitalization. 3: On the day of surgery. 4: 3 days after. 5: 2 weeks after. 6a, 6b: 1 month after

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The impact of correlating symptoms to cerebrospinal fluid dynamics: a Machine Learning-led exploration of infusion study metrics

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Introduction: Cerebrospinal fluid (CSF) testing via infusion studies yields multiple compensatory parameters. Such metrics allow for the inference of hydrodynamic properties that may be altered in the CSF compartment in patients with NPH. Only resistance to CSF outflow (Rout) has shown clear correlation to clinical outcomes. The relationship between symptoms/duration towards altering the predictive outcome of Rout is less certain. In this study, we utilized Machine Learning (ML) to model correlations between CSF infusion study parameters and symptoms to outcomes.
Methods: 309 adult patients were included from the NPH programme in Cambridge, whose infusion study parameters were available for analyses; 140 patients (51 females and 89 males, mean age of 71.9 ± 8.7) had data collected on symptoms and 83 patients, their duration. The dataset was analyzed based on two testing scenarios – (i) Analysis with patients' *duration of symptoms* undefined (i.e. null) [N = 140], ii) Analysis excluding null or zero *duration of symptoms* [N = 83]. We applied ML methodologies to interrogate both the overall dataset and symptom/duration subset for best model and top feature predictions. Subsequently, we performed perturbations on the NPH dataset, including stratifying by differing time epochs of duration, to test for robustness of measures, effect of missing data and range of metrics.
Results: Using the Cambridge Outcome Scale, Rout was significantly correlated with sustained improvement vs. short-term improvement vs. no-improvement (ANOVA: 3.687; $p = 0.028$). When any category of improvement was considered vs. no-improvement, Rout was still significantly correlated with outcomes (Student's t-test: 2.725; $p = 0.008$). On ML-led exploration, data cleaning of fields reduced the AUC-weighted scores of the overall dataset and symptom/duration subset from 0.996 and 0.793 to 0.675 and 0.854 but demonstrated more consistent and reliable top features (Rout and duration) distinguishing between good and poor clinical outcomes.
Conclusions: ML approaches allow for modelling of datasets to test for the disproportionate influence of key parameters/ subsets.

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Morphological and clinical changes after shunt

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Introduction: Disproportionately Enlarged Subarachnoid-space Hydrocephalus (DESH) is a simple and well accepted score to diagnose and evaluate hydrocephalus patients based on his cerebral MRI. DESH score could be an element for specifying improvement in chronic adult hydrocephalus (HCA) patients. The idiopathic Normal-Pressure Hydrocephalus grading scale (iNPH_GS) quantify patient clinical symptomatology. The aim of this work is to quantify expected change in DESH and iNPH_GS in shunted hydrocephalus patients.
Methods: 11 HCA patients (mean age 75 ± 6 years) who had received a shunt underwent pre- and post-surgery a morphological 3D FLAIR MRI.
We calculated DESH parameters before and after surgery (focusing on Evans index and callosal angle), Scheltens, FAZEKAS, and iNPH_GS. Ventricular volume change was also measured using a morphological analysis.
Paired with morphological analysis, statistical test evaluated potential significance difference between pre and post surgery measurements.
Results: Post-operatively, the callosal angle (CA) was significantly higher than pre-operatively (83° ± 22 versus 74° ± 18; $p < 0.02$). Global iNPH improved post-operatively (63 ± 28 versus 47 ± 25; $p < 0.002$). DESH reduced post-operatively (7 ± 2 versus 4 ± 3; $p < 0.001$). Scheltens improved in 6/11 and stabilized in 3/11. Fazekas index was stabilized in 7/11 patients. Evans index after didn't change after shunt (0.35 ± 0.04 versus 0.35 ± 0.04). CA change negatively correlated with ventricular volume change ($r = -0.76$, $p < 0.05$).
Conclusions: DESH, iNPH_GS and Scheltens significantly improved after shunt, whereas Fazecas index didn't change. The most notable change was seen in the CA and Scheltens, indicating that these accessible, non invasive radiological markers should be helpful for the hydrocephalus patient's outcome and identify shunt malfunctions.

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The role of spontaneous retinal venous pulsations in the post-operative follow-up of patients with intracranial hypertension

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Introduction: Spontaneous Retinal Venous Pulsations (SVP) assessed with Optic Coherence Tomography (OCT) infra-red video recordings can be used as a non-invasive marker for intracranial pressure. Raised ICP has been demonstrated to be associated with absence of SVPs. Traditional ophthalmic markers of raised ICP, such as disc swelling and RNFLT, can take long periods of time to reflect normalization of ICP

and may not be reliable when there is established optic disc atrophy. The effect of shunt surgery and normalization of intracranial pressure (ICP) on SVPs has not been studied before.
Methods: Retrospective single-centre study. Patients who received neuro-ophthalmic assessment before and after shunt insertion (or revision) surgery were included, a maximum interval of 3 months was allowed between assessments and surgery date. RNFLT was used as a surrogate to quantify optic disc swelling. Data on pre- and post-surgery ophthalmic assessments were collected, this included RNFLT measurements and SVP grading according to a previously published protocol. The assessor collecting ophthalmic data was blinded to the patients' stage of treatment.
Results: Sixteen patients met the inclusion criteria (13F, mean age 35 ± 10 years). Thirteen patients had new shunt insertions, while 3 underwent shunt revisions for shunt blockage (surgically confirmed). Pre-operatively, SVPs were visible in only 24% of the tested eyes. After surgery, SVP returned to visible in 83% of the eyes (Fisher's exact test $p < 0.001$). The difference between pre- and post-treatment RNFLT was not statistically significant (paired t-test $p = 0.057$). SVPs normalised in patients having chronic disc atrophy pre-operatively.
Conclusions: SVPs can be a valid adjunct in the postoperative follow-up of patients treated with shunt surgery for intracranial hypertension. Compared to RNFLT, SVPs seem more reliable in confirming normalization of ICP in patients with atrophic optic discs. Larger prospective studies will be needed to confirm these findings.

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The grasp reflex in patients with idiopathic normal pressure hydrocephalus

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Introduction: To investigate the prevalence and intensity of grasp reflexes and to examine changes in these reflexes after shunt surgery in patients with idiopathic normal pressure hydrocephalus (iNPH).
Methods: We enrolled 152 patients with probable iNPH. A standard procedure was used to determine the presence of grasp reflexes, and the intensity of these reflexes was assessed using a four-category classification. Clinical rating scales and their correlation with grasp reflexes were also evaluated. Grasp reflexes were reassessed in 75 patients 1 year after surgery.
Results: We found that approximately 50% of patients with iNPH exhibited a positive grasp reflex, which demonstrates greater sensitivity compared to the applause sign. Except for the Functional Balance Scale and Counting-backward Test (CBT) reverse effect index, the grasp reflex score was significantly correlated with the iNPH Grading Scale (iNPHGS) total score, modified Rankin Scale score, both the completion time and number of steps of the Timed Up and Go (TUG) test, Movement Disorder Society-Unified Parkinson's Disease Rating Scale total score, Mini Mental State Examination score, Frontal Assessment Battery score, Trail Making Test-A (TMT-A) score, CBT First error score, iNPHGS urination subscale score, and Neuropsychiatric Inventory score. Surgical interventions led to a reduction (41.3%) or maintenance (30.7%) of the reflex intensity in 72% of iNPH patients. The changes in reflex intensity showed significant positive correlations with changes in the Trail Making Test-A scores. Nevertheless, the preoperative reflex intensity does not serve as a predictor for postoperative outcomes.
Conclusions: This retrospective study identified grasp reflexes as a highly prevalent phenomenon in patients with iNPH. These reflexes can reflect the severity of various symptoms, including gait, cognitive, urinary, motor and neuropsychiatric symptoms. However, the evaluation of grasp reflexes holds little value in predicting postoperative outcomes.

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Telemetric intracranial pressure readings: algorithms to guide the long-term management of patients with cerebrospinal fluid disorders

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Introduction: The advent of implantable intracranial pressure (ICP) reading reservoirs like M.scio has revolutionized the clinical management of patients with cerebrospinal fluid (CSF) dynamics disorders. This study describes the M.scio ICP readings of a group of patients seen in an outpatient clinic setting and their utility in the clinical decision-making process.
Methods: Single-centre retrospective study. Patients attending hydrocephalus outpatient clinics within the past 12 months were screened and included in the study if meeting the following inclusion criteria (i) ventriculoperitoneal shunt in situ, incorporating M.scio reservoir, (ii) M.scio ICP readings recorded during the clinic appointment, (iii) clear description of patient's symptoms and documentation of management plan, (iv) no evidence of shunt malfunction/blockage. Results were stratified by diagnostic group.
Results: 140 patients met the inclusion criteria (61% females, mean age 48 ± 19 years). The patients' diagnoses were as follows: 58 hydrocephalus (secondary/congenital), 38 Idiopathic Intracranial Hypertension (IIH), 22 Normal Pressure Hydrocephalus (NPH), 12 Longstanding Overt Ventriculomegaly in Adults (LOVA) and 10 Chiari Malformation. 83 patients described worsening symptoms at the time of assessment, while 57 reported feeling better or stable compared to previous visits. Patients with NPH and/or LOVA who had worsening of symptoms, had significantly lower ICPs compared to the patients in the same diagnostic groups who improved (mean supine ICP 9 mmHg versus 13.3 mmHg). An opposite trend was noted for IIH patients, with higher supine ICPs in patients with worsening symptomatology (15.2 mmHg versus 11.8 mmHg). Amongst patients with hydrocephalus, no obvious ICP trend was observed. M.scio-guided shunt adjustments and their outcome will be presented.
Conclusions: This study gives an insight on the characteristics of telemetric ICP readings in a cohort of patients affected by CSF dynamics disorders and their association with symptoms control. These results could provide evidence to support the design of future prospective studies.

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Clinical long-term outcome in idiopathic normal pressure hydrocephalus (iNPH) after CSF shunt surgery: Is long-term improvement common or exceptional?

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Objective: Long-term efficacy of cerebrospinal fluid (CSF) shunt surgery in idiopathic normal pressure hydrocephalus (iNPH) patients is differently reported. The aim of this study was to assess responsiveness, symptom improvement and long-term outcome after shunt surgery.
Methods: Altogether, 307 shunted patients with improved Hakim symptoms after preoperative test CSF diversion were retrospectively investigated. Ventriculo-atrial (in 26.1%) or ventriculo-peritoneal (in 73.9%) shunts and anti-siphon devices (in 22.8%) were used. Epidemiological data were retrospectively assessed using hospital records and telephone interviews (59.9 months mean follow up, FU).
Results: Patient age at the time of shunt surgery was 70.3 mean $\pm$ 9.0 years. 18 patients were lost to FU. Of the remaining 289 cases, 253

(87.5%) showed postoperative symptom improvement, and 36 patients (12.5%) did not respond to shunt surgery. Most frequent symptom prior to surgery was gait disturbance (99.4%) followed by cognitive impairment (80.6%) and urinary incontinence (69.3%). A complete Hakim's Triad was present in 60.2%. Postoperative symptom improvement was observed in 80.6%, 46.9% and 40.8% for gait disturbance, cognitive impairment, and urinary incontinence. Improvement of all three symptoms was seen in 25.6%. Average duration of symptom improvement was 51.5 months (4.3 yrs, from 0 to 21 yrs), 56% had continuing improvement of symptoms after 10 years of FU. Neither comorbidity nor longer symptom duration were statistically significant negative shunt outcome predictors. Overall surgical complication rate was 17.3%, shunt infection rate was 3.3%, and shunt revision rate 14.9%, mostly due to shunt dislocation and/or dysfunction.
Conclusion: Surgical CSF diversion by implanting shunt systems is an effective and long-lasting treatment method for iNPH, especially concerning the improvement of gait, with up to 21 years symptom improvement in our study. However, surgical complications are common and shunt revision surgery rate was found higher than commonly expected.

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Impact of frailty on gait outcomes in idiopathic normal pressure hydrocephalus after shunting

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:124

Introduction: Frailty, characterized by decreased physiological reserve and increased susceptibility to insult, is common in the idiopathic normal pressure hydrocephalus (iNPH) population and may negatively impact gait outcomes. We sought to interrogate the influence of frailty on gait outcomes following ventriculoperitonteal shunting (VPS) for iNPH.
Methods: We retrospective identified patients treated with VPS for iNPH at a single tertiary care center by the senior author, between December 2017 and January 2023, who underwent pre- and postoperative objective videographic gait analysis. Patients were categorized by modified Frailty Index (mFI) into non-frail (mFI = 0), pre-frail (mFI = 1), and frail (mFI ≥ 2) groups. Multivariable logistic regressions were used to evaluate whether frailty predicted improvement in gait measures at 1-month and at last follow-up after controlling for baseline gait performance.
Results: A total of 162 patients were included (30 non-frail, 79 pre-frail, and 53 frail). On preoperative gait analysis, gait velocity ($p = 0.01$), stride length ($p = 0.01$), and portion of gait cycle in stance ($p < 0.01$), and single support phases ($p < 0.01$) all correlated with frailty score. However, at last follow up (median 23 months), average improvement from baseline for gait velocity, cadence, stride length, step width, gait stability ratio, total support, and step length did not differ statistically ($p > 0.05$) between groups. Multivariate logistic regression controlling for baseline gait performance showed baseline frailty was not predictive of patients' improvement in gait parameters for any metric at 1-month follow-up. Similar analysis at last follow-up showed baseline frailty only predicted change in proportion of the gait cycle spent in total support and single support.
Conclusion: Frail patients demonstrated comparable percentage improvement to non-frail patients on objective gait testing following VPS for iNPH. Final performance was best predicted by baseline performance. The data suggest shunt placement affords significant gait improvement in iNPH patients regardless of frailty.

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Evaluating longitudinal changes of objective gait parameters following shunt placement in patients with idiopathic normal pressure hydrocephalus

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:125

Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is characterized by gait deterioration, cognitive disturbances, and urinary incontinence. Gait instability can result in frequent falls, yet objective assessments of gait improvement following ventriculoperitoneal shunt (VPS) placement are limited. The present study aims to assess objective improvement in gait parameters following VPS placement for iNPH.
Methods: All patients treated with VPS for iNPH by the senior author at a single tertiary care center between December 2017 and January 2023 were retrospectively reviewed with inclusion of patients who underwent detailed motion analysis testing (gait velocity, gait cadence, stride length, stride width, gait stability ratio, right and left legs total support, single support, initial double, and step length support) preoperatively and at interval follow-up (1-, 6-, 12-, and 24-months) with statistical comparisons performed using paired Wilcoxon rank test.
Results: A total of 157 patients (mean age 75.5 years, 64.3% male) met inclusion criteria. At 24-month follow-up, statistically significant ($p < 0.001$) improvements from baseline gait metrics were noted in gait velocity (53.6%), stride length (57.6%), step width (30.2%), and gait stability ratio (30.0%). For gait velocity, improvement from baseline at 1-, 6-, 12-, and 24-months was noted in 87.1%, 79.0%, 80%, and 77.6% of patients. For stride length, improvement from baseline at 1-, 6-, 12-, and 24-months was noted in 66.0%, 63.1%, 87.3%, and 79.3% of patients. For gait stability ratio improvement from baseline at 1-, 6-, 12-, and 24-months was noted in 87.2%, 82.4%, 91.8%, and 87.9% of patients. For gait cadence, improvement from baseline was observed in 68.8% of patients at 1-month, but such improvement was not demonstrated as statistically significant at 6- and 12-months with decline to 36.2% at 24-months.
Conclusions: Improvements in objective gait metrics are noted following VPS for iNPH with a plateau observed with longer term follow-up.

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A prospective study evaluating the risk of glaucoma after ventriculoperitoneal shunts for patients with normal pressure hydrocephalus

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:126

Introduction: Given a theoretical risk that ventriculoperitoneal shunting (VPS) could worsen glaucoma by increasing the translaminar gradient, we sought to prospectively monitor normal pressure hydrocephalus (NPH) patients with VPS and evaluate for the development and progression of glaucoma.
Methods: Patients with NPH and VPS were prospectively and consecutively enrolled. Patients had baseline and serial eye exams, OCT of the optic nerve, and visual field assessments. Patients diagnosed with possible glaucoma were independently reviewed by a neuro-ophthalmologist and glaucoma specialist.
Results: A total of 94 patients with NPH and VPS implantation were enrolled with 74 patients having baseline and post-operative testing. Development of primary open angle glaucoma (POAG) after VPS was noted in 2 patients. An additional 2 patients with POAG prior to VPS experienced disease progression. Agreement between specialists was noted in 87% (13/15) of cases while the remaining 13% of cases were reviewed for consensus.
Conclusions: This prospective study suggests there may be an increased risk of glaucoma after VPS, but comparisons against control patients of equal follow-up are required to confirm these findings.

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Associations between DESH pattern on MRI and enlarged perivascular space and WMH load in the mayo clinic study of aging (MCSA) (max 153 characters)

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:127

Introduction: Are enlarged perivascular spaces (PVS) observed on MRI related to the presence of the CSF spatial pattern of disproportionately enlarged subarachnoid hydrocephalus (DESH) in the epidemiologically-recruited Mayo Clinic Study of Aging (MCSA) cohort? CDESH, a pattern similarity score for DESH, PVS load, and white matter hyperintensity (WMH) load can be automatically calculated from MRI. We ask whether distributions of PVS and WMH load differ between older adults with vs without a DESH-like CSF space pattern.
Methods: MCSA participants with T1-weighted, T2-weighted and FLAIR imaging were selected. The CDESH score is based on observed regional CSF volumes measured on the T1-weighted image. The T1-weighted, T2-weighted and FLAIR images were fused to allow automated detection of enlarged perivascular spaces as well as probabilistic tissue segmentation including gray matter, white matter, deep gray matter, WMH and CSF compartments. The ratios of observed enlarged PVS and WMH volumes relative to the volume of tissue at risk in the centrum semi-ovale and corona radiata were calculated. CDESH + and CDESH- subgroups were determined based on previously defined CDESH thresholds. A two-sample Kolmogorov–Smirnov test was used to assess the dissimilarity of the PVS and WMH ratio distributions between groups (DESH features present vs absent).
Results: The study included a total of 1171 participants age > 60 years, 568(48%) female. 5.0% of participants were in the CDESH + group, 87% were in the CDESH- group with the balance excluded as indeterminant. WMH loads were different between groups (K.S. test $p < 0.001$) with the CDESH + group shifted toward higher load. PVS load distributions were not significantly different between groups (K.S. test $p = 0.12$).
Conclusions: We found CDESH + study participants aged 60 + years in the MCSA have different WMH load distributions than CDESH- participants. PVS load distributions were not different, implying that DESH and PVS are not obviously related.

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Predictors of shunt revision in idiopathic normal pressure hydrocephalus

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:128

Introduction: While ventriculoperitoneal shunt (VPS) placement is increasingly considered the definitive standard of care for idiopathic normal pressure hydrocephalus (iNPH), many patients may require revision. This study aimed to identify independent predictors of shunt revision following VPS for iNPH.
Methods: All patient treated with shunting for iNPH at a tertiary care center between January 2000 and January 2023 were retrospectively reviewed, and independent predictors of shunt revision were identified utilizing multivariable logistic regression.
Results: Of 574 total patients, 88 (15.3%) underwent shunt revision. Comparisons between revised and non-revised patients disclosed associations of revision with age (73.2 ± 6.4 vs 75.0 ± 6.2 years; $p = 0.02$), prior shunt placement (2.3% vs 0.0%; $p = 0.02$), shunt type (ventriculoperitoneal: 94.3% vs 98.8%; ventriculoatrial: 5.7% vs 1.2%; $p = 0.02$), valve type (fixed: 63.6% vs 37.2%; programmable: 36.4% vs 62.8%; $p < 0.01$), distal catheter placement technique (open surgery 71.1% vs 50.8%, laparoscopy 28.9% vs 49.2%; $p < 0.01$), and proximal catheter placement approach (frontal 61.4% vs 41.8%, occipital approach 38.6% vs 58.2%, $p < 0.01$). Multivariable logistic regression showed that shunt revision was associated with younger age (OR = 1.04; $p = 0.02$), ventriculopleural/ventriculoatrial placement (OR = 4.48 [vs VPS]; $p = 0.02$), fixed setting valve (OR = 2.85 [versus adjustable]; $p < 0.01$), open approach for distal catheter placement (OR = 2.33 [versus laparoscopic]; $p < 001$), frontal proximal catheter (OR = 2.16 [versus parietal]; $p < 0.01$), and detection of overdrainage on radiographic follow-up (OR = 4.56; $p < 0.01$). Similar results were noted when analyzing predictors of revision when excluding patients undergoing revision for infection (10 patients).
Conclusion: Shunt revision amongst iNPH patients is associated with factors relating to surgical technique. Shunt revision rates appear lower amongst patients with VPS using an occipital proximal catheter with an adjustable valve and laparoscopic distal catheter placement.

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3T MRI characteristics and gait assessment scales in iNPH patients: insights into pathophysiolo

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:129

Introduction: Multiple theories exist regarding the underlying brain structures involved in the development of symptoms in idiopathic Normal Pressure Hydrocephalus (iNPH), but few studies have examined correlations between morphological neuroimaging variables and severity of symptoms at the time of diagnosis. This study aims to analyze the preoperative neuroimaging parameters and gait impairment in iNPH patients enrolled in the Pro-Hydro study.
Methods: The study included 113 patients classified as iNPH and included in Pro-Hydro study on the basis of clinical and radiological features from September 2015 to December 2023. All of them underwent both 3 T brain MRI and instrumental gait analysis prior to shunt surgery. Neuroradiological investigations, in addition to morphological parameters and aqueductal flow assessment, also included calculation of midbrain and aqueductal areas.
Results: The anterior callosal angle (ACA) was significantly correlated with Tinetti Balance (TB) scores ($p = 0.036$). Patients with an ACA $\leq 100°$ had significantly longer Timed Up and Go (TUG) times compared to those with an ACA $> 100°$ ($p = 0.013$). The aqueductal area was significantly correlated with Timed Get Up and Go (TG) ($p = 0.022$), and showed a trend towards significance with TB ($p = 0.051$) and aqueductal CSF flow ($p = 0.075$). The aqueductal area also demonstrated a significant inverse correlation with the mesencephalic tegmentum area ($p = 0.023$).
Conclusions: Correlations between ACA and motor symptom severity support the involvement of frontal lobes in iNPH. Midbrain morphological abnormalities do not correlate with the severity of motor deficits and should not be used as an exclusion criterion in the diagnostic algorithm. The associations between aqueductal area, motor deficits, and aqueductal flow underscore the central role of CSF dynamics disorders in this condition.

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Intracranial volume change studied by PC-MRI in hydrocephalus patients and healthy volunteers

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Introduction: The Monro-Kellie doctrine states that the total intracranial volume, comprising the brain parenchyma, CSF, and blood, remains constant over time. However, this principle does not fully apply during the small scale of time and volume of one Cardiac Cycle (CC). Indeed, it has been demonstrated that CSF oscillations through the spinal canal do not completely balance intracranial blood volume changes, resulting in the origin of ICP pulses. We aim to compare the Intra Cranial Volume Change (ICVC) dynamics between Healthy Elderly Volunteers (HEV) and hydrocephalus patients.
Methods: The study included twenty patients (74 ± 6 years) with Hakim's hydrocephalus, who showed improvement post-shunting, and twenty HEV (72 ± 7 years). All participants underwent phase-contrast MRI to quantify CSF flow at the spinal C2-C3 level and cerebral arterial and venous flows intracranially, before the Willis polygon and through the sagittal and straight sinuses. Arterio-venous flow curve, obtained by subtracting venous outflows from arterial inflows, was combined with the spinal CSF flow curve to calculate the ICVC volume during CC. Hydrocephalus patients also underwent an infusion test to measure the amplitude of resting ICP pulses.
Results: ICVC amplitude was significantly lower ($p = 0.001$) in hydrocephalus patients (0.42 ± 0.20 ml/CC) compared to HEV (0.63 ± 0.19 ml/CC). However, ICP pulse amplitude in patients (3.2 ± 1.7 mmHg) appear higher than reference values in HEV (2.0 ± 1.3 mmHg. *Jacobson* et al. *J neurosurg 2019*).
Conclusions: Contrary to the Monro-Kellie doctrine, ICVC is not constant during CC, CSF oscillations do not completely balance vascular flows and show a small intracranial volume change (less than 1 ml). Given that intracranial compliance during CC is defined as the change in ICVC divided by the change in ICP Amplitude. Considering that in HCA, ICP amplitudes increase and ICVC decrease in comparison with healthy we conclude that hydrocephalus patients present lower intracranial compliance than healthy population.

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A thermodynamic model of obstructive hydrocephalus

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Introduction: The traditional view that obstructive hydrocephalus is caused by malabsorption of CSF fails to account for several important aspects of the disorder, such as the failure of the subarachnoid spaces to dilate prior to the ventricles, reversal (rather than widening) of the CSF-venous pressure gradient, and studies that demonstrate that ventricular dilation is dependent on increased ventricular CSF pulsatility. Flow MRI imaging shows that hydrocephalus is associated with marked redistribution of CSF pulsatility.
We propose that intracranial dynamics are best understood from the perspective of energy flow through blood and CSF. We present a new model of intracranial thermodynamics based on the view that pulsatile abnormalities cause obstructive hydrocephalus.
Methods: We use a simple electrical circuit model of the cerebral windkessel. The effectiveness of the windkessel is:

$$W = \frac{LK}{R}$$

W is windkessel effectiveness, L is inertance which is the size of the pulse, K is the elastance of the CSF space, and R is the resistance to the pulse. We model obstructive hydrocephalus by increasing the resistance to pulsatility in the CSF path.
Results: Simulation of obstructive hydrocephalus shows windkessel impairment and redistribution of CSF pulsatility. Modeling of ventricular dilation shows improved windkessel function, and modeling of shunting shows windkessel restoration.
Conclusions: We propose that obstructive hydrocephalus is caused by windkessel impairment due to high resistance to pulsatile CSF flow, with redistribution of pulsations to the ventricular CSF and high amplitude pulsatile stress on the capillaries. Ventricular dilation lowers CSF path resistance and is an active adaptation to windkessel dysfunction. CSF malabsorption plays no role in our model. Shunting drains pulsatile energy, ameliorates windkessel dysfunction, and reverses adaptive ventricular dilation. We propose that obstructive hydrocephalus is a disorder of intracranial thermodynamics due to high impedance to CSF pulsations in the CSF pathways.

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Unveiling the Transition: Exploring Mechanisms in the Evolution from External to Internal Hydrocephalus in Children—Insights from 21 Cases

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:132

Introduction: This retrospective study aims to delve into the pathogenesis and outcomes of 21 pediatric patients grappling with evolving hydrocephalus.
Methods: Clinical data from 21 children with evolving hydrocephalus, admitted to our center between 2013 and 2024, were meticulously gathered. A thorough examination of pathogenetic patterns ensued, alongside a meticulous synthesis of corresponding imaging features.
Results: The cohort, averaging 8 months of age (ranging from 2 to 35 months), comprised 14 male and 7 female cases. Among the etiologies, craniocerebral trauma accounted for 10 cases, followed by 6 cases of meningitis, 4 cases of tumors, and 1 case of cerebrovascular malformation. External hydrocephalus, stemming from primary pathologies, metamorphosed into internal hydrocephalus with ventricular dilatation after 2–4 weeks of treatment. All children underwent drilling and drainage, culminating in ventriculoperitoneal shunting, with 8 cases necessitating craniotomy (Fig. 1). Throughout the hydrocephalus progression, magnetic resonance cerebrospinal fluid cinematography unveiled intriguing dynamics. The mean peak velocity of midbrain aqueduct descent during systole averaged 8.40 cm/s, while ascent during diastole averaged 8.01 cm/s. Flow rates depicted downward averages of 0.11 ml/s and upward averages of 0.17 ml/s (Fig. 2).
Conclusions: External-type hydrocephalus emerges as a common manifestation post craniocerebral trauma and infections in children, with select patients transitioning into communicating hydrocephalus, mandating ventriculoperitoneal shunts. This transition appears intricately linked to shifts in cerebrospinal fluid directionality and volume within the ventricular system, underscoring the multifaceted nature of hydrocephalus progression.

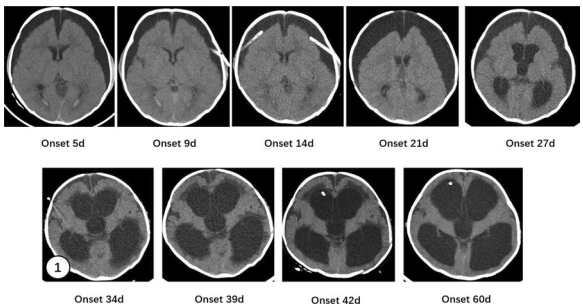

Fig. 1. metamorphosed into internal hydrocephalus with ventricular dilatation after 2–4 weeks of treatment.

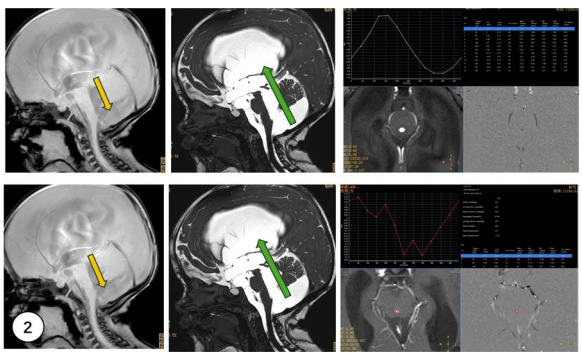

Fig. 2. The mean peak velocity of midbrain aqueduct descent during systole averaged 8.40 cm/s, while ascent during diastole averaged 8.01 cm/s. Flow rates depicted downward averages of 0.11 ml/s and upward averages of 0.17 ml/s.

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Different dynamic craniospinal CSF and spinal cord patterns in spontaneous intracranial hypotension (SIH), and idiopathic intracranial hypertension (IIH) resolved by phase-contrast MRI

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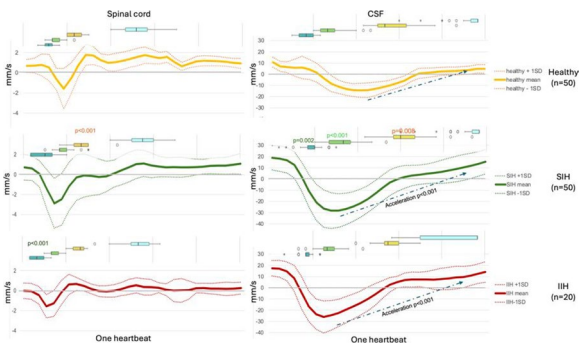
Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:133

Introduction: Phase-contrast MRI of CSF and spinal cord dynamics has been previously introduced as a possible technique to non-invasively collect biomarkers in patients with spontaneous intracranial hypotension (SIH) and idiopathic intracranial hypertension (IIH): increased velocity ranges (mm/s) and increased total displacements (mm) (≈area under the curve) in SIH, and reduced values in IIH have been demonstrated. While this easy to assess readout provides first insights, refined analysis of the temporal dispersion might add to the interpretation and understanding of the diseases.
Methods: Data of a prospective study in healthy volunteers (n = 50), SIH (n = 20), and IIH (n = 20)) was pooled with retrospectively gathered routine data in SIH (n = 30). Prospectively ECG-triggered phase-contrast MRI of craniocaudal CSF, and spinal cord velocity curves at segment C2/C3 over one heartbeat were analyzed. Time resolution was between 30-40 ms. The timepoints of turns and peaks relative to one standardized heartbeat, and acceleration data were compared.
Results: The initiation of the downward CSF-flow was delayed in SIH patients (after 0.33 ± 0.07 vs. 0.27 ± 0.07 per heartbeat, $p = 0.002$, Fig. 1), and the entire downward motion prolonged. Upward CSF acceleration was higher in SIH and IIH (4.9 ± 1.8 cm/s^2 and 6.0 ± 2.7 cm/s^2 vs. 3.2 ± 10 cm/s^2, $p < 0.001$, respectively). Initiation of the spinal cord downward motion was much earlier in IIH (0.07 ± 0.04 vs. 0.12 ± 0.03, $p < 0.001$). Duration of downwards spinal cord motion was prolonged in SIH (0.3 ± 0.1 vs. 0.2 ± 0.07, $p < 0.001$). The relations CSF downward acceleration to spinal cord downward acceleration was much higher in IIH compared to controls and compared to SIH (11 ± 9 vs. 2 ± 2, vs. 3 ± 2 $p < 0.001$, $p < 0.001$ respectively).
Conclusions: Different temporal dispersion of craniospinal spinal cord and CSF velocity patterns between SIH and IIH can be depicted by high-resolution phase-contrast MRI.



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Normal pressure hydrocephalus: a syndrome, not a disease

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:134

Introduction: The diagnosis of normal pressure hydrocephalus (NPH) relies on recognition of key symptoms/signs, ventriculomegaly, and shunt response. However, recent advances in biomarkers and genetics (i.e., discovery of *CWH3* variants in a high proportion of patients with symptomatic congenital hydrocephalus) suggest that NPH is better conceptualized as a syndrome, not a disease. This study aimed to further explore potential syndrome contributors by characterizing clinical, biomarker, and imaging heterogeneity in patients with NPH.
Methods: Clinical data, neuroimaging, CSF biomarkers, and response following high-volume lumbar puncture were considered in 38 consecutive patients diagnosed with NPH at Mayo Clinic in Florida. Brain MRIs were independently reviewed by two neurologists for presence/absence of disproportionately enlarged subarachnoid spaces (DESH) and white matter lesions (Fazekas score).
Results: Patients median age was 73.6 years (range: 47.9–81.3) with near-equal distribution of males and females (47%). Head circumference was measured in 33 patients (median 57.0 cm, range 52.5–62.5). Eleven patients (33%) had a head circumference > 98th percentile, suggesting a congenital contribution. DESH (71%) and moderate-to-severe white matter disease (Fazekas score 2–3; 53%) were present in most patients. Median score on the Short-Test of Mental Status was 31/38 (range 22–36); scores were lower in the 7 (18%) patients with CSF biomarkers suggestive of Alzheimer disease neuropathologic change (pTau181/Aβ42 > 0.022; 26.5 [22–32] vs 31.0 [22–36], p = 0.052). Gait improved transiently in 22 patients (58%) following a high-volume lumbar puncture. 23/27 patients (85%) had a favorable response following ventriculoperitoneal shunting, including 20 patients (53%) with positive response to high-volume lumbar puncture (κ = 0.335, p = 0.08).
Conclusions: Clinical, neuroimaging, and biomarker data suggest a myriad of potential contributors to NPH, including congenital/genetic factors, impaired CSF absorption, and concurrent cerebrovascular and Alzheimer disease. The complex pathogenesis of NPH is better represented as a syndrome.

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The importance of statistical power in neurosurgery: analyzing the statistical power of 21 hydrocephalus randomized clinical trials in a post-hoc fashion

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Introduction: Neyman and Pearson were notable statisticians who helped to build the foundation of evidence-based medicine around power. Unfortunately, several randomized clinical trials (RCTs) neglect those concepts. Therefore, a systematic review was conducted to unveil the power scenario in hydrocephalus RCTs.
Methods: The authors searched PubMed for every RCT published addressing hydrocephalus. To be included, the study had to be randomized, comparing two interventions in separate groups of patients with hydrocephalus. Studies with more than two groups, without interventions, including patients without hydrocephalus, and studies without primary outcomes and sample size calculations were excluded. After selection, outcomes from the articles were extracted considering the primary outcomes of the study. The post-hoc power calculation encompassed dichotomous or continuous variables between both groups. The probability of error type I (alpha) was defined as 0.05. A satisfactory power was considered to be 80%.
Results: Out of 861 results, 21 RCTs fit the inclusion criteria. From those, 11 had clear primary outcomes but no sample size calculation, 9 had clear primary outcomes and sample size calculation and 1 study had no clear primary outcome but had the sample size estimated. The origin of the RCTs included Asia (5), Europe (7), North America (4), South America (2), and Multicenter (3). The mean power was 31.1%, with a standard deviation of 32.62, ranging from 2.8%-100%. The median power was 14.8%, and only four studies had outcomes with power ≥ 80%. Endoscopic ventriculostomy vs. shunt, lumboperitoneal shunt, and valve research highlighted satisfactory power.
Conclusions: The existing body of hydrocephalus literature is unsatisfactory in terms of power and sample sizes of individual studies, despite the limitations of post-hoc analyses. Future research should calculate sample sizes before initiation. The lack of power in the context of individual studies highlights the value of meta-analyses.

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CSF proteomics in spontaneous intracranial hypotension

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:136

Introduction: Spinal CSF leaks affect CSF dynamics, but sparse knowledge about metabolic change exists. Currently, one of the main diagnostic modalities for confirming a CSF leak is myelography, while effective, involves radiation exposure and sometimes fails to confirm the diagnosis. There is a need for CSF markers of SIH in order to improve the understanding, diagnosis and management of patients with CSF spinal leaks.
Methods: This cohort study was conducted in a large SIH referral center and involved CSF samples from patients with a confirmed spinal CSF leak and a control group. Samples underwent label-free proteome analysis, High-Performance Liquid Chromatography (HPLC) on a MARS column, and processing using the Single-Pot Solid-Phase-enhanced Sample Preparation (SP3) bead protocol, measured on a Q Exactive mass spectrometer. Statistical analysis was performed with the Limma software, focusing on pairwise comparisons to identify differentially expressed proteins.
Results: The study included 18 participants (9 SIH and 9 controls). A total of 919 proteins were identified and quantified.
Applying stringent criteria—adjusted p-value < 0.05 and a log2 fold change ≥ 0.58 or ≤ -0.58—51 proteins showed significant alteration in SIH patients. Using moderated p-values with the same log2 fold change criteria, 164 proteins were identified as altered. These findings are conclusive of a significant alteration in the proteomic landscape of SIH subjects suggested by either statistical approach showing that SIH might be linked to a whole change in the proteome spectrum in CSF and revealing metabolic disturbance.
Conclusion: Our study provides the first promising results that point to a discernible proteomic profile unique to SIH patients. Not only do these findings offer novel insights into the biochemical underpinnings of SIH, but they may set the ground for biomarker and radiation-free diagnostic modality.

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Comparison of decline in different cognitive domain in patients with normal pressure hydrocephalus

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Introduction: We sought to describe the cognitive profile of patients with Idiopathic Normal Pressure Hydrocephalus (iNPH) using a comprehensive neuropsychological battery. Based on age and education correlated norms, we aimed to compare performance in each measured cognitive domain: executive functions (EFs), verbal memory (VM), non-verbal memory (nVM), visuoconstructional abilities (VA) and attention/psychomotor speed (A/PS).
Methods: Patients diagnosed with iNPH underwent comprehensive neuropsychological evaluation before shunting. Their performance was compared to the age and education correlated norms. Correlation of different cognitive domains in iNPH profile was performed.
Results: A total of 53 iNPH patients (73.21 ± 5.48 years) were included in the study. All of the measured cognitive domains were significantly damaged. The most affected domains were EFs and VM ($p < 0.001$ and $p < 0.001$, respectively). A/PS domain was affected milder than EFs and VM ($p < 0.001$). The least affected domains were nVM ($p < 0.001$) and VA ($p < 0.001$).
Conclusions: Patients with iNPH are affected in all cognitive domains and the cognitive decline is uneven across these domains. The impairment of memory was shown to depend on the presented material. VM was shown to be much more severely affected than nVM and along with VM, EFs were shown to be the most affected. A/PS speed was shown to be less affected than VM and EFs and the least affected domains were nVM and VA.

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Two families presenting normal pressure hydrocephalus had the variant of *KIF18B*. Case reports and a review of Kinesin association with hydrocephalus

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Introduction: Nine pedigrees of iNPH, including the family reported by our group, have been reported to date. These phenotypes were the same as iNPH, and the responsible genes were not found.
Methods: Areas B and C were 40 km apart, and there was no evidence of pedigrees between family B in area B and family C in area C, which is located in the northern part of Japan. These families were also not pedigrees of family A and habituated in different areas we reported in 2011 (Takahashi Y et al. J Neurol Sci 308(1–2):149–151). Family B had five patients with hydrocephalus in two generations, and they presented the triad (gait disturbance, cognitive impairment, and urinary incontinence) in their 50 s-60 s. Family C had three patients of siblings with hydrocephalus who showed the triad in their 50 s-80 s. Whole-blood samples were obtained from two patients in family B and a patient and an unaffected individual in family C. Genomic DNA was extracted and purified by MagMax CORE Nucleic Acids Purification kit (ThermoFisher). DNA was confirmed by using the Agilent 4150 Tapestation system and performed next-generation sequencing (ThermoFisher, cat. 4,477,685). Based on Pubmed and Gene Ontology, known associated genes of hydrocephalus, ciliopathy, and kinesinopathy were examined, with pathogenic deleterious variants filtering functional annotation scores of LoF, CADD and Mutation Taster.
Results: The *KIF18B*: p.V85L variant was found in all three patients in families B and C. It causes a missense variant and is seen in 0.004% frequency among ToMMo 54KJPN (Japanese), which had no information in ClinVar (pathological database). Kinesin superfamily (KIF) codes proteins involved in intracellular trafficking, and some variants were reported in patients with hydrocephalus.
Conclusions: There are pedigrees of NPH whose phenotype mimics iNPH which we should consider pathogenesis. *KIF18B* is supported to be a candidate of that.

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Radiological markers in PsP vs NPH. Systematic review and meta-analysis

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Introduction: Normal Pressure Hydrocephalus (NPH) and Progressive Supranuclear Palsy (PsP) are neurological disorders which share clinical and radiological features, with reported frequent overlap, making the differential diagnosis deeply challenging. The aim of the present study was to comparatively investigate differences in neuroimaging between NPH and PsP with the purpose of identifying markers distinguishing these disorders.
Methods: A systematic literature search was performed using the following databases: PubMed and Scopus/Embase/Ovid to identify studies that compared radiological markers between NPH and PsP. Mean values, standard deviations and sample size were collected for Evans Index (EI), Callosal Angle (CA), Disproportionately Enlarged Subarachnoid Space Hydrocephalus (DESH) score, Magnetic Resonance Parkinsonism Index (MRPI), MRPI 2.0, Ventricular Volumetry (VV), Magnetic Resonance Hydrocephalic Index (MRHI), Focally Enlarged Sulci (FES). Number of events, true positive (TP), true negative (TN), false positive (FP) and false negative (FN) were collected for DESH pattern and Hummingbird sign. The meta-analysis was performed using the mean difference for continuous variables and risk ratio for dichotomous variables. A random effects model was fitted to the data.
Results: We identified 1888 studies, of which 15 met the inclusion and/or exclusion criteria, with a total of 352 NPH and 501 PsP patients respectively. The meta-analysis showed significant larger values of EI for NPH ($p < 0.00001$), CA for PsP ($p < 0.00001$), DESH score for NPH ($p = 0.006$), MRPI for PsP ($p = 0.03$) and MRHI for NPH ($p < 0.00001$). No statistical differences were detected for MRPI 2.0 ($p = 0.1$), VV ($p = 0.92$) and or FES ($p = 0.89$). Presence of DESH pattern was associated with NPH diagnosis, RR 14.96 95% CI (6.16–36.33) ($p < 0.00001$), Hummingbird sign was not associated with PsP, RR 1.15 95%CI (0.96–1.39) ($p = 0.13$).
Conclusions: The results of our systematic review show that compared to PsP patients those with NPH have significantly higher values of EI, DESH score and MRHI and significant lower values of CA and MRPI. In addition, presence of DESH pattern is associated with NPH. However, our findings were constrained by the diverse study designs and substantial clinical and methodological variability across studies including the application of clinical diagnostic criteria for NPH and PsP and different measurement and acquisition methods for certain MRI markers.

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Training the local teams: a review of a new service training local physicians to assess, measure shunt pressure and adjust shunts in remote areas

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Introduction: Neurosurgery is treated as a tertiary service in most areas / countries. This results in more remote / isolated hospitals having to send patients quite some distance for neurosurgical care including subsequent follow-up. One centre, requiring flight or ferry transport, with a referral agreement with the authors institution, agreed to set up a remote service. This involved local specialist neurology staff trained in how to adjust shunts and read intracranial pressures via implanted Miethke M.Scio telemetric intracranial pressure (ICP) sensors.
Methods: We performed a retrospective review of all patients in our service who had experienced this pathway over the first 12 months of its existence. Patients were assessed against our standard expectant number of reviews following shunt surgery and the subsequent number of visits to this hospital prevented.
Results: Nine patients have been involved in this joint approach since the program commenced 12 months ago. 3 NPH, 2 ventriculomegaly, 2 congenital, 1 IIH, 1 suspected raised pressure. Six patients are currently jointly managed with a ventriculoperitoneal shunt. Three are currently not under active treatment/investigations. The six actively managed patients have undergone multiple pressure valve measurements and valve adjustments at their local unit. All were discussed between the two centres prior to any intervention by the local team. A total of 14 trips to the author's hospital for out-patient management have been prevented, having been reviewed/treated locally.
Conclusions: Advances in technologies have made both remote monitoring and communication more effective. Training longstanding members of staff to measure ICP and adjust shunts, allows for neurosurgical patients to be assessed locally, have a plan put in place with specialist hydrocephalus teams, and be treated locally without the need for long, expensive and unnecessary transport to a hydrocephalus centre. This can benefit patients, local centres and open additional space in neurosurgical centres.

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Advice to our colleagues: family practitioners and geriatricians

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Dementia is a major public health problem expected to increase due to the aging of the world population. Alzheimer disease (AD) is the most common form of dementia; less common causes include cerebrovascular disease, frontotemporal degeneration, Lewy body disease, and Parkinsonism. Depression, untreated sleep apnea, thyroid problems, vitamin deficiencies, and alcohol consumption cause dementia-like symptoms, often reversible with treatment. Another often unrecognized and reversible cause of dementia is Idiopathic normal pressure hydrocephalus (iNPH).
The diagnosis of dementia is for the multiplicity of etiologies listed earlier and also because mixed dementia seems to be the norm, not the exception. Recognizing iNPH is extremely important because dementia and the other symptoms of iNPH will be reversed by surgical intervention in > 75%.
In a study conducted in Umea, Sweden, iNPH prevalence for those > 65 years was 3.7%, about 1 in 27people. Prevalence of iNPH was 4 times higher among those aged > 80 years (8.9%) than aged 65–79 (2.1%) (P < 0.001).
More than 56 million adults ages > 65 live in the United States, according to the.
U.S. Census Bureau. Based on the Umea study iNPH cases in the US should approximate 2,072,000 (~ 3.7% of the 56 million population older than 65,).
Primary care physicians and geriatricians can improve the detection of iNPH in patients with dementia-like symptoms by:

1. Having a high index of suspicion for comorbid gait/balance problems (almost always present in iNPH)

Requesting the callosal angle (defined as the angle between medial superior borders of the left and right ventricle on the coronal images through the posterior commissure, perpendicular to the anterior–posterior commissure) from the radiologist on the initial brain image provides the best tool to discriminate iNPH from its mimics. If ≤ 71 degrees, referral to neurosurgery is appropriate for further confirmatory diagnostic workup and treatment.

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Distinguishing pathological gait by artificial intelligence and fluctuation analysis: research with motion capture application TDPT-GT considering Hakim's disease (iNPH)

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Introduction: It has been challenging for us to describe how pathological the gait of patients and to differentiate it from normal, especially when it is mild. We have tried to develop semi-automatic assistance with the iPhone application.
Methods: TDPT-GT captured the subjects walking in a circular path of about 1 m in diameter with an iPhone camera, generated the three-axis 30 frames per second coordinates of 27 body points from head, arms, to toes. I. Distinguishing pathological gait by artificial Intelligence (AI): subjects were pathological gait group (n = 114) of patients with idiopathic normal pressure hydrocephalus (iNPH) (n = 48), Parkinson's disease (PD) (n = 21), and other neuromuscular diseases (n = 45), and the control (n = 160). A light gradient boosting machine with stratified k-fold cross-validation (k = 5) was applied for the gait collection. The median ability model tested 200 frames of each person's data for its distinction capability. II. Fluctuation of body parts during walking: subjects were iNPH (n = 23), PD (n = 23), and controls (n = 92). For 128 frames of body points, after the Fourier transforms, the slopes (indices for fluctuation) in the graph of the log power spectral density against the log frequency. Differences in the average slopes were tested by one-way ANOVA and multiple comparisons between every two groups.
Results: I. The ability of differentiation of pathological against normal was the area under a curve of 0.719. II. The impaired fluctuations of body movement in the upper and lower body may contribute to gait and balance disorders in patients.
Conclusions: The pathological gait captured by the iPhone could be distinguished by AI. The fluctuation of body parts would be a convenient index for subtle gait disorder. These would be reflected in advanced applications on the smart device.

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LP shunt in patients with iNPH: surgical technique

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Introduction: The SINPHONI-2 study (Japanese prospective multicenter cohort studies) was carried out and showed the safety and efficacy of LP shunt surgery for iNPH. Although our high level of success with surgery may be considered to be a minor point, it is worth reporting, as minor differences in technique and know-how can markedly affect the efficacy of shunt surgery. We show a video of our LP shunt procedure.
Methods: A total of 927 probable iNPH patients underwent LP shunt surgery at our NPH center between April 2009 and April 2024 (mean age of 77.8 ± 6.8 years). Aspects of our surgical technique include: 1) General anesthesia, 2) Use of the original drape, 3) Upward insertion of the spinal tube through L2/3 via a paramedian puncture for highly deformed lumbar spine patients, using the intraoperative C-arm imaging. 4) Placement of a Codman-Hakim programmable valve with Siphonguard™ in the back, 5) Inclination of the table at 30°angle. 6) Laparotomy via rectal muscle splitting, and 7) Running the peritoneal tube obliquely from the upper lateral to lower medial (to eliminate the space permitting tube expulsion).
Results: Of the 762 patients followed up at the NPH Center for 1 year after LP shunt surgery. During the first year after surgery, 68 of 693 patients(9.8%) developed postoperative complications including tube occlusion in 24(3.5%), chronic subdural hematoma requiring evacuation in 18(2.6%), migration of the spinal or abdominal tube in 12(1.7%), lower limb numbness in 7, rupture of the spinal tube in 5, and shunt infection in 2.
Conclusions: Our LP shunt procedure generally seems to be acceptable from the viewpoint of complications. The low-invasive LP shunt that does not require ventricular puncture is preferred and has become the first-line procedure for iNPH in Japan. We would like to popularize the use of this surgical procedure worldwide.

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Is Less more? Management of late clinical deterioration in shunted NPH-patients

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Objective: Late deterioration of shunted NPH patients is reported in up to 50%. There is no consent if a simple down-regulation should suffice, or a comprehensive diagnostic assessment for potential shunt obstruction may be necessary. This study aims to evaluate the merits and drawbacks of these various approaches.
Methods: We surveyed six hydrocephalus experts globally regarding their management approach for a representative case of a shunted normal pressure hydrocephalus patient experiencing late clinical deterioration. We compared their diagnostic work-ups in terms of costs, time required for different procedures, as well as benefits and risks.
Results: Two experts opted for reducing the valve's opening pressure upon receiving information about late deterioration, while one of them suggested an additional "pumping tap" test. The remaining four recommended initiating the diagnostic process with a CT scan, with 3 of them advocating for X-ray shunt series, and 4 would do CSF puncture of the reservoir, spinal tap or shunt flow study before deciding on further treatment.
Discussion: Valve down-regulation can be accomplished in less than 5 min during the medical consultation with no additional costs. Although there is a risk of exacerbating overdrainage, the procedure carries no risk of infection. Conversely, CT scans, X-ray series, and invasive tests are time-consuming and costly, with a potential risk of infection. However, they might offer the safest means of diagnosing inadequate shunt drainage. Non-invasive procedures are often more acceptable to patients, doctors, caregivers, and health insurance providers. Invasive procedures require lead time and may impede timely diagnosis and subsequent treatment substantially. Less may indeed be more. Future research should validate that the minimalistic approach does not introduce unforeseen risks.

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Reversible cognitive dysfunction in spontaneous intracranial hypotension (SIH) – a spinal dementia

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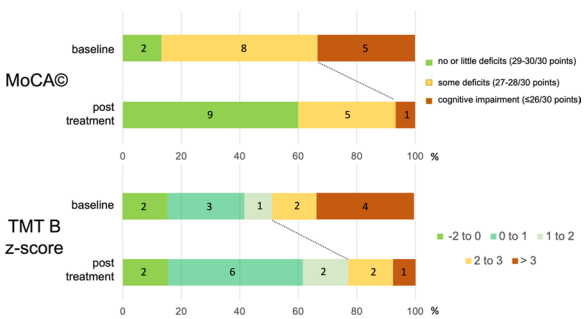
Introduction: Behavioral variant frontotemporal dementia (bvFTD) has been recognized as a rare clinical feature in severe brain sagging and herniation in patients with spontaneous intracranial hypotension (SIH). But also SIH patients without such severe herniations frequently report self-received cognitive decline, often non-specifically described as "brain fog". We aim to delineate and quantify cognitive function in SIH and its response to treatment.
Methods: Retrospective analysis of a consecutive cohort of SIH patients without tonsillar herniation that were treated at our CSF center between May to July 2023. Standard tests for cognitive dysfunction involved the Montreal Cognitive Assessment (MoCA©), and the trail-making-test part B (TMT B). Tests were administered at admission and within 72 h post targeted therapy for closure of the spinal CSF leak. Therapies were performed under general anesthesia.
Results: 18 patients were tested at baseline (seven with ventral leak, three with lateral leak, eight with CSF-venous fistula). Mean age was 53.6 ± 11 years. The mean MoCA© score at baseline was 26.5 ± 2 /30 points, with five patients (28%) scoring below 26 points that is indicative for at least mild cognitive impairment. Performance in TMT B was impaired in 9 patients (50%, z-score > 1.9). Upon treatment of the CSF leaks, MoCA© scores immediately improved from 26.5 ± 2 to 28.5 ± 1, $p = 0.001$ ($n = 14$), and performance on the TMT B was significantly faster (2.1 ± 2 vs. 1.1 ± 1, $p = 0.015$, $n = 13$).
Conclusions: Cognitive impairment can be observed in a regular SIH cohort. Closure of the spinal CSF leak leads to immediate improvement of cognitive dysfunction. We conclude that a causal relationship exists between cognitive dysfunction and spinal CSF leaks, potentially indicating a distinct, and most importantly, reversible form of spinal dementia.



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Post-hemorrhagic hydrocephalus (PHH) in newborns: assessing stem cells role in intraventricular hemorrhage (IVH) as a way of outlining strategies to minimize morbidity in preterm patients

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Introduction: Preterm infants often face severe complications such as intraventricular hemorrhage (IVH) leading to post-hemorrhagic hydrocephalus (PHH). With advancements in healthcare, survival rates have increased, but there's a lack of algorithms to prevent PHH after IVH.
Methods: Following PRISMA guidelines, a systematic search on PubMed for stem-cell-based treatments for PHH following IVV yielded five relevant articles. These included two on stem cell treatments: one supporting the use of mesenchymal stem cells (MSC) and the other of unrestricted somatic stem cells (USSC), one on neuroimaging in these cases, and one on in vitro studies.
Results: The lateral ventricular perimeter (LVP), crucial for brain development, is often injured in PHH. Diffusion MRI with a semi-automated segmentation algorithm is valuable for studying this area. Other studies focused on microstructural effects using dMRI and new image-processing techniques, offering insights into IVH/PHH effects and potential therapeutic interventions. Additionally, studies on stem cell infusions showed promising outcomes for IVH/PHH.
Conclusions: A stem cell-focused approach holds promise for improving outcomes in IVH/PHH patients, highlighting the need for innovative treatments to enhance prognosis in this population.

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Cerebral blood and CSF volume change dynamics studied by PC-MRI in hydrocephalus

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Introduction: Following the Monro-Kellie doctrine, during the cardiac cycle, Cerebral Blood Volume Changes (**CB-VC**) should mirror CSF Volume Changes (**CSF-VC**) through the spinal canal. Most studies calculate CB-VC using vascular flows measured at the cervical level. However, considering the variability in extracranial cerebral veins anatomy and compliance, we hypothesize that, as in healthy populations, intracranial and extracranial vascular levels interact differently with spinal CSF in Hydrocephalus patients.
Methods: Twenty patients (74 ± 6 years) with Hakim's hydrocephalus, who showed improvement after shunting, underwent phase-contrast MRI before surgery. We quantified CSF oscillations at C2-C3 level in the spinal canal during the cardiac cycle and calculated CSF-VC dynamics. Cerebral arterial and venous flows during the cardiac cycle were also quantified at the C2-C3 and intracranial (before the Willis polygon and through the sinuses) levels. Then, two arterio-venous flow curves were calculated by subtracting venous outflows from arterial inflows to obtain intracranial and extracranial CB-VC dynamics. For each patient, linear regressions evaluated the relationship (R^2 and slope) between the CSF-VC and CB-VC curves dynamics during the cardiac cycle at both intracranial and extracranial levels.
Results: R^2 and linear regression slope values at the intracranial level (R^2:0.88 ± 0.13; slope: -0.61 ± 0.20) were significantly higher ($p < 0.001$) compared to the extracranial level (R^2:0.55 ± 0.34; slope: -0.39 ± 0.22).
Conclusions: CSF response to vascular volume variation within the craniospinal system is more consistent with the arterial and venous flow measurements acquired at the intracranial plane. The differences observed between both levels are mainly attributed to the venous compartment, as extracranially, the internal jugular veins show greater inter-subject variability in vessel morphology and flow pulsatility. Rapidly, because of the compliance of the internal jugular veins, blood volume can easily expand outside the cranium, modifying the cerebral blood volume curve dynamics. Consequently, intracranial pressure is more closely related to intracranial CB-VC than extracranial CB-VC measurements.

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The efficacy of ventriculosubgaleal shunt in managing neonatal hydrocephalus due to intraventricular hemorrhage: a systematic review and meta-analysis

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Introduction: In neonates, intraventricular hemorrhage (IVH) is a severe complication leading to posthemorrhagic ventriculomegaly and hydrocephalus. Temporary management is required due to contraindications for permanent shunt placement. The subgaleal space serves as a site for temporary drainage, particularly with the subgaleal ventricular shunt (VSGS). Therefore, we conducted a systematic review and meta-analysis to assess the efficacy and safety of using VSGS in the treatment of hydrocephalus caused by IVH in neonatal patients.
Methods: We searched Medline, Embase, Web of Science databases following PRISMA guidelines. Single proportion analysis with 95% confidence intervals under a random-effects model, I^2 to assess heterogeneity, and Baujat plot and sensitivity analysis to address high heterogeneity. Publication bias was assessed by funnel-plot analysis and Egger's test. Eligible studies included those with ≥ 4 patients, focused on neonates with hydrocephalus caused by IVH treated with VSGS and outcomes included infection, shunt revision, migration, obstruction, cerebrospinal fluid (CSF) leak, permanent shunt, mortality and related mortality.
Results: Nineteen studies involving 562 patients were selected. Among the 547 neonates analyzed, 64 had infections, resulting in a rate of 9%. Regarding the need for shunt revision, we observed that 12 out of 206 patients required it, yielding a rate of 4%. In neonates, obstruction was seen in 10 out of 178 cases, resulting in a complication rate of 2%. Migration of the shunt occurred in 1 out of 81 neonates, with a rate of 1%. Analyzing CSF leakage, we found 23 cases out of 260 neonates, with a rate of 6%. Permanent shunts were required in 290 out of 382 patients, resulting in a rate of 75%. The rate of procedure-related mortality was 1%, with 13 deaths among 349 neonates analyzed.
Conclusions: This systematic review and meta-analysis identified VSGS as a safe and effective option for treating hydrocephalus caused by IVH in neonates.

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Idiopathic normal pressure hydrocephalus: associations between CSF biomarkers, clinical symptoms, and postoperative outcome

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Introduction: The neurochemical alterations related to the typical symptomatology of idiopathic normal pressure hydrocephalus (iNPH) and their associations with outcome after shunt surgery are unsettled. We explored associations between concentrations of CSF biomarkers reflecting amyloid and tau pathology, neuronal degeneration, and astrocytic activation, and specific clinical symptoms and evaluated whether these biomarkers can predict the postoperative outcome.
Methods: We included 81 patients diagnosed with iNPH according to guidelines at Sahlgrenska University hospital. Symptoms were assessed using the iNPH-scale including subdomains of gait, balance, cognition and urinary function as well as by specific clinical tests measuring gait, balance and cognitive function before and 3–6 months after shunt surgery. Pre-operative lumbar CSF concentrations of Aβ38, Aβ40, Aβ42, sAPPα, sAPPβ, T-tau, P-tau, MCP-1, and NFL were analyzed. Correlation and regression analyses between biomarker concentrations and clinical symptoms at baseline as well as postoperative change in symptoms were performed.
Results: A higher NFL correlated with more pronounced impairment in all clinical tests ($r_p = 0.25–0.46$, $p < 0.05$). Higher T-tau and P-tau correlated with poorer performance in cognitive tests ($r_p = 0.26–0.39$, $p < 0.05$). No biomarker could differentiate between improved and unimproved patients. A higher preoperative P-tau was weakly correlated with less pronounced overall clinical improvement ($p = 0.021$, $r2 = 0.067$).
Conclusions: Axonal degeneration, as indicated by an elevation of NFL, is associated with worse symptomatology in iNPH, supporting the subcortical nature of disease, but is not predictive of treatment response. Tau pathology seems involved in cognitive decline, probably as a sign of comorbid Alzheimer's disease, but elevated tau markers should not be used to exclude patients from shunt surgery.

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Distal ventriculoperitoneal shunt catheter failure after primary shunt insertion, what can go wrong? A single-centre retrospective study on the causes of distal catheter malfunction

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Introduction: Ventriculoperitoneal shunt (VPS) placement is an effective method for treating hydrocephalus but remains imperfect. Failures often relate to the main components of the VPS, the proximal catheter, valve, or distal catheter. This retrospective study of 1755 cases assesses the frequency and nature of distal catheter malfunction following primary VPS insertion.
Methods: All patients who underwent VPS placement at our hospital over a 15-year period were identified. Patients with subsequent 'distal catheter maintenance' coded were sought and records, including imaging and operative notes, and operating surgeon were reviewed manually. Tied off distal catheters and infections were excluded from analysis. Causes of catheter failure were categorised into intraperitoneal blocked catheter, disconnection, fracture, subcutaneous catheter migration and pre-peritoneal misplacement.
Results: 1755 primary VPS insertions were performed, in adults and paediatrics. 31 cases (1.8%) of distal catheter failures were identified after exclusion of incorrectly coded data. We identified 12 intraperitoneal blockages (38.7%), 8 distal catheter migrations (25.8%), 4 pre-peritoneally placed catheters (12.9%), 1 catheter rupture (3.2%), 2 disconnections (6.5%), 2 catheters causing intra-abdominal irritation (6.5%) and 2 indeterminate-cause blocked catheters (6.5%). The mean time to revision for a blocked intraperitoneal shunt was 1227 days (IQR 2197), for pre-peritoneal placement 67 days (IQR 134) and for distal catheter migration 177 days (IQR 109.5). Pre-peritoneal catheter placement ($n = 4$) was more common in surgeons with low VPS volume. Intraperitoneal blockage rates were equally distributed by surgeon experience. Catheter migration appears related to tunnelling technique (deep to anterior rectus shealth: 0 in $n = 782$ vs subcutaneous: 8 in $n = 973$, $p = 0.01$).
Discussion: The rate of intraperitoneal catheter blockage is unrelated to operator technique or experience, but surgeon experience seems to relate to preperitoneal placement and tunnelling technique to the risk of catheter migration. The follow-up duration is relatively short, so we expect our data to underrepresent distal shunt fractures.

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Quantitative measurement of CSF and brain volumes in patients with spontaneous intracranial hypotension using a convolutional neural network

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Introduction: CSF hypovolemia is a suspected core feature of spontaneous intracranial hypotension. Quantifying intracranial CSF volumes could improve the follow-up of SIH patients. Neural networks and automated brain segmentation of structures using deep learning are challenging tasks that have gained a lot of interest. The purpose of this study was to compare CSF volumes across SIH stages and to test the clinical applicability of these measures using a neural network.
Methods: This cohort study was conducted in a large SIH referral center and involved brain MR imaging of patients treated surgically for a ventral spinal CSF leak. An automatic threshold-based segmentation method using a recomposed 3D U-Net (Neural Network U-net) was used for different overlapping brain areas. MPRAGE sequences with Gadolinium injection were used, and CSF volumes were analyzed pre-operatively and at the follow-up timing (3 months post-op). The brain volume was also assessed using the same methodology. Statistical analysis was performed using R software.
Results: 25 SIH patients treated surgically were included. The mean brain CSF volumes observed were 123.83 mL pre-operatively and 150.47 mL at the follow-up timing. A paired t-test found a statistically significant difference between the two measurements ($p \approx 0.0089$). The surgery has had a substantial effect on the intracranial CSF Volumes. This was also the case when using % of CSF/Brain Volume.
Conclusion: Our study has demonstrated promising results that point to a discernible CSF volume profile using a CNN with automated segmentation. The increase in mean CSF volume post-surgery suggests a notable surgical outcome that could have important implications for

patient treatment response, recovery process and follow-up monitoring in patients with SIH.

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Almost 2 decades of Normal Pressure Hydrocephalus referrals: trends of clinical and imaging characteristics

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Introduction: The increasing awareness of Normal Pressure Hydrocephalus (NPH) has resulted in a change in the quantity and quality of referrals for this condition. This retrospective study analyses the characteristics of the referrals for suspected NPH to a tertiary/quaternary neurosurgical centre.
Methods: Single-centre retrospective study. Patients referred for suspected NPH were identified through a database and were included in the study if the original referral was available. Data on the patients' demographics, clinical presentation and imaging report was collected and summarised by years. The data was then split into two "cohorts" (2006–2014 and 2015–2023) and the results compared.
Results: 468 patients were identified (64.5% male, mean age 74 ± 7 years). Most patients suffered mobility disturbances at the time of referral (98%), cognitive and urinary disturbances were less common (79% and 73% respectively). Most patients were referred by neurologists (59%) or geriatricians (12%). We identified 108 referrals in the first "cohort" and 360 referrals in the second "cohort" (2015–2023). Demographic characteristics did not differ between the two periods. There was a significant increase in the proportion of referrals coming from neurologists in the second "cohort" (from 50 to 62%, Fisher's exact $p = 0.03$). The proportion of patients presenting with the complete triad of symptoms has decreased (from 66 to 58%, n.s.). Patients referred in the second cohort were more likely to have acute callosal angle reported on imaging (20% versus 4%, $p = 0.002$) and to have DESH sign (45% versus 44%, $p < 0.001$), compared to patients referred in the first cohort.
Conclusions: In recent years patients are more likely to be referred for suspected NPH even in the absence of the complete triad of symptoms. In addition, recent referrals are more likely to present the typical imaging signs of NPH on radiology reports, raising the suspicion that referring teams may be reluctant to refer patients without these imaging features.

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Expert opinion on procedures for conducting CSF tap tests for iNPH in Japan

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Introduction: A questionnaire survey was conducted on how Japanese experts conduct tap tests.
Methods: A web-based survey on the tap test was conducted in February 2024 among representatives of iNPH practice at facilities belonging to members of the Japanese Society of iNPH. The questionnaire consisted of the following sections: information on respondents and facilities; criteria for patients for whom the tap test is performed; lumbar puncture procedure; methods for assessing symptoms; and how to determine the outcome.
Results: One hundred and ten valid responses were received: 84% belonged to neurosurgery, and 91% had specialist qualifications in dementia and/or neurosurgery. Most respondents indicated that they performed tap tests according to procedures recommended in the Japanese Guideline for Management of iNPH third edition: e.g. lumbar puncture with CSF exclusion volume of over 30 mL; use of TUG, MMSE and iNPHGS in symptom assessment; and how to judge improvement according to changes in each assessment tool. The timing of post-tap assessment varied from the day of tapping to one week later. Both gait and cognitive assessments were conducted once before tapping, but post-tap assessments were conducted multiple times in many institutions. While the experts had used criteria for determining improvement in the tap test with each rating scale, they also considered the patient's and family's sense of improvement in making the final decision and considered the possibility of false positives and false negatives based on symptoms, MRI findings, the patient's personality and whether the tap test was carried out in accordance with the prescribed procedure.
Conclusions: While many of the Japanese experts had conducted tap tests based on the recommendations of the guidelines, they made clinical decisions based on qualitative assessments as appropriate in addition to the prescribed procedure.

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Enhancing surgical decision-making in idiopathic normal pressure hydrocephalus: a predicting modeling approach

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Introduction: The current standard for selecting patients with idiopathic normal pressure hydrocephalus (iNPH) for shunt surgery relies on measurable improvements in gait or cognitive measures following a cerebrospinal fluid tap test (CSF-TT). However, there are no clinical guidelines for assessing objective and quantitative changes, which limits the clinician's ability to predict the therapeutic effect of surgical treatment. At Hôpital de l'Enfant-Jésus de Québec (HEJ), a protocol for assessing gait (4 measures) and cognitive functions (12 measures) was implemented over two days, pre- and post-CSF-TT. The aim of this study was to develop a standardized model enabling clinicians to predict whether the patient is a good candidate for shunt surgery.
Methods: Retrospective data from 175 iNPH patients who underwent the protocol at HEJ were analyzed. Patients were classified into two groups based on clinical judgment: CSF-TT responders ($n = 119$) and CSF-TT non-responders ($n = 56$). Stepwise logistic regression was used to identify factors predicting whether patients were likely to be referred for shunt surgery. The independent variables tested were deltas in performance for gait and cognitive tests (post- minus pre-CSF-TT). Covariates sex, age and years of education were included.
Results: Stepwise logistic regression revealed two gait-related factors (i.e., Berg Balance Scale and 10 Meter Walk Test) as predictors of outcomes. The model revealed an area under the ROC curve of 0.811, with sensitivity and specificity at 87.0% and 81.8%, respectively. Findings were incorporated into a Microsoft Excel® spreadsheet with automatic formulas, making it possible to predict whether a patient is a good candidate for shunt surgery.

Conclusions: This study reinforces previous research, highlighting that improvement in gait following CSF-TT is the most reliable prognostic indicator of a positive shunt outcome. Additionally, it introduces a tool helping practitioners in decision-making regarding a referral to the shunt surgery.

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Lateral ventricular volume predicts unfavourable outcome and earlier death in elderly who fall

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Introduction: Falls are the leading cause of injury among adults ≥ 65 years. Ventricular enlargement is associated with neurodegeneration and conditions causing gait disturbances, including normal-pressure hydrocephalus (iNPH). Evans' Index is a simplified indicator of ventricular volume, but any linear measurement will underestimate dilatation and is inferior to volumetry. Here, we compared automatically segmented lateral ventricular volumes with clinical outcomes, such as mortality, future falls, and fractures in elderly seeking health care after falling.
Methods: We retrospectively included 215 patients aged ≥ 65 years who had fallen between June 2013 and June 2014 and undergone brain CT and collected clinical data. The time lapse between index falls and data extraction represents a retrospective "observation time" of 9.95 ± 0.48 years. Brain CT scans were quantified using ScanDx, an automated deep-learning-based tool that segments and quantifies brain tissue volumes in CT images including lateral ventricles and total intracranial volume. This ratio was defined as "Volumetric Evans' Index" (VolEI). Patients were dichotomized into normal and large VolEI employing a cut-off of ≥ 1 SD.
Results: 73% had expired at analysis. Kaplan–Meier analysis yielded significantly increased mortality in the large VolEI group ($p = 0.0013$). Patients with dementia and incontinence had larger VolEI than those without ($p < 0.0001$). Also, patients with present or upcoming (< 1year) nursing home placement had larger VolEI ($p < 0.001$). There was no difference regarding rate of recurrent falls or future fractures.
Conclusion: Our findings suggest that lateral ventricular volume/index is associated with mortality and relevant morbidity in elderly that fall and should be considered an important prognostic factor for clinical outcome. Fully automated segmentations can be obtained from CT scans and implemented in radiology reports with minimal effort from the radiologist. Automatically derived volumetric data may become a useful clinical biomarker. Contrary to our a priori hypothesis, ventricle volume could not predict recurrent falling, fracturing, or iNPH diagnosis.

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Evaluation of imaging predictors and their relationship with postoperative outcome in patients with normal pressure hydrocephalus undergoing ventricular shunt

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Introduction: Various radiological signs have been recognized as valuable adjuncts to clinical criteria in normal pressure hydrocephalus (NPH) diagnosis. Certain magnetic resonance imaging (MRI) findings may also provide information on prognosis and postoperative outcomes of patients undergoing ventricular shunting. Nevertheless, the evidence remains inconclusive and necessitates further investigation.
Methods: We conducted a retrospective cohort study that included patients from the Center for Clinical Care of NPH at Fundación Santa Fe de Bogotá. We assessed the association between pre-operative MRI findings and the patients' comparative pre- and postoperative clinical status.
Results: We studied a cohort of patients from our NPH clinical care center between 2016 and 2023; 52 patients who were diagnosed with NPH and underwent ventricular shunt surgery were included. We did not find an association of a callosal angle under 90° with postoperative improvement. We found an association between the dilation of the Sylvian fissure and enhanced postoperative gait, while sulcal compression was associated with improvement in cognitive status and urinary continence. Periventricular hyperintensities were also linked to cognitive improvement. Furthermore, the preoperative presence of disproportionately enlarged subarachnoid space hydrocephalus (DESH) was associated with postoperative improvement in gait, cognitive status, and urinary continence.
Conclusions: Preoperative brain MRI findings, such as Sylvian fissure dilation, sulcal compression, periventricular hyperintensities, and DESH, may serve as valuable predictors of clinical improvement following shunt surgery. These markers should play a critical role in patient selection for the procedure. Our study highlights their significance, emphasizing the need for continued research to optimize NPH outcomes.

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Outcomes of hydrocephalus ventriculoperitoneal shunt surgery at a rural hospital

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is common among the elderly population with a 3.7% prevalence (65 years or older). The main treatment is shunt insertion, to transport cerebrospinal fluid (CSF) from the ventricles to the peritoneal cavity, a ventriculoperitoneal (VP) shunt. The aim of this study was to evaluate the shunt response and complication rate among patients who received a VP-shunt at a rural hospital.
Methods: Sixty-seven patients underwent surgery at Östersund's Hospital from 2016 to 2020 after being chosen by a neurologist and a neurosurgeon. In this retrospective study, the medical records of all patients who received a shunt were reviewed, and data were collected using protocols from the Swedish National Hydrocephalus Registry. Patients were tested preoperatively, 3 months and 12 months postoperatively. A modified version of the iNPH score was used to evaluate shunt response. Complications were found in medical records.

Results: Three months postoperatively, 82% of the patients improved significantly in their modified iNPH-score ≥ 5p, and 60% significantly improved ≥ 5p in the twelve-months postoperative examination. The six months revision rate was 6%, caused by infection, subdural hematoma, and distal catheter obstruction. All complications amounted to 9%, with 3% being subdural hematoma.
Conclusion: VP shunt surgery for iNPH at a rural hospital resulted in a shunt response rate of 82%, and a low complication rate (6%) compared to the literature.

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Pathological and neuronal evaluation in human brain biopsies from patients with idiopathic normal pressure hydrocephalus, iNPH
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Introduction: The findings in animal models of Alzheimer's disease (AD) suggest that the neuronal function is altered already in pre-amyloid plaque deposition and that microglia play a pivotal role at this stage. In this study, we focus on iNPH patient's early stage using neurophysiological and immunohistochemical methods.
Methods: We demonstrate that it is possible to obtain slices for ex vivo, whole-cell patch clamp recordings. After completion of the electrophysiology measures, we performed triple staining for the patched neuron (neurobiotin), microglia (IBA1), and Aβ plaques (82E1). Moreover, to investigate the pathological state of the samples, we analysed the presence of Aβ and phospho-Tau (p-Tau), in 30µm re-slices after the electrophysiology measures.
Results: The preliminary results show populations of neurons with characteristic electrical responses from Glutamatergic neurons and GABAergic interneurons. Results also show the abundant Aβ plaques and Tau in the sample of an iNPH patient diagnosed with AD. On the other hand, a sample from a cognitive intact iNPH patient with no comorbidities shows small Aβ plaques with no tau pathology. Finally, we performed an analysis of the action potential characteristic from the neurons of iNPH patients with a mini-mental state examination (MMSE) to compare normal vs cognitive impaired patients.
Conclusions: The preliminary results show a significant impairment in the firing threshold in neurons from the cognitive impaired iNPH patients. Although further analysis dividing neuronal subtypes and sex, will provide specific information, so far, the results indicate that neurons from the cortex are affected in patients that show cognitive impairment.

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Preventing shunt peritoneal catheter displacement by eliminating catheter exposure to dead space
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Introduction: Displacement of the peritoneal catheter is a reported complication of lumboperitoneal shunt (LP shunt) surgery. It has been suggested that reducing the catheter's traversal through a dead space in subcutaneous tissues created during surgical manipulation can decrease this complication. This report evaluates the effectiveness of a technique that ensures the catheter does not traverse any dead space along its entire path, with a demonstration through actual surgical videos.
Methods: This study included 279 patients who underwent LP shunt surgery from April 2020 to March 2023. In all cases, the shunt valve was placed in the back. From September 2021, techniques such as mattress suturing and Z-suturing were used to prevent exposure of the peritoneal catheter to dead space. These patients were followed for one year postoperatively, and the number of cases where the catheter deviated subcutaneously was compared before and after the introduction of these techniques.
Results: Of the 279 cases, 49 before the implementation of preventive measures (Median [IQR] 80 years old, [77–83], Men 23 (46.9%)), and 230 afterward (Age 81 years old [74–85], Men 133 (57.8%)) were analyzed. The number of complications involving catheter deviation into the subcutaneous space was 2/49 (4.1%) before, and 0/230 (0%) after the introduction of the technique ($p = 0.0022$).
Conclusion: By meticulously ensuring that the peritoneal catheter does not expose to any subcutaneous dead space along its entire path, the displacement of the catheter into the subcutaneous tissue can be minimized.

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Electric circuit analog of intracranial pressure dynamics – direct simulation in MATLAB/Simulink
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Introduction: Understanding intracranial pressure (ICP) dynamics is crucial in diagnosing and managing various neurological conditions. Electric circuit analogs have long been used to model these dynamics, but recent advancements in simulation technology offer new opportunities for accurate and detailed analysis. This study introduces an innovative electric circuit model to simulate ICP variations based on patient-specific data, providing a practical tool for clinicians.
Methods: I designed an electric circuit model inspired by the Ursino model to represent ICP dynamics. The model incorporated vital signs (heart rate, respiratory rate, blood pressure) and intracranial parameters (outflow resistance) from 21 patients undergoing infusion tests for suspected normal pressure hydrocephalus. MATLAB/Simulink was used to simulate ICP changes, including oscillations and infusion test responses. The accuracy of the model was validated by comparing simulated results with actual clinical measurements.
Results: The electric circuit model successfully replicated both steady-state ICP and dynamic fluctuations observed during infusion tests. Statistical analysis showed a strong correlation between simulated and measured ICP values ($R^2 = 0.9$; $p = 0.05$). The high degree of concordance suggests that the model reliably reflects real-world ICP dynamics, validating its utility in clinical contexts.
Conclusions: This study presents a validated electric circuit model for simulating intracranial pressure dynamics using MATLAB/Simulink. The model's ability to simulate patient-specific ICP changes accurately suggests its potential use in clinical practice, particularly in understanding intracranial compliance and assessing neurological conditions. The approach provides a rapid and reliable tool for exploring ICP dynamics and could lead to improved diagnostic and therapeutic strategies in neurosurgery. Future research could explore the model's broader applications and its potential to enhance patient care.

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Growing up with differential valves does not cope with anti-siphon devices in young adults – a case series with pathophysiological considerations
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Introduction: Overdrainage is a common problem in CSF-shunt therapy and antisiphon devices are known to minimize overdrainage

significantly. Therefore, we assume that patients serve best with modern valves with gravitational units. But some of them experience significant headaches after a valve change. Pathophysiological considerations and therapeutic implications are made on the basis of a case series from our department.
Methods: A case series of 3 patients is presented. All of them experienced disabling headaches after changing the valve from differential pressure to gravitational valves. Their distinct history and the events leading to the reasons and solutions to their complaints were briefly reported.
Results: All 5 patients received their shunts in early infancy and had grown up with a differential valve. They all had radiologic features of long term overdrainage but were clinically asymptomatic during growth. After valve replacement with a gravitational unit, they all experienced disabling headaches which did not resolve before removing the gravitational unit.
Conclusions: Ambulatory patients growing up with a differential pressure valve are used to asymptomatic overdrainage and a distinct CSF drainage pattern. Changing the valve in these young adults to a gravitational unit leads to a fundamental change in drainage pattern based on a restricted intracranial compliance which leads to severe headaches despite a patent shunt system. Patients who grew up with differential pressure valves and were asymptomatic according to overdrainage serve best with maintaining overdrainage by keeping their valve type in case of revision surgery.

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Changes in callosal angle and Evans index following shunt surgery in patients with idiopathic normal pressure hydrocephalus

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Introduction: Idiopathic normal pressure hydrocephalus (iNPH) is characterized by gait disturbance, cognitive impairment and urinary incontinence. In patients who show no response to shunt surgery, there is a lack of objective radiological findings to diagnose shunt malfunction. This study aimed to assess changes in Evans index and callosal angle during a prospective long-term follow-up of patients with iNPH who underwent shunt surgery.
Methods: Clinical (NPH Japanese Scale) and radiological (Evans index, callosal angle) data were collected pre- and postoperatively (3, 6, 12 months) in 19 patients with iNPH treated with a programmable valve (Sphera Pro). Imaging studies were evaluated by the same neuroradiologist throughout the follow-up period.
Results: Patients demonstrated a decrease in NPH Japanese Scale scores over time ($p < 0.001$). There were no significant differences among Evans index values during the follow-up ($p = 0.24$). The preoperative average callosal angle was 72 ± 15, which increased to 91 ± 18 at 6 months postoperatively ($p = 0.003$).
Conclusions: In this study, patients with iNPH who underwent shunt surgery with a programmable valve showed an increase in callosal angle concurrent with neurological improvement. Evans index did not show significant changes during the follow-up period.

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Comparison of non-invasive ICP waveforms analysis between hydrocephalus patients who are asymptomatic and patients presenting with shunt dysfunction

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Introduction: Accurate diagnosis of shunt malfunction in hydrocephalus patients is paramount. This condition can range from severe complications with patients presenting in critical condition to milder symptoms, resulting in a diverse spectrum of manifestations. Our objective was to conduct a comparative analysis of non-invasive intracranial pressure waveform (nICPw) data from patients with asymptomatic shunts and those experiencing shunt dysfunction, including cases of hypodrainage and hyperdrainage.
Methods: In our department, we conducted monitoring of patients with shunt dysfunction alongside asymptomatic individuals using nICPw. We collected data on the P2/P1 ratio and time-to-peak (TTP) in three positions: lying down, at a 30-degree incline, and standing. Our analysis focused on comparing the average P2/P1 ratio and TTP between the two groups, as well as examining the mean difference between them.
Results: A total of 19 patients were included, seven patients with shunt dysfunction and 12 patients with asymptomatic shunts underwent evaluation. In patients with shunt dysfunction, the P2/P1 ratios while lying down, at a 30-degree incline, and standing were 1.4 (± 0.33), 1.19 (± 0.11), and 1.37 (± 0.08) respectively, reflecting a mean difference of 0.38 ± 0.132, 0.13 ± 0.067, and 0.38 ± 0.068 compared to asymptomatic shunt patients. Similarly, TTP values in patients with shunt dysfunction were 26.71 (± 8.14), 18.75 (± 6.28), and 16.54 (± 6.74) while lying down, at a 30-degree incline, and standing respectively. The mean differences compared to asymptomatic shunt patients in corresponding positions were 7.96 ± 3.79, 2.5 ± 2.54, and 8.0 ± 1.84 respectively.
Conclusions: Patients with stable shunts, as well as those experiencing hypodrainage and hyperdrainage, exhibit notably distinct nICPw dynamics. This observation hints at the potential of nICPw as a valuable supplementary diagnostic tool for detecting shunt malfunction, assessing patient progress, and establishing baseline nICPw characteristics. Such insights could prove invaluable should patients encounter complications throughout their lifetimes.

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Ethnic, racial and socioeconomic disparities in the management and outcomes of hydrocephalus: a scoping review of the literature

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Introduction: Socioeconomic, racial, and ethnic disparities significantly impact the management and outcomes of various neurological disorders. This scoping review explores these disparities within the context of hydrocephalus.
Methods: Following PRISMA, we searched *PubMed*, *Embase*, and *Web of Science* for studies fitting the following criteria: retrospective, prospective, or cross-sectional studies (1), with the primary aim of evaluating socioeconomic, racial, or ethnic disparities in the management or outcomes of hydrocephalus (2). Revisions, case reports, case series, and

studies with different main objectives were excluded. Data extraction encompassed the origin country, the number of patients, the types of hydrocephalus, the ethnic, socioeconomic, and racial background of the patients, and the age group studied. We analyzed whether the study detected the presence of significant disparities in the patients' management or outcomes.
Results: Out of 828 articles retrieved, 20 met the inclusion criteria, covering 98,776 patients. The majority (85%) of studies originated from North America, with singular studies from Europe and Africa, and one multicenter study; no studies were identified from Latin America. Pediatric cases were the subject of 70% of the articles. A total of 13 articles reported ethnic and racial disparities, 12 noted socioeconomic disparities, while 3 studies found no disparities in these areas. Notably, Black or African American pediatric populations faced higher mortality and more non-routine discharges compared to their white counterparts. Additionally, factors such as non-white race, lower socioeconomic status, and public insurance were linked to increased shunt complications. Lower family income and educational levels were also correlated with a diminished quality of life. Language barriers contributed to delayed neurosurgical care.
Conclusions: The review highlights important disparities in hydrocephalus management and outcomes based on ethnic, racial, and socioeconomic factors. Physicians should consider this when addressing different populations. Future research should improve methodological robustness, diminish geographical biases, and include adult populations.

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Investigating the Impact of Macrophage Infiltration on Secondary Chronic Hydrocephalus in Vestibular Schwannoma

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Introduction: Vestibular schwannomas (VS) are frequently associated with secondary chronic hydrocephalus, a phenomenon whose etiology remains poorly understood and it has rarely analyzed from a pathological standpoint. Herein, we investigated the relationship between secondary chronic hydrocephalus in VSs and the number of infiltrating macrophages within tumor tissue using histological and radiological data.
Methods: For this retrospective study, we retrieved 57 VSs operated in our institution between 2017 and 2023. The quantity of macrophages within the tumor was histologically assessed, and a macrophage count constituting 10% or more of the tumor was considered high-macrophage ratio. The co-occurrence of secondary chronic hydrocephalus was evaluated through CT scans and examination of medical records.
Results: Among the 57 patients with VS, 17 developed secondary chronic hydrocephalus—9 with communicating hydrocephalus and 8 with obstructive hydrocephalus. Of these, 6 (35.3%) exhibited a high-macrophage ratio, compared to 10 cases (25%) among the 40 patients without hydrocephalus. Within the hydrocephalus group with a high-macrophage ratio, 4 had communicating hydrocephalus and 6 had obstructive hydrocephalus.
Conclusions: These findings suggest a potential link between macrophage infiltration and secondary chronic hydrocephalus in VS patients.

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ventriculoperitoneal shunting obstruction: a multicentre clinical research for cerebrospinal fluid parameters and its prediction role

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Introduction: Shunt obstruction is a type of ventriculoperitoneal shunt (VPS) failure. Whether changes in cerebrospinal fluid (CSF) parameters influence shunt outcomes is up for debate.
Methods: In this study, we retrospectively included adult hydrocephalus patients who received VPS from November 2013 to September 2021. Inclusion criteria: Patients with hydrocephalus of all etiologies that underwent shunt surgery from 6 general hospitals in different provinces of China were included in the study. The exclusion criteria were: 1.Patients under the age of 18 years; 2.Patients who had previous shunt surgery, 3. Shunt failure from other factors; 4.Patients dead from other causes; 5. Patients with incomplete data. The CSF of shunt patients had been analyzed at the time of shunt insertion. The CSF samples were collected and analyzed when the shunt was implanted. The relationship between CSF parameters and the incidence rate of shunt obstruction in one year was analyzed.
Results: A total of 717 eligible patients from 6 hospitals were included, of whom 59(8.23%) experienced obstruction. Multivariate logistic regression analysis identified that protein level(odds ratio [OR] 1.161, 95% CI 1.005 ~ 1.341, p = 0.043), decreased glucose level(2.5 mmol/L) (odds ratio 3.784, 95% confidence interval 1.872 ~ 7.652, p = 0.001) and protein level increase(> 0.45 g/L) (odds ratio 3.653, 95% confidence interval 1.931 ~ 6.910, p = 0.001)were also independent risk factors for shunt obstruction.
Conclusions:This study suggested that increased protein level (> 0.45 g/L) and decreased glucose level (< 2.5 mmol/L) in CSF indicated an increased risk of shunt obstruction in a patient with hydrocephalus.Thus, shunt surgery should be more carefully considered when the CSF glucose and protein are abnormal.

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Prenatal versus postnatal surgical management for myelomeningocele: a systematic review and comparative meta-analysis

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Introduction: Myelomeningocele (MMC) is a malformation in the vertebral arches with further exteriorization of the spinal cord covered by the meninges. The management of this disease is a matter of discussion. The authors conducted a systematic review and comparative meta-analysis to assess MMC surgical management.
Methods: Fulfilling PRISMA guidelines, the authors searched the Embase, PubMed, Web of Science, and Cochrane databases to identify articles reporting comparative cohorts of more than four patients with MMC being submitted for prenatal or postnatal repair. Odds Ratio (OR) with 95% CI and random effects were used to measure effects in comparative analysis.
Results: We included 16 studies with 2,628 patients in the analysis. Of these patients, 1,465 received postnatal repair and 1,163 prenatal repair. Prenatal repair presented with a lower likelihood of developing CSF leak (OR = 0.36, 95% CI: 0.18 to 0.72; I2 = 38%, as well as developing hydrocephalus (OR = 0.23, 95% CI: 0.13 to 0.41; I2 = 71%). Analysis showed that prenatal repair presented a lower likelihood of developing motor dysfunction (OR = 0.54, 95% CI: 0.36 to 0.80; I2 = 0%). Prenatal repair also had a lower likeliness of developing infections (OR = 0.34, 95% CI: 0.18 to 0.63; I2 = 28%) and urinary incontinence (OR = 0.21, 95% CI: 0.08 to 0.54; I2 = 0%). There was no statistical difference between groups regarding hindbrain herniation (OR = 1.17, 95% CI: 0.27 to 5.08; I2 = 84%), mortality (RR = 1.68, 95% CI: 0.84 to 3.37; I2 = 0%), CSF shunt requirement (RR = 0.12, 95% CI: 0.01 to 1.06; I2 = 94%) and tethered cord (RR = 1.54, 95% CI: 0.87 to 2.74; I2 = 31%). Heterogeneity dropped to zero in some cases when omitting specific studies. The Baujat plot identified the main outliers.
Conclusion: Prenatal MMC repair was associated with lower odds of developing CSF leak, hydrocephalus, motor dysfunctions, infections, and urinary incontinence. Overall, this data indicates that prenatal repair of MMC is a superior procedure when compared to postnatal repair.

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Quantification of regional neural tissue dynamics in type I chiari malformation

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Introduction: Type I Chiari malformation (CMI) is believed in part to be a cerebrospinal fluid (CSF) related disorder. The unique anatomy of CMI at the cervicomedullary junction causes an impedance to CSF flow, resulting in abnormal tissue motion. This abnormal tissue motion and CSF flow may result in altered tissue strain. We hypothesized that tissue motion and strain resulting from the altered flow of CSF in symptomatic CMI patients would be different from healthy controls and asymptomatic CMI patients. These results provide the first comparison of tissue motion dynamics between asymptomatic and symptomatic CMI patients.
Methods: Rostral-caudal tissue motion was quantified using displacement-encoding with stimulated echoes (DENSE) MRI. Principle strain in four brain regions was derived from displacement: the pons, medulla, cerebellar tonsil, and upper spinal cord. Peak-to-peak displacement and mean principle strains are reported for 60 patients.
Results: Mean peak-to-peak rostral-caudal displacements ± SD of the upper spinal cord (SC) for the control, symptomatic, and asymptomatic groups were 0.05 ± 0.03, 0.14 ± 0.10, and 0.10 ± 0.08 mm, respectively and of the cerebellar tonsil were 0.05 ± 0.05, 0.12 ± 0.09, and 0.14 ± 0.11 mm, respectively. The average principles strains (extension % ± SD/compression % ± SD) in the SC for the control, symptomatic, and asymptomatic groups were 1.19 ± 0.37%/1.25 ± 0.34%, 1.20 ± 1.18%/ 0.95 ± 0.79%, and 1.48 ± 1.18%/1.16 ± 0.39%, respectively.
Conclusions: These results indicate that significant differences in neural tissue dynamics exist between symptomatic CMI patients, asymptomatic CMI patients, and healthy controls. At present, it is not known if these differences relate to presenting symptoms or the effects of decompression surgery on these dynamics. Alone, neural tissue parameters are not able to diagnose CMI, but in combination with morphometrics and symptomatology show promise in identification of surgical candidacy selection.

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Variation in cerebrospinal fluid production rate during asleep and awake states

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Introduction: Sleep serves several essential and diverse functions for the maintenance of healthy brain activity. Our study aimed to evaluate whether sleep influenced cerebrospinal fluid flow rate and if there was a variation in net cerebrospinal fluid production rate (PRcsf) during asleep and awake states.
Methods: A prospective observational study was performed in all compos mentis patients in our hospital who required CSF drainage as part of their ongoing management. The drain was connected to a LiquoGuard7 (Möller-Medical, Germany) pump with the intracranial pressure sensor at the level of the external auditory meatus. The internal software and flow-rate data of the LiquoGuard7 pump was used to calculate net PRcsf during asleep and awake states for each individual patient. The methodology requires the patients to lie completely flat for 30 min during the measurement. Hence only the patients who slept lying flat were included in the study. Measures were taken to not wake the patients during data collection such as ensuring that the bed space was clutter-free to allow easy access and the lights and curtains remained closed to minimise disruption. Statistical analysis used SPSS (version 25.0, IBM) by paired t-test, comparing the measured flow rates during asleep and awake states in individual patients.
Results: After exclusion PRcsf was calculated in 14 patients in both awake and asleep states (4 M:10F, average age 64 years, n = 10 NPH, n = 2 IIH, n = 2 CSF leak). Net CSF flow rate was found to be between 20-45 ml/hour higher during asleep state than awake state in individual patients ($p < 0.001$). Quality of sleep and the use of pharmacological sleeping aides appeared to influence PRcsf during sleep.

Conclusions: There is variation in PRcsf during asleep and awake states in individual patients. This preliminary study will require validation with larger patient numbers.

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Cerebrospinal fluid dynamics in an adult with benign external hydrocephalus presented with spontaneous CSF rhinorrhea

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Introduction: Benign external hydrocephalus (BEH) is a condition usually diagnosed in infancy and is characterized by enlarged subarachnoid spaces—specifically at the frontotemporal lobes—and normal or moderately enlarged ventricles. BEH is commonly considered as a self-limiting condition. However, BEH is rarely seen in adulthood.
Methods: A 60-year-old gentleman was presented with two years history of intermittent spontaneous cerebrospinal fluid (CSF) rhinorrhea. No history of head injury. Patient was operated on for endoscopic transnasal CSF leak repair by ENT surgeon. Patient had an uncomplicated operation. He received treatment with acetazolamide for a few weeks, postoperatively. Furthermore, patient was referred to neurosurgery for investigation of possible idiopathic intracranial hypertension. Magnetic resonance imaging (MRI) of the brain showed significantly enlarged frontotemporal subarachnoid spaces without ventriculomegaly. Neurological and ophthalmological examinations were unremarkable. CSF dynamics study was done by lumbar puncture with the Likvor CELDA™ system aiming to assess patient's CSF dynamics parameters.
Results: **ICP = 17.3 mmHg**, [median normal values (5th—95th percentile): 11.6 mmHg (7.8–14.3 mmHg)], **CSF conductance = 11.7 [µl/(s kPa)]**, [normal median value: 13.0 [µl/(s kPa)]. **CSF resistance = 10.7 [mmHg/(ml/min)]**, [normal median value: 8.6 [mmHg/(ml/min)]. **Resting ICP pulse amplitude = 4.13 mmHg** [normal: 2.0 ± 1.3 mmHg]. Decision for no neurosurgical intervention was made as patient had been asymptomatic, clinicaly stable and without recurrence of CSF leak. Three years after the initial diagnosis of BEH, patient has been well. He denied headaches, vision problems or CSF rhinorhea. Neurological and opthalmological examinations have been unremarkable. Also, his 3 years postoperatively follow up MRI brain showed no significant changes.
Conclusions: BEH characterized by abnormal CSF dynamics. Despite its rarity, spontaneous CSF rhinorrhea can be a presenting symptom. Decision for insertion of CSF shunt shall be tailored in patient's nosology.

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A case of acute ischemic stroke due to untreated normal pressure hydrocephalus improved by shunting

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Introduction: The concept of cerebrospinal fluid (CSF) absorption pathways has changed dramatically to include the designation of the intra-arterial intramedullary drainage pathway and the glymphatic system as major CSF absorption pathways. Some patients with untreated normal pressure hydrocephalus (NPH) show a gradual decrease in ventricular forward flow with worsening clinical symptoms, indicating irreversible progressive cerebral ischemic damage.
Methods: We describe a case of untreated NPH with a hydrocephalus pathology that resulted in progressive cerebral ischemic damage and acute cerebral infarction.
Results: An 80-year-old man presented with generalized weakness and a history of progressive gait disturbance, cognitive decline, and urinary incontinence over several years. Two weeks before admission, he experienced falls and developed incontinence 2 days before admission, which led to his bedridden status. Physical examination revealed no abnormalities. Magnetic resonance imaging revealed bilateral ventricular enlargement, disproportionately enlarged subarachnoid-space hydrocephalus, an Evans index of 0.38, corpus callosum angle < 90°, and acute cerebral infarction in the corona radiata, indicating hydrocephalus and acute ischemic stroke. Treatment with intravenous ozagrel sodium was initiated, followed by oral clopidogrel. A tap test on day 21 of admission improved the patient's walking rate (from 1.255 to 1.339 steps/s) and Mini-Mental State Exam score from 11 to 16. On day 41, the patient underwent a right ventriculoperitoneal shunt. Subsequently, independent walking improved, whereas cognitive function and dysuria improved slightly. Follow-up computed tomography on day 50 revealed a reduction in ventricular size. The patient was transferred to a convalescing hospital on day 64 after showing overall improvement in symptoms and function.
Conclusions: Patients with hydrocephalus who develop acute ischemic stroke due to progressive cerebral ischemic damage benefit from shunting after stroke treatment can provide through marked improvement in clinical symptoms.
Note: Consent to publish has been obtained by the patient.

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Identifying markers predicting shunting efficacy in idiopathic normal pressure hydrocephalus

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Introduction: The Cerebrospinal Fluid Tap Test (CSF-TT) is used to select patients living with idiopathic normal pressure hydrocephalus (iNPH) for ventriculoperitoneal shunting (VPS). Due to the lack of standardized protocols, practices vary widely across clinical settings, resulting in a high rate of false negatives. This study aims to improve CSF-TT's predictive value by identifying the neuropsychological and physiotherapy tests predicting shunt outcomes.
Methods: Data from 94 iNPH patients who underwent CSF-TT and VPS at Hôpital de l'Enfant Jesus (HEJ; Quebec, Canada) were analyzed retrospectively. The CSF-TT protocol included pre- and post-lumbar puncture (LP) assessments of gait (4 measures) and cognitive functions (12 measures). Independent variables were results of neuropsychological and physiotherapy tests. Dependent variables were clinical impressions and delta scores on the Idiopathic Normal Pressure Hydrocephalus Grading Scale (iNPHGS) and the newly developed Quebec NPH Clinical Grading Scale (QNPH-CGS). Covariates included sociodemographic factors, cardiovascular comorbidities, and control variables (i.e. volume of CSF withdrawn during CSF-TT, year of CSF-TT, interval between VPS and post-VPS assessments, and baseline scores on dependent measures). Multivariate regression analyses and elastic net regression were used to identify predictors of shunt outcomes.
Results: In multivariate regression analyses, the model utilizing all predictors was most effective, explaining 26% of QNPH-CGS delta variance. Significant predictors included pre-VPS QNPH-CGS score, post-LP Stroop interference score, and alcohol consumption. Using a cross-validated elastic net regression, only ÉQcG-HPN delta could be

significantly predicted above chance (permutation test $p < 0.05$), with a set of predictors including control variables, comorbidities, and sociodemographic factors, albeit with low accuracy (cross-validated $R^2 = 0.05$). This model's most influential predictors were pre-VPS QNPH-CGS score, diabetes, cholesterol, and alcohol consumption.
Conclusions: These results highlight the significance of cardiovascular comorbidities in predicting shunt outcomes and introduce the QNPH-CGS as a valuable tool for assessing iNPH symptoms.

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Pupillary responses to the glare illusion in patients with normal-pressure hydrocephalus
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Introduction: The glare illusion enhances the perceived brightness of a central white region encircled by a luminance gradient, despite no physical change in luminance. The pupillary response to the glare illusion is considered to be related to not only a light reflex via the brainstem but also cortical functions. To explore how cognitive dysfunction affects the perception of glare illusions, we compared pupillary responses to the glare illusion between patients with normal pressure hydrocephalus (NPH) and healthy controls.
Methods: Pupillary responses were assessed in 32 NPH patients (mean age 71.8 ± SD 9.2) and 20 healthy controls (73.3 ± 2.5). The stimuli comprised the glare stimuli with luminance gradations converging onto a central area and the halo (control) stimuli with the opposite gradations, with each condition presented randomly in 12 trials. A two-way ANOVA was conducted to examine pupil responses, considering maximum constriction and constriction velocity, with conditions as the within-subject factor and group (NPH, healthy control) as the between-subject factor.
Results: Significant main effects of stimuli and group conditions on maximum pupil constriction were found [$F(1, 45) = 5.710$, $p = 0.021$ 、$F(1, 45) = 6.705$, $p = 0.013$]. Pupil constriction was greater in response to the glare stimuli compared to the halo stimuli, and NPH patients exhibited reduced constriction compared to healthy controls. Furthermore, a significant main effect of stimuli [$F(1, 45) = 6.781$, $p = 0.012$] and interaction [$F(1, 45) = 8.194$, $p < 0.01$] were observed for pupil constriction velocity. NPH patients showed slower pupil constriction velocity in response to the glare stimuli compared to healthy controls.
Conclusions: The results indicate disparities in the responses of NPH patients and healthy controls to the glare illusion. The impairment of the neural system responsible for cognitive dysfunction in NPH patients may potentially alter their responses to illusions.

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Investigating shunt catheter obstruction: a comparative flow study between modified and commercial catheters
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Introduction: Cerebrospinal fluid (CSF) shunts are the cornerstone of hydrocephalus management. However, their frequent failure, primarily due to shunt catheter obstruction, necessitates an in-depth examination. Understanding the factors contributing to catheter obstruction is crucial to improving patient outcomes.
Methods: We conducted a comparative analysis to measure the CSF flow rates in both modified and commercial shunt catheters. The objective was to assess their efficacy by quantifying CSF flow under controlled conditions. Concurrently, we initiated an examination of cellular adhesion on the catheters, focusing on the impact of hole size and positioning. Additionally, Indian ink was utilized to visualize the flow dynamics through the various holes of the modified catheter.
RESULTS: CSF flow rates exhibited no notable variance between the modified and commercial shunt catheters. Ink-based flow experiments revealed that the higher flow velocity occurs at the holes that are most distal to the catheter tip, mirroring observations in commercial catheter. Presently, we are investigating the influence of hole dimensions, angulation and distribution on cellular adhesion on each hole individually in these two shunt catheters.
Conclusions: These results suggest that altering hole sizes in shunt catheters may not be the sole solution to reduce catheter obstruction. The complexity of this issue may involve factors beyond hole size, such as material properties, design, or other variables. Further research is needed to explore a more comprehensive approach to enhance shunt reliability and address catheter obstruction, which remains a significant challenge in the management of hydrocephalus.

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Retrospective analysis of long-term outcome for CSF shunted probable iNPH patients whose Dat Scan showed DAT disorder
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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:175

Introduction: Parkinson disease (PD)-related disease is an important differential diagnosis for idiopathic normal pressure hydrocephalus (iNPH), the presence of which can be suspected by examining a dopamine transporter scintigraphy (Dat Scan). On the other hand, there are reports that iNPH patients also have dopamine transporter (DAT) disorders, and the surgical indication of probable iNPH with DAT disorder is controversial. In our department, we perform a Dat Scan before or after surgery to confirm the presence or absence of DAT disorder in cases judged to be atypical for iNPH.
Methods: We retrospectively reviewed CSF shunted patients who had DAT disorder to confirm roles of Dat Scan for decision of surgical indication with probable iNPH patients.
Results: There were 8 patients who were surgically shunted and showed DAT disorder, consisted of 6 males and 2 females, ranging in age from 66 to 79 years (mean 74 years). Six patients who underwent preoperative Dat Scan had mild to moderate DAT disorder. The other two patients underwent postoperative Dat Scan because of poor postoperative course. Tap test was positive in 6 patients and slightly improved in 2 patients. All patients underwent VPS shunting. MIBG scintigraphy was performed in 4 patients, and was normal in 2, decreased in 2. 2 patients with poor postoperative course both showed decreased uptake in MIBG scintigraphy.
Conclusions: The result indicates that patients with DAT disorder do not necessarily have a poor outcome, but those with decreased MIBG scintigraphy had a poor outcome. In the future, if a DAT scan is performed in an atypical case and DAT disorder is found, it is advisable to perform a MIBG scintigraphy as well. And if both show a decrease, the surgical indication may be inappropriate. We show illustrative cases and discuss the treatment indication for probable iNPH with positive Dat Scan.

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35-year overview of the registry for patients with NTD pathology in Estonia

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Introduction: Estonia, a North-European country with a population of 1.3 million, experienced a birth rate of 1.3 children with NTD pathology per 1,000 births in late 1980s. The long-term prognosis and survival of young adults are of concern. We present an overview of prospective 35-year monitoring of patients with NTD pathology (spina bifida and hydrocephalus).
Methods: Mapping of the epidemiologic situation and evaluating the disease progression and survival rate for affected individuals. As of January 2024, we have 296 patients under dispensary surveillance, and their DNA is stored and genotyped at the Estonian Genome Center for family-based genetic analysis.
Results: Although birth rates in Estonia have been low in recent years, the number of newborns with SpB and HC pathology has drastically decreased mostly due to implementing folic acid prophylaxis since 2012 along with a significant reduction in artificial and repeated abortions. The survival rate of SpB patients is significantly better than in patients with isolated HC. Severe developmental delay (and socially non-functional state) was affecting 26% of isolated HC patients, but only 10.9% of SpB patients. Analysis of case-parent trios revealed transmission of deleterious genetic variants from both parents, but no variants in *L1CAM*—the most common cause of the congenital hydrocephalus.Since 1993, when we started self-catheterization for neurogenic bladder—no one has died from kidney failure. All youngsters carrying an HC shunt from infancy have had to undergo replacement of the shunt valve or the entire shunt at different ages due to hydrodynamic disturbances.
Conclusions: We propose analysis of genetic data will identify the most common genetic variants associated with NTD pathology in the Estonian region and find prognostic correlations between these genetic defects and clinical symptoms. This could help us choose the best treatment options for our patients to improve their quality of life.

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The effect of coexisting progressive supranuclear palsy on post-shunt clinical course of idiopathic normal pressure hydrocephalus

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Introduction: While it is increasingly recognized that progressive supranuclear palsy (PSP) can coexist with idiopathic normal pressure hydrocephalus (iNPH), the post-shunt clinical course of iNPH with concomitant PSP, compared to iNPH alone, remains unclear. This study aimed to elucidate the postoperative prognosis of clinically diagnosed PSP patients who fulfill the diagnostic criteria for probable iNPH.
Methods: We retrospectively analyzed clinical data from 128 consecutive patients with probable iNPH who underwent shunt surgery at our NPH center in Japan between January 2018 and December 2019. PSP was diagnosed according to NINDS-SPSP criteria. Shunt responsiveness was assessed using the timed up-and-go test (TUG) and Mini-Mental State Examination (MMSE) scores before and after tap tests and at 1, 3, 6, and 12 months post-surgery. Changes in scores were analyzed using the Mann–Whitney U-test with Bonferroni adjustment.
Results: Four patients were identified as iNPH concomitant with PSP (iNPH + PSP), while the remaining 124 patients had iNPH without PSP (iNPH-PSP). No significant differences were found in preoperative TUG, MMSE scores, or tap test improvement between the two groups. TUG changes at 1, 3 and 6 months post-surgery did not significantly differ, although the improvement rate in TUG at 12 months was significantly lower in the iNPH + PSP group. MMSE changes at 1, 3, 6, and 12 months did not differ significantly.
Conclusions: The co-occurrence of PSP in patients with iNPH may attenuate the improvement in walking function one year after shunt surgery for iNPH. Shunt surgery may offer potential benefits for iNPH patients with concurrent PSP over a relatively short period, warranting further investigation.

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Prevalence of hydrocephalus and its relationship with cervical spinal canal stenosis

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Introduction: Recent studies indicated a potential correlation between cervical spinal stenosis (CSS) and hydrocephalus, however understanding hydrocephalus in patients with CSS remains limited. This retrospective cross-sectional study proposed to examine the prevalence and relationships of hydrocephalus in patients with cervical spinal stenosis.
Methods: This study included 2 independent groups. First group was 60 patients undergoing anterior cervical discectomy and fusion (ACDF) for degenerative cervical spinal stenosis or cervical radiculopathy with pre-operative brain imaging. Another group was 145 patients with idiopathic normal pressure hydrocephalus (iNPH) who have responded to shunt surgery (definite iNPH) with pre-operative MRI cervical spine in sagittal plane at least. Clinical evaluations incorporated the triad of iNPH, the Time Up and Go (TUG) test, Thai Mental State Examination (TMSE), and signs of cervical myelopathy. Radiological parameters, such as CSS grading, Evans' index, and iNPH Radscale score, were evaluated, with assessments conducted by blinded radiologists.
Results: Patients with complete CSS with cord signal change had a threefold higher hydrocephalus prevalence (20.0%) compared to those with lower severity (7.69%). Among ACDF patients, four who exhibited partial improvement post-surgery showed positive responses to the tap test or CSF shunt surgery. Logistic regression analysis demonstrated a significant relationship ($p = 0.001$) between age and hydrocephalus. Receiver operating characteristic (ROC) analysis identified an age cut-off of 65 years for predicting hydrocephalus in ACDF patients, with a sensitivity of 1 and specificity of 0.62. Furthermore, in definite iNPH patients, the study found a 6.2% prevalence of cervical myelopathyand seven with severe CSS still responded to lumboperitoneal shunt(LP shunt).
Conclusions: The study indicated age-related trends in CSS and hydrocephalus severity. It advocated for screening concomitant iNPH in partially improved post-operative CSS patients due to misdiagnosis from overlapping clinical presentations. LP shunt remained effective in patients with completely obliterated cervical spinal subarachnoid space.

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Development of robust next-generation double image-guided lumboperitoneal shunt technique for normal pressure hydrocephalus

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Introduction: Lumboperitoneal shunt (LPS) has the great advantage of no brain injury but overcoming various types of shunting complications and spinal catheter fragility has been problematic. Based on our analysis of the causes of shunting troubles and spinal catheter fragility, we have developed a next-generation LP shunt technique that is highly accurate, minimally invasive, stable over the long term, and robust against various shunting complications.
Methods and results:
Shunt Techniques and Complication Prevention:
1) Fluoroscopic-guided Para-Median Approach and Myelography:
This method ensures rapid and accurate placement of spinal catheters under fluoroscopic guidance. It prevents delayed rupture caused by catheter proximity to spinous processes or laminae. Myelography via spinal catheter detects and corrects kinks or U-turns in the catheter, which can cause root pain. It also identifies and corrects misplacements into the subdural space.
2) Fascial Fixation of Stepped Connector:
The spinal catheter connects to a stepped connector immediately after piercing through the fascia. The connector is securely fixed at three points on the fascia. Then, a few cm long abdominal catheter connects from the connector to the valve. This technique prevents delayed rupture by running a robust abdominal catheter rather than fragile spinal catheter in the subcutaneous tissue, which is mechanically stressful.
3) Ultrasonic-Guided Lateral Rectus Abdominis Muscle Approach:
Using intraoperative ultrasonic echo equipment, the lateral edge of the rectus abdominis muscle is identified. The abdominal catheter is placed by incising the rectus sheath at its lateral edge. Ultrasonic echo can also detect peritoneal adhesions, allowing avoidance. Running the abdominal catheter below the external oblique muscle prevents protrusion of the catheter.
Conclusions: The combination of these techniques avoids various shunt problems and overcomes the disadvantages of LPS. These techniques cause a paradigm shift to an era in which LPS is the first choice in the treatment of normal pressure hydrocephalus.

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Understanding the relationship between cognitive impairment and gait characteristics in iNPH

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Introduction: Normal gait is complex, involving not only motor functions but also higher-level cognitive processes. Individuals diagnosed with idiopathic normal pressure hydrocephalus (iNPH) commonly exhibit impairments in both cognition and gait. However, for research as well as diagnostic purposes cognition and gait are often evaluated independently, suggesting inadequate understanding of the relationship between these features in iNPH. Therefore, this study aimed to characterize the cognitive impairments in iNPH and examine the association between cognitive functioning and gait characteristics.
Methods: People with suspected iNPH underwent a comprehensive battery of neuropsychological assessment and laboratory-based gait analysis prior to their scheduled tap test. Cognitive functioning was evaluated using the Repeatable Battery for the Assessment of Neuropsychological Status and Delis Kaplan Executive Function System Colour-Word Interference test. Additionally, participants visited a gait laboratory where they performed walking trials along a 10-m pathway during which their gait characteristics (i.e., gait speed, stride length and width, strides per minute, cycle time) were evaluated using 3D motion capture technology.
Results: Preliminary findings from eight participants with suspected iNPH (M_{age} = 76.1 years, SD = 7.3 years, 2 women) show a widespread cognitive dysfunction with a predominance of memory and executive function deficits. While significant correlations were observed between inhibition function and certain gait characteristics, no such associations were found for other cognitive functions.
Conclusions: While our preliminary findings reveal a widespread cognitive dysfunction in people with suspected iNPH, the precise association between cognitive deficits and gait impairment remains unclear. The negative relationship between inhibition function (i.e., ability to suppress or control inappropriate/irrelevant responses during goal-directed actions) may at least partially explain why people with iNPH have difficulties in controlling movements during walking. Understanding these relationships is key for enhancing diagnosis and developing interventions to improve the quality of life for people affected by iNPH.

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Combining endoscopic third ventriculostomy and tumor biopsy did not increase the risk of leptomeningeal tumor dissemination for intraventricular and paraventricular tumors with obstructive hydrocephalus

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Introduction: Combining endoscopic third ventriculostomy (ETV) and tumor biopsy is a reasonable treatment for obstructive hydrocephalus associated with intraventricular and paraventricular tumors. However, there is a potential risk that ETV may increase leptomeningeal tumor dissemination (LTD) after biopsy due to direct communication between ventricles and cisterns. The aim of this study was to clarify whether ETV combined with biopsy might increase the frequency of LTD in patients with intraventricular and paraventricular tumors (IVPVT) as compared with endoscopic biopsy alone.
Methods: Seventy-seven patients with IVPVTs who underwent endoscopic biopsy in a single institute between April 2005 and March 2022 were retrospectively reviewed. ETV combined with biopsy and endoscopic biopsy alone was performed in 36 and 41 patients, respectively. The frequency of LTD was compared between the groups.
Results: There were more patients with germinomas in ETV combined with biopsy group than in endoscopic biopsy alone ($p < 0.001$). In ETV combined with biopsy group the average age was younger ($p = 0.005$), and the proportion of pineal body tumors was higher ($p = 0.014$) compared with those with endoscopic biopsy alone. Between the patients with ETV combined with biopsy (31/36) and endoscopic biopsy alone (35/41), there was no significant difference in the proportion of malignancies ($p = 0.91$). The frequencies of LTD were not different between ETV combined with biopsy (8.3%) and endoscopic biopsy alone (9.8%). Histological diagnoses of LTD were nongerminomatous germ cell tumor, anaplastic astrocytoma grade 3, glioblastoma, pineoblastoma, and pineal parenchymal tumor of intermediate differentiation. LTD was not observed in the benign tumor group.
Conclusions: Combining ETV and biopsy did not increase the frequency of LTD compared with endoscopic biopsy alone in patients with IVPVTs. Based on histological diagnoses of disseminated tumors, the biological characteristic of tumors is a risk of LTD.

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Myelin basic protein in the cerebrospinal fluid of patients with idiopathic normal pressure hydrocephalus

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Introduction: The clinical role of the myelin basic protein (MBP) measurement in the cerebrospinal fluid (CSF) for the evaluation of hydrocephalus has not yet been established. This study aimed to examine the MBP value in the CSF in the ventricle and/or lumbar canal in adult patients with idiopathic normal pressure hydrocephalus (iNPH).
Methods: This study included 14 adult patients clinically diagnosed with iNPH in our hospital. The CSF was collected via a lumbar puncture for 6 iNPH patients, and a ventricle puncture during shunt surgery in all patients.
Results: All MBP values from the lumbar and shunt valve punctures were within the normal range (< 40 pg/ml). On the other hand, all MBP values from the ventricle CSF were high, ranging from 67 to more than 2000 pg/ml. The ventricle MBP concentration increased following the clinical progression of the symptoms in patients with hydrocephalus. Gait disturbance and incontinence were not observed for patients with low ventricle MBP values. Clinical improvement was mainly observed in hydrocephalus patients with low ventricle MBP values.
Conclusions: The ventricle MBP value may become an index of the destruction of the cerebrum and a predictor of clinical improvement following shunt surgery.

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By referring to preoperative 3D MRI, inter-rater reliability of callosal angle can be obtained even with 5 mm thick CT

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Introduction: While Evans index changes little after shunt surgery, callosal angle changes by about 20 degrees, which may be a good indicator of shunt function. However, the value of callosal angle changes greatly if the measurement position shifts. With 3D MRI, it is not difficult to identify the coronal plane to be measured. We investigated whether there is inter-rater reliability when measuring callosal angle using 5-mm-thick head CT scans during routine outpatient follow-up.
Methods: Using head CT scans of 5 mm thick slices taken one week after surgery in 10 recent cases of lumbar peritoneal shunt surgery, an examiner who was accustomed to measuring callosal angle and an examiner who had never measured callosal angle measured callosal angle. Inter- rater reliability was calculated when subjects were simply instructed to measure callosal angle on MPR images in a coronal section passing through the posterior commissure and perpendicular to the AC-PC line on routine CT. Next, we compared and examined the inter-examiner reliability when remeasuring callosal angle using the 3D MRI images which were used to measure the corpus callosum angle before surgery.
Results: When the preoperative MRI images were not referred to, the difference between the two was 0.9 to 22.1 degrees, and the inter-rater reliability ICC (2,1) was 0.42, which was determined to be unreliable. On the other hand, when the preoperative MRI image was used as a reference, the difference between the two was 0.3 to 14.3 degrees, and the inter- rater reliability ICC (2, 1) was 0.73, which was determined to be reliable.
Conclusions: Measurement of the corpus callosum angle may reflect postoperative shunt function, and inter-examiner reliability can be improved by referring to preoperative 3D MRI images even with 5-mm-thick slice CT.

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Near-infrared fluorescence indocyanine green mice cisternography for normal and hydrocephalus mice

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Introduction: We established an in vivo imaging method of mice cerebrospinal fluid (CSF) space and movement using near-infrared fluorescence.
Methods: At first, we injected trypan blue solution into lumber subarachnoid space and removed the brain and spinal cord 4 h after the injection. Trypan blue distributed brain and spinal cord surface and we confirmed the efficacy of our method of subarachnoid space injection. After general anesthesia and lumber laminectomy, nude mice were injected with an indocyanine green solution into the lumbar subarachnoid space. Nude mice were exposed to near-infrared light and emission light was detected with a cooled CCD camera. The presence and movement of indocyanine green in subarachnoid space were imaged. Hydrocephalus was induced in newborn mice with intracranial injections of transforming growth factor.
Results: Cisterna magna and cerebello-pontine angle cistern were clearly delineated and the time-intensity curve demonstrated CSF flow and wash-out. Image acquisition was rapid and repeatable. The equipment was portable and not expensive. Spatial resolution was sufficient and time resolution was excellent. Hydrocephalic mice showed diminished intracranial CSF flow.
Conclusions: Our system is sufficient to show altered CSF flow in a mouse hydrocephalus model. Optical imaging using near-infrared is an effective modality to image CSF space and movement. This novel method introduced new opportunities for in vivo imaging of small animals. In the future, it may be possible to apply this method for clinical human imaging of CSF space.

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Strategies for neuroendoscopic evacuation of hypertensive thalamic hemorrhage to avoid acute and chronic hydrocephalus

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Introduction: Neuroendoscopic evacuation rescues patients with hypertensive thalamic hematoma. However, acute noncommunicating and chronic communicating hydrocephalus persisted in some patients even after evacuation. Risk factors for the development of hydrocephalus were analyzed, and surgical strategies are discussed.
Methods: From 2010 to 2024, 29 patients (19 men and 10 women, aged 66.3 years) underwent surgery. Patients were classified according to the mechanism of cerebrospinal fluid pathway obstruction: hematoma filling the third ventricle (filling type, n = 17) and hematoma shifting the third ventricle (shift type, n = 12). Acute and chronic hydrocephalus were defined as patients dependent on ventricular drainage for more than 7 days after surgery and patients requiring a ventricular peritoneal shunt, respectively. Pre- and postoperative intraparenchymal and intraventricular hematomas were evaluated as risk factors for hydrocephalus.
Results: Acute hydrocephalus and long-term drainage dependency were observed in four patients (24%) with the filling type. The postoperative amount of intraventricular hematoma was a risk factor ($p = 0.02$). Those of the shift type were observed in 5 patients (42%). The postoperative amount of intraparenchymal hematoma was a significant factor ($p = 0.01$). Chronic hydrocephalus was observed more frequently in the shift type (33%) than in the filling type (6%, $p = 0.03$). The risk factors for shift type were postoperative intraventricular

(p = 0.002) and intraparenchymal (p = 0.03) hematomas. In contrast, preoperative hematoma volume did not influence any outcome.
Conclusions: Reducing intraventricular hematoma in the filling type and intraparenchymal hematoma in the shift type was effective for managing acute hydrocephalus. Avoiding chronic hydrocephalus is necessary to reduce intraventricular and intraparenchymal hematomas.

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The utility of instrumental, clinical, and radiological methods of diagnosis in Idiopathic Normal Pressure Hydrocephalus: a systematic review
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Introduction: Idiopathic Normal Pressure Hydrocephalus (iNPH), also known as Hakim-Adams Syndrome is an often-missed diagnosis which mainly affects elderly patients. The condition is characterized by the triad of: gait instability, urinary incontinence, and cognitive decline. While effective treatment strategies for iNPH exist, mainly through cerebrospinal fluid (CSF) diversion, the challenge of achieving a prompt, accurate diagnosis remains. In this study, we sought to systematically analyze both instrumental, and radiologic means of diagnosing iNPH.
Methods: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), we systematically searched PubMed, from inception to February 6th, 2024 for studies which satisfied our inclusion criteria. These criteria included: only English language studies performed on human subjects which performed any clinical, instrumental, or radiologic methods of diagnosing iNPH, with reported outcomes of CSF diversion. Our search yielded a total of 475 articles, 136 of which were included after full-text review.
Results: Our preliminary results revealed the following: we included a total 10,247 patients. 73% (100/136) of studies examined the presence of ventriculomegaly while only 52% (71/136) looked at Evan's Index (EI). 52% (71/136), 17% (23/136) and 20% (27/136) of all studies performed preoperative instrumental testing through tap test (TT), external lumbar drainage (ELD), or lumbar infusion testing (LIT), respectively, as either part of an institutional diagnostic method for confirming iNPH, or to predict shunt responsiveness. Gait testing was performed in 94% (128/136) of studies reviewed.
Conclusion: The current data strongly suggest a trend towards non-instrumental methods of diagnosing iNPH with a preference towards radiologic and clinical means instead. However, the variability between the use of these means remains a limiting factor and further analysis for elucidating their accuracy is required.

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Risk factors for idiopathic normal pressure hydrocephalus (INPH): a study from the Shizuoka National Health Insurance (Kokuho) database
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Introduction: Risk factors for the onset of idiopathic normal pressure hydrocephalus (iNPH) have been reported to include older age, male, hypertension, diabetes mellitus, hyperlipidemia, obesity, and depression. No large-scale database studies have been reported in Japan. The Shizuoka National Health Insurance database (Kokuho) was used to explore the risks associated with the onset of INPH. The analysis was conducted on the Shizuoka National Health Insurance database which enrolls in Shizuoka Prefecture from April 2012 who had undergone specified health examinations.
Methods: The starting point for the analysis was either the date of insurance enrolment or 1 April 2012, and the period up to the occurrence of the disease was defined as the observation period. The INPH was defined as those who had undergone hydrocephalus shunt surgery (claim code: 150,301,710) and had no previous injury or illness that could have caused secondary hydrocephalus. In addition to the previously reported risk factors, common chronic diseases and health examination items were used as candidate risk factors, and multivariate analysis was conducted using the Cox proportional hazards model to identify risk factors.
Results: Of the 509,428 cases analyzed, hydrocephalus surgery was performed in 31,328 cases, 169 with INPH and 27,833 with secondary hydrocephalus. In multivariate analysis, risk factors were identified as male (HR 1.80, 95% CI 1.01–2.95), systolic blood pressure (HR 3.06, 95% CI 1.38–6.78), depression (HR 2.36, 95% CI 1.20–4.62) and rheumatic diseases (HR 2.92, 95% CI 1.26–6.75) and identified as risk factors. On the other hand, no significant differences in LDL cholesterol, HgbA1c, and BMI were found between the groups.
Conclusions: In addition to the previously reported risk factors of males, high blood pressure and depression, a history of rheumatic disease was identified as a risk factor for imp. A further prospective observational study is currently underway in this database.

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Successful endoscopic third ventriculostomy for a patient with 40 years of ventriculoperitoneal shunt dependency: a case report
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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:88

Introduction: Ventriculoperitoneal shunt (VPS) malfunction is a common complication in patients suffering from hydrocephalus. The standard treatment for VPS malfunction has traditionally been shunt revision, especially for patients who have been reliant on the shunt system for an extended period.
Case presentation: This report details the case of a 40-year-old male patient who had been dependent on a VPS since infancy due to neonatal meningitis. Despite his long-term dependence on the shunt and the infectious origin of his condition, he successfully underwent an endoscopic third ventriculostomy (ETV) for VPS malfunction. The successful management of his hydrocephalus via ETV was attributed to the presence of aqueductal stenosis and the preservation of his cerebrospinal fluid absorptive capacity.
Conclusions: This case indicates that even patients who have been reliant on a VPS since infancy, irrespective of the duration of reliance or infectious etiology, may potentially be weaned off the shunt system through the application of ETV. This suggests a promising alternative treatment pathway for similar cases in the future.
Note: Consent to publish has been obtained by the patient.

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Endoscopic surgery in thalamic hemorrhage with ivh provides prevention secondary hydrocephalus and cost-effectiveness
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Introduction: Thalamic hemorrhage with intraventricular hemorrhage (ThH + IVH) was often reported to be relevant to incidence of secondary hydrocephalus. IVH causes hydrocephalus for mechanical and chemical reasons. It was recently reported that hematoma iron

causes ependymal cell damage and cilia damage, leading to ventricular enlargement. Based on these previous reports, prompt removal of IVH is expected to prevent hydrocephalus.
Methods: 3Cases; Patient A is a 60-year-old man. He underwent ventricular drainage for left ThH. He required long-term drainage management and underwent shunt surgery on day 43. Patient B is an 80-year-old woman who underwent ventricular drainage for left ThH. As the hematoma resolved, cerebral edema and hydrocephalus worsened, and the intraventricular and thalamic hemorrhage was removed by endoscopic surgery on day 19. Patient C is an 85-year-old man. Endoscopic removal of an Rt. ThH + IVH was performed on the onset day. ventricular drainage was performed, but the hydrocephalus resolved and the drainage was removed on the 2 days after operation.
Results: In ICH + IVH, drainage alone promotes drainage of excess spinal fluid and contributes to improvement of hydrocephalus, but does not remove the hematoma, mechanical obstruction and hematoma-induced chemical toxicity are unavoidable.
In fact, both drainage cases showed progressive cerebral edema and worsening hydrocephalus in the subacute phase. This is also the time when hemoglobin is metabolized to methemoglobin. The intraventricular environment deteriorated due to damage to the ventricular walls and increased intracranial pressure, resulting in progressive cerebrospinal fluid circulatory failure. It is speculated that endoscopic surgery can simultaneously release the mechanical and chemical factors of the hematoma by promptly removing the hematoma, thus avoiding hydrocephalus. We also expected that it would be appropriate to perform the surgery before the hematoma hemoglobin is metabolized to methemoglobin.
Conclusions: We discussed the possibility of a treatment that could avoid secondary hydrocephalus to ThH + IVH.
Note: Consent to publish has been obtained by the patients.

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Extradural arachnoid cyst: an extremely rare complication associated with lumboperitoneal shunt

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Introduction: The Lumboperitoneal shunt (LPS) is a safe and effective procedure used to manage idiopathic normal pressure hydrocephalus (iNPH). However, there have been reports of some complications related to the spinal catheter.
Methods: This paper describes a case of cauda equina syndrome induced by an extradural arachnoid cyst (EDAC) eight years after the implantation of an LPS. It presents the treatment for the EDAC and reviews the literature on other complications associated with the spinal catheter of LPS and the epidemiological features of spinal EDACs.
Results: The EDAC was reduced in size by converting from LPS to a ventriculoperitoneal shunt (VPS). Radicular pain is the most common, yet rare (comprising less than 5%) complication in LPS. EDACs, primarily found in the thoracic spine, account for 1%–3% of spinal tumors and are typically treated by surgical removal. To our knowledge, EDACs associated with LPS have not been reported previously.
Conclusions: This is the first report indicating that a symptomatic EDAC can occur in conjunction with the lumbar catheter of the LPS. Invasive lumbar surgeries may not be necessary for this condition.

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Ancient schwannoma masking diagnosis of Secondary Normal Pressure Hydrocephalus in a 65-year-old male presenting with gait instability: a systematic review and illustrative case

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Introduction: NPH can present as primary or secondary. Recent studies indicated that most symptoms can emerge early, while some showed delayed onset. These differences in patterns underscores the complexity of NPH relationship with its underlying causes and highlights the need for further research to elucidate the temporal dynamics of its development, aiding in early detection and appropriate management strategies.
Methods: We report a case of a 65-year-old male diagnosed of sNPH, initially treated for a confounding left cerebellopontine angle schwannoma. A systematic search was conducted using MeSH keywords "Secondary Normal Pressure Hydrocephalus", "Intracranial Tumors" and "Normal Pressure Hydrocephalus" in February 2024, across multiple databases. A total of 504 records were identified, wherein 110 articles were excluded and only four studies satisfied the inclusion criteria.
Results: A total of 1312 cases were identified and diagnosis of NPH made through clinical history, PE and imaging studies. Of the etiologies identified in 2 studies, SAH accounted for 46.5%, post-traumatic 29%, and malignant pathology for 6.2% only. VPS insertion was the preferred treatment in all of the studies. In the study of Daou, 84.2% of patients with sNPH from SAH improved after shunt insertion, while 83% of patients with post-traumatic sNPH and 86.4% of patient with tumors, which is similar to the other studies.
Conclusions: Prompt identification of sNPH is crucial because its outcomes differ from iNPH. A comprehensive evaluation to determine the etiology of sNPH is indispensable in guiding appropriate management strategies to ensure optimal outcomes for affected individuals.
Note: Consent to publish has been obtained by the patient.

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The clock drawing test findings in patients with iNPH

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Introduction: The Clock Drawing Test (CDT) is a simple test, just asking patients to draw a clock image of a given specific time of 10:10, for evaluating cognitive function. We reported the effectiveness of the CDT in the Tap Test (TT) in the Hydrocephalus 2023 conference. In this report, the purpose is to know the characteristics of CDT findings in the patients with iNPH, we retrospectively assessed our data of CDT in the TT.
Methods: 38 consecutive patients with iNPH without comorbid neurodegenerative dementia (e.g., Alzheimer disease (AD)) were included in this study. Mistakes in the clock image drawn were counted according to Freedman's 15-point scoring method, and compared to the data of patients with AD which was previously reported.
Results: The mistakes were numbers not in the correct position by 74%, The center of the clock was not drawn by 47%, and also The minute hand did not indicate the correct number by 45%. These misdrawn points were improved by CSF drainage. The pattern of mistakes was similar to patients with AD. Patients with iNPH showed lower scores in the CDT than in the MMSE (MMSE: 23.7 ± 5.0, CDT: 10.2 ± 3.2), conversely, patients with AD showed higher scores in the CDT than in the MMSE (MMSE: 19.8 ± 4.7, CDT: 11.5 ± 3.4).
Conclusions: Unbalanced clock images are drawn by patients with iNPH, similar to patients with AD. However, patients with iNPH may be worse at drawing the correct images than patients with AD.

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Practical aspect of ventriculo-atrial shunt: surgical technique, operation time, and anesthesia time

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Introduction: Since 2004, we have treated normal pressure hydrocephalus by means of ventriculo-atrial shunts (VAS). The surgical technique has not been changed after making minor modifications in 2019. The purpose of this study is to investigate retrospectively the operation time and the duration of hospital stay with description of our current surgical technique.
Methods: One hundred and seventy-eight consecutive NPH cases received VAS under general anesthesia (2020 Jan to 2024 Feb) were retrospectively investigated. The ventricular catheter was inserted through occipital horn with vertical occipital incision and the atrial catheter was inserted directly through internal jugular vein (IJV) with horizontal neck incision. Operation time and the days of hospital stay were investigated with reference to previously reported operation times for various types of CSF shunt surgery for NPH. Data were shown in median (IQR).
Results: Median age was 80.0 years old (74.0—84.0). Median operation time was 27.5 min (25.0 – 32.0). Median days of hospital stay were 12.0 days (11.0 – 13.0).
Conclusions: Previously reported operative times for various types of CSF shunt surgery for NPH are as follows: VP shunt (37.5 min(median, Surg Endosc 23; 1449–1455, 2009) to 65 min (mean, J Neurosurg 105; 869–872, 2006), LP shunt under general anesthesia (3838–72.4 min (mean, J Neurosurg Spine 32; 548–553, 2020), VAS under local anesthesia (59.5 min (mean, World Neurosurg 166; 135–140, 2022), and LP shunt under local anesthesia (42 mIn (median, unpublished data, 2020). Days of hospital stay: VP shunt (13 cdays(median, Surg Endosc 23; 1449–1455, 2009). The operative time and hospital stay days for VAS under general surgery were shorter than previously reported values. VAS can be the first line surgery for NPH.

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The impact of an advanced clinical practitioner in improving and developing the NPH service

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Introduction: Advanced Clinical Practitioners (ACP) are increasingly being utilized in the United Kingdom to transform service delivery and meet the population's increasing health needs. ACPs are non-medical healthcare professionals, educated at master's degree level and trained to make autonomous decisions in the assessment, diagnosis, and treatment of patients. With increasing pressure on our NPH service we developed an ACP role to improve service capacity, efficiency and enhance the patient experience.
Methods: Following a period of training and mentorship the ACP role was established in October 2021. Prospective evaluation of the role's impact was undertaken up to March 2024, and compared against historic data. Two new ACP-led services were created: a dedicated diagnostic clinic undertaking high-volume lumbar puncture (LP) to reduce the waiting list for inpatient extended lumbar drain (ELD) tests; a post VP shunt follow-up service to improve longitudinal follow-up and patient access to the NPH service.
Results: Following selection in a multidisciplinary clinic, 65 patients were assessed and had high-volume lumbar puncture performed in the ACP-led diagnostic clinic. Of these, 37 patients (57%) were offered a shunt without the need for ELD, 14 (22%) proceeded to ELD and 14 (22%) declined further investigation. This avoided 51 patient admissions and 153 bed days. Over a 17-month period, 60 patients were seen in the follow-up clinic amounting to 83 h of clinical time.
Conclusions: We have demonstrated the successful introduction of an ACP-led service to reduce the pressure on inpatient resources and consultant clinical time. Furthermore, this service provides continuity of care and enables improved access for patients. Measures of patient satisfaction are ongoing and cost–benefit analysis is planned. This model, as part of a multidisciplinary approach, provides an alternative to the traditional consultant delivered service.

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Utility of Patient Reported Outcome Measures in assessing improvement in health following ventriculoperitoneal shunt insertion

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Introduction: Patient reported outcome measures (PROMS) have been integrated within the UK NHS to inform improvement in quality of care. The importance of PROMs in demonstrating the benefit to patients following ventriculoperitoneal shunt insertion has the potential to transform health care provision into a more patient-centered model.
Methods: Patients who underwent ventriculoperitoneal shunt (VPS) insertion for Normal pressure Hydrocephalus between 01 July 2022 – 31 January 2024 were included. Patients were invited to complete questionnaires on their general health (EQ-5D-5L) alongside a clinician-rated assessment of symptoms (iNPH grading scale) prior to VPS shunt insertion (baseline) and at 6 months post-surgery.
Results: Twenty-one patients underwent VPS insertion (15 Male, 6 Female). Mean (SD) age was 75(±6) years. 19 patients (90%) reported an improvement in their overall health (EQ-VAS). Mean (SD) VAS Score increased from 62(±16)% to 70(±12)% ($p<0.05$). Whilst patient-reported health improvement was seen in all five domains of the EQ-5D-5L, most significant improvement was in the "Mobility" and "Usual Activities" domains with median score improving from 3 ("moderate problems") to 2 ("slight problems") ($p<0.05$). Median iNPH grading scale improved from six to three at six months post shunt insertion ($p<0.05$), with the domains of gait and memory having the most improvement.
Conclusions: Patients with suspected iNPH treated with a VPS report an improvement in their overall health 6 months after surgery. We continue to integrate the use of PROMs as a key endpoint within individual patient care as it builds relationships with patients, enhances clinical encounters, and validates shared decision making. PROMS completion and feedback supports the evaluation and development of the NPH service to ensure better health outcomes.

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The Influence of Cerebrospinal Fluid Protein Concentration and Volumetric Bulk Flow Rate on Polydimethylsiloxane Shunts used to Treat Hydrocephalus

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Introduction: Hydrocephalus is often characterized by a misbalance between production and absorption of cerebrospinal fluid (CSF). Insertion of a shunt system to divert CSF and reduce any heightened intracranial pressure is common, but high shunt failure rate necessitates costly revisions and a potential decline in quality of life for the patient and their caregivers. Shunts consist of two polydimethylsiloxane (PDMS) catheters connected by a one-way pressure valve to regulate CSF outflow. Shunt obstruction is the most significant form of shunt failure, and current preventive measures are limited. Retrospective analyses of explanted shunt catheters reveal substantial astrocyte and macrophage attachment and a significant overexpression of proliferation markers.
Methods: This study investigates the impact of CSF flow rate and protein content on PDMS surface protein adsorption, hypothesizing a connection to shunt obstruction. We utilized a novel in-vitro setup to create an efficient method for quantifying protein adsorption through fluorescence spectroscopy and mapping protein adsorption through confocal imaging. An in-vitro platform utilizing reciprocating pumps was employed to mimic CSF flow and evaluate performance of flat polydimethylsiloxane (PDMS) catheters under 18, 58, and 150 mg/dL, representing the physiological range of albumin protein concentration conditions in a high-throughput pulsatile flow manner. The PDMS catheters were also subject to 0.1, 0.3, and 0.7 which represents the physiological range of volumetric flow of CSF.
Results: The results revealed a strong positive correlation between both protein concentration in solution and protein adsorption, and volumetric bulk flow rate and protein adsorption on PDMS. A multivariate linear regression model resulted in an adjusted R^2 value of 0.968 ($p < 0.001$).
Conclusions: The study underlines the potential role of protein adsorption in shunt obstruction, stresses the need for physiologic flow simulation in in-vitro models, and leads to a potential link between patient CSF protein content and predictive analytics of cellular attachment, proliferation, and ultimately shunt obstruction.

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Initiation of a global collaborative research between South Korea, Japan, and Thailand for the development of a comprehensive Hakim's disease management system based on multimodal factors including voice, gaze, hearing, gait, and balance

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Introduction: South Korea is experiencing the fastest aging population in the world, with over 10 million elderly individuals aged 65 and older and 1 million living with dementia. In response, since 2020, the Ministry of Health and Welfare and the Ministry of Science and ICT have collaboratively established the Korea Dementia Research Center (KDRC) to implement national support initiatives. A significant project focusing on Hakim's disease has been awarded to our global consortium involving institutions from South Korea, Japan, and Thailand.
Methods: Hakim's disease, a treatable form of dementia characterized by gait, cognitive impairments, and urinary incontinence, often presents subtly, complicating early diagnosis. Recent studies on non-invasive biomarkers such as voice, gaze, hearing, gait, and balance have shown promising results in various degenerative brain diseases, including potential indicators for Hakim's disease. Based on dramatic improvements observed pre- and post-surgery, the consortium aims to collect time-series data on these multimodal factors to facilitate early diagnosis and track disease progression.
Results: The KDRC will commit $2.2 million over three years for this initiative. Key contributors include Dr. Shigeki Yamada from Nagoya City University Graduate School of Medical Sciences in Japan, and Mahidol University Faculty of Medicine Ramathibodi Hospital in Thailand. This multinational effort will focus on identifying biomarkers that aid in screening for Hakim's disease, with findings to be presented at the annual meeting of the International Society for Hydrocephalus and Cerebrospinal Fluid Disorders. The ultimate goal is to develop innovative medical devices for managing and preventing Hakim's disease, potentially transforming the paradigm of dementia care.
Conclusions: This report aims to garner support and participation from additional countries and institutions, reflecting the global scope and significance of this initiative. The development of global diagnosis and management devices for Hakim's disease could revolutionize the speed and effectiveness of diagnosis and treatment.

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Novel connectomic biomarkers for identifying possible idiopathic normal pressure hydrocephalus patients with high disproportionately enlarged subarachnoid space hydrocephalus (DESH) score

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Introduction: Disproportionately enlarged subarachnoid space hydrocephalus (DESH) is crucial for identifying patients with idiopathic normal pressure hydrocephalus (iNPH). However, its associated cerebral dysfunction remains unclear, with no established role for functional imaging in managing iNPH patients. This study aims to compare cortical network functional connectivity (FC) in DESH-high versus DESH-low possible iNPH patients and provide novel connectomic biomarkers for understanding DESH's pathophysiology.
Methods: Between 2017 and 2023, possible iNPH patients were retrospectively reviewed and prospectively recruited. The iNPH grading scale (iNPHGS) and DESH score quantified clinical symptoms and structural imaging. An optimal individual metabolic brain network model extracted FC from fluorodeoxyglucose positron emission tomography (^{18}FDG-PET). Cerebral cortex areas were divided into five subnetworks, and the performance of isolated and interactions between subnetworks was compared using parametric analyses. Machine learning methods extracted connectomic biomarkers, with linear regression confirming functional imaging's role.
Results: Of 35 possible iNPH patients, 25 had DESH ≥ 5 (G1) and 10 had DESH < 5 (G2). Firstly, iNPH patients exhibited lower FC than NC. Among iNPH patients, G1 showed lower global FC than G2. However,

there was no difference in subnetwork FC between G1 and G2. The interactions between subnetworks revealed a decrease in performance of the frontoparietal network to cingulo-opercular network (FPN-CON), interactions within FPN, and within CON in G1 compared to G2. Secondly, the left middle frontal gyrus, right hippocampus, and left angular gyrus were identified as the top three regions differentiating G1 from NC. Finally, the DESH score correlated with iNPHGS and network indices, respectively, emphasizing the versatility of DESH and supporting the role of FC.
Conclusions: Reduced cerebral network FC and dysfunction of subnetwork interconnection were confirmed as pathognomonic for possible iNPH patients. ^{18}FDG-PET-generated network indices potentially serve as a predictive biomarker for iNPH.

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Magnetic Resonance Imaging Texture Analysis (MRTA) in patients affected by probable idiopathic Normal Pressure Hydrocephalus

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Introduction: Magnetic Resonance Imaging Texture Analysis (MRTA) is an emerging application of radiomics that can detect subtle MR signal fluctuation and obtain latent image information not visible among pixels. This study aimed to compare seven different MRTA derived parameters (Intensity Based Mean Absolute Deviation, Intensity Based Under the Curve, Intensity Histogram Mean, Intensity Histogram Variance, Intensity Histogram Skewness, Intensity Histogram Kurtosis, Intensity Histogram Median) among a group of patients affected by probable iNPH.
Methods: 40 patients diagnosed with probable iNPH were submitted to a diagnostic MR examination, including a 3D-T1W MPRAGE sequence, on a 3.0 Tesla-Magnet before a lumbar infusion and Tap-Test. Twenty-five patients were positive for the invasive test (Positive Patients group, PP), while 15 were negative (Negative Patients group, NP). MRTA different derived parameters were calculated from 2 different volumes of interest (VOIs) covering deep and periventricular white matter of the corona radiata of both hemispheres. Comparison between the distribution of MRTA derived parameters among the two different groups of patients and correlation with invasive test results were performed with a parametric welch Two Sample t-test.
Results: Relevant differences were found in the Intensity Base Mean Absolute Deviation (101.54 vs 70.19; p = 0,029) distribution between the PP and NP groups. No statistically significant differences were observed in the distribution of the other variables, although all second-order Histogram MRTA features were higher in the PP group than in the NP group.
Conclusions: the results indicate that MRI Texture Analysis could be a promising non-invasive technique for evaluating patients affected by probable iNPH.

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Differential diagnosis of posttraumatic ventriculomegaly in unresponsive wakefulness and minimal consciousness state patients: hydrocephalus or atrophy?

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Introduction: Differential diagnosis of posttraumatic ventriculomegaly remains a problem especially in patients with severe disorders of consciousness due to the absence of clear diagnostic criteria for surgery.
Methods: Twenty-three patients with posttraumatic ventriculomegaly in either unresponsive wakefulness or minimal consciousness state were included in a prospective study. All the patients underwent a unified high-resolution magnetic resonance (MR) study including T2 CUBE in sagittal plane and MR-cisternography. In cases of communicating hydrocephalus, pseudo continuous arterial spin labelling (pCASL) MR perfusion was performed to evaluate cerebral blood flow (CBF) in several regions of interest. Later patients underwent a standard tap-test with dynamic neurological assessment and a repeated evaluation of CBF was performed. Twenty patients with neurological improvement and or obstructive hydrocephalus were shunted. Three patients have shown no clinical improvement after tap-test and were not operated on.
Results: High resolution MRI revealed focal damage in various structures of the brain while the level of injury affected the outcome of treatment. Intraventricular obstruction preoperatively was diagnosed in 17,7% of cases and changed surgical strategy in all cases. Significant improvement after surgical treatment was achieved in 15 cases (75%). Unsatisfactory results were observed in 5 cases with a mortality rate of 5%. Shunt-infection complicated post-operative course in 3 cases. Changes of CBF measured by MRI in pCASL varied greatly in each case and without correlation between the changes in CBF and clinical improvement.
Conclusions: Damage to the deep structures of the brain affects the outcomes of shunting. Shunting of posttraumatic hydrocephalus improves the outcomes and facilitates rehabilitation of patients with severe disorders of consciousness.

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Factors that improve ETVSS reliability in pediatric hydrocephalus cases

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Introduction: Endoscopic third ventriculostomy (ETV) is an effective treatment for hydrocephalus. However, its application in pediatric cases requires careful consideration, as there may be discrepancies between the predicted efficacy using the ETV success score (ETVSS) and the actual surgical outcomes. Therefore, in this study, we examined the outcomes of ETV procedures performed at our institution and investigated factors that could influence these outcomes, aiming to identify additional predictors of efficacy beyond ETVSS.
Methods: We retrospectively analyzed 27 cases of ETV performed at our institution in three years (mean age: 7.3 years; range: 6 months to 22 years; male: 14, female: 13). We defined effectiveness of ETV not only as successful shunt removal or avoidance but also as a reduction in shunt dependency. We compared ETVSS, preoperative developmental status, third ventricular ballooning, and brain parenchymal thickness between the effective and ineffective groups and examined their associations.
Results: There were 15 cases in the effective group and 12 cases in the ineffective group, with an overall effectiveness rate of 55.5%. The mean ETVSS was 70.6 in the effective group and 65.8 in the ineffective group, with no significant difference between the two groups ($P = 0.144$). In the effective group, there were 11 cases with good developmental status and 4 cases with developmental delay, while in the ineffective group, there were 4 cases and 8 cases, respectively, suggesting a potential association between developmental status and ETV effectiveness ($P = 0.057$). No significant differences were observed in other factors such as ballooning and brain parenchymal thickness.

Conclusions: Developmental status may influence the effectiveness of ETV, even in cases with similar ETVSS scores. Evaluating preoperative developmental status in addition to ETVSS may be useful in predicting the effectiveness of ETV in each case.

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Trans-burr hole ultrasound to confirm Reflow System Mini function and proximal catheter patency in a hydrocephalus patient with a ventricular shunt

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Introduction: The only current methods for determining proximal catheter patency in a ventricular shunt require percutaneous reservoir tap. Egress of cerebrospinal fluid (CSF) is then interpreted. A radiotracer can also be injected and imaged via positron emission tomography (PET), but the results may be nondiagnostic, and the workflow is cumbersome. Tapping the reservoir requires shaving hair, introduces risk of infection, and may encourage ventricular collapse around the catheter causing obstruction. Dynamic real time imaging of the ventricular system post-operatively through the burr hole via ultrasound provides an alternative when a proximal catheter flushing mechanism is in place, such as the Reflow System Mini.
Methods: A patient with idiopathic intracranial hypertension (IIH) underwent ventriculoperitoneal shunt implantation as standard of care, with placement of a Reflow System Mini in series proximal to the differential pressure valve. A 2 cm sonolucent PMMA burr hole cover was placed to reconstruct the burr hole. Transcutaneous, trans-burr hole ultrasound was performed using a phased array probe on a point of care system.
Results: The patient presented for outpatient follow up at 4 weeks and 10 weeks post-operatively. At both visits, he complained of persistent headache. Ultrasound was performed of the ventricular system while the Reflow System Mini was depressed to create a proximal flush. During the flush, tissue deformation was seen, including bowing of the septum to the contralateral side. This technique was able to confirm proximal catheter patency on both occasions. This was well tolerated and there were no complications, including infection.
Conclusions: Trans-burr hole ultrasound in post-operative hydrocephalus patients is establishing as a technique for ventricular imaging. While previous reports have focused on feasibility of static imaging for quantitation, this report serves as an example of using it for dynamic imaging to confirm proximal catheter patency and Reflow device function.

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Starting off right: optimal initial shunt valve setting for Hakim's disease (iNPH) patients

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Fluids and Barriers of the CNS 2024, **21(Suppl 1)**:203

Introduction: Ventriculoperitoneal (VP) shunt is the mainstay treatment of Hakim's disease (idiopathic NPH). Optimizing VP shunt valve settings to alleviate these symptoms while minimizing over-drainage-associated complications has been a conundrum. This study aims to characterize the optimal initial valve setting that would strike a balance between achieving optimal improvement and minimal risk of over-drainage, based on objective and subjective outcome parameters.
Methods: A single-centre retrospective observational study was conducted on Hakim's disease patients who had the Miethke M. blue plus VP shunt inserted following a positive trial of lumbar drain. Initial valve pressure settings and clinical outcomes were retrieved retrospectively from electronic patient records. Exclusion criteria were secondary NPH and insertion of shunt systems besides M. Blue plus. Patients' 10-m walking speed was the objective outcome parameter while subjective outcomes referred to patient/carer-reported symptoms.
Results: Ninety patients underwent Miethke M. Blue plus VP shunt insertion between May 2020 and July 2023, of whom 38 were females (42.2%) and 52 were males (57.8%). Mean age was 77.7 ± 7.10. The mean opening pressure of the adjustable (proGAV 2) component was 5.75 ± 1.90 mmHg whereas the mean gravitational unit opening pressure (M. blue) was 30.3 ± 3.61 mmHg. The mode was 5/30 mmHg (n = 49, 54.4%). Patients whose initial valve pressures were set at 5/30 mmHg showed significant objective clinical improvement in terms of walking speed compared to their pre-lumbar drainage (RR: 0.467, 95% CI, 0.161 to 1.354, p = 0.0804) and post-lumbar drainage (RR: 0.542, 95% CI, 0.258 to 1.14, p = 0.0523) timings. This clinical improvement at 5/30 mmHg was clinically significant compared to other valve pressure settings.
Conclusions: The initial VP shunt valve pressures were predominantly set at 5/30 mmHg in our institution. Our study affirms the efficacy of setting the initial valve pressures at 5/30 mmHg given the significant symptomatic improvement, objectively and subjectively.

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Colloid cysts natural history and patient subgroup analysis

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Introduction Colloid cysts are benign lesions found in the third ventricle that can clinically become symptomatic by causing obstructive hydrocephalus. Despite the availability of risk prediction scores aimed at guiding informed treatment strategies, data regarding the natural history and nuanced characterisation of patient subgroups are scarce.
Methods This is a single centre retrospective case series study of patients identified by screening the hospital's radiological report database of cross-sectional imaging from 2017–2022. Demographic data, clinical and radiological presentation, as well as treatment modality and outcomes were recorded.
Results 206 patients were included in the study, amongst which 138 colloid cysts were diagnosed incidentally. The mean follow up was 28.5 months (SD ± 54.29;min/max interval: 0–285 months). 75 underwent surgery, with 17 patients treated by shunt insertion, 35 endoscopic and 23 microsurgical resection (frontal transcortical or interhemispheric transcallosal approach). Patients requiring surgical treatment were younger (41.2;SD ± 14.07 vs 52; SD ± 17.9 years; p < 0.0036), had a higher degree of ventriculomegaly (FOHR 0.41;SD ± 0.06 vs 0.36;SD ± 0.04; p < 0.0001) and an increased cyst diameter (12.29; SD ± 5.47 vs 6.86; SD ± 2.74; p < 0.0001). Patients presenting with acute hydrocephalus were noted to have mixed signal intensities on MRI scan. There were three cases recorded of sudden death (mean age 29.3 years; mean cyst diameter 15.6 mm). Colloid cyst size reduction was observed on interval scans in 7 cases (mean

4.5 mm), with two recorded complete resolution. Of the 131 conservatively treated patients, 61 have a cyst diameter ≥ 7 mm. Colloid cyst risk scores were calculated and compared against clinical treatment decision.

Conclusion: This work provides an overview analysis of different subgroups of patients with colloid cysts.

Keywords: colloid cysts, natural history, colloid cyst risk score, hydrocephalus.

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Understanding hydrocephalus in subarachnoid hemorrhage

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Introduction Inflammation has been appreciated as playing a crucial role in hydrocephalus development via cerebrospinal fluid (CSF) overproduction in neonatal post haemorrhagic hydrocephalus or animal models. Toll-Like Receptor 4, expressed on the choroid plexus surface, are activated by blood breakdown products triggering a whole immune cascade, and stimulating proinflammatory cytokine production resulting in increased activity of STE20/SPS1–related proline/alanine-rich kinase (SPAK) and Na + /K + /2Cl– ion co-transporter (NKCC1) and subsequent CSF hypersecretion. This study investigates the relation between neuroinflammation and hydrocephalus development in patients with subarachnoid haemorrhage (SAH).

Methods This is an observational translational study involving patients with aneurysmal SAH requiring external ventricular- or lumbar drain insertion (EVD, LD). Over a period of 10 days, daily CSF samples were investigated for an extended biomarker panel (i.e. Olink 96 ® neuroinflammation) and correlated with the CSF production rate with the primary outcome of identifying differences in the level of CSF biomarkers that can predict hydrocephalus and shunt dependence. Secondary outcomes were to establish the relationship between CSF production rate and neuroinflammation.

Results 18 (12F, 6 M) patients with a mean age of 57.25 years (SD ± 13.52) were included. Aneurysms in the anterior circulation were predominant (16/18 patients). 89% of the patient underwent endovascular treatment. 50% (9/18) patients required EVD insertion on average day one following symptom onset. The majority of patients presented as WFNS 3–4, Hunt and Hess 3–4, Fisher grade 4. Preliminary data show a variability element in terms of CSF production amongst patients, with values ranging from 20–160 ml/h. CSF production appears to be increased in the first day following bleeding, decreased between days 5–8 only to increase again after day 9. Olink ® biomarker analysis will be performed in May/June 2024.

Conclusion Preliminary data shows that patterns could be identified between neuroinflammation, CSF production and hydrocephalus development in patients with SAH.

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Ventriculoperitoneal shunt insertion in palliative patients with hydrocephalus secondary to cerebral metastasis: a single-centre case series

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Background Ventriculoperitoneal shunt insertion is an important palliative procedure in the context of cerebral metastatic disease. This work serves the aim of identifying complications, risks and provide insight into the overall outcomes of palliative shunts with the goal of enhancing patient counselling.

Methods This is a single institution retrospective case-series study of patients with cerebral metastatic and/or leptomeningeal disease undergoing VPS insertion between 2019–2023. Patients with primary brain tumours were excluded. Demographic, clinical, and radiological data was derived from the electronic patient record.

Results 32 patients with a mean age at intervention of 58.2 years (SD ± 13.7) were included. The average Karnofsky Index was 67.4 with 50% scoring 0–1 on the ECOG scale. The most common tumour primary was breast, with 8 (25%) cases of invasive ductal carcinoma. 37.5% of cases had > 3 intracerebral metastases and 7 (21.9%) cases showed leptomeningeal carcinomatosis. The decision to insert a palliative shunt was made following discussion between neurosurgery and oncology in 56.3% of cases. 53.1% of patients reported subjective symptom improvement and 28.1% showed objective improvement in mobility. The median survival after intervention was 62 days (IR 28.8–164 days). 4 (12.5%) cases required revision after an average of 17 days (SD ± 18.3), this was due to shunt dysfunction and catheter displacement. Invasive ductal carcinoma was significantly associated with shunt revision ($X^2 = 10.0$, $p < 0.05$).

Conclusions Ventriculoperitoneal shunts effectively manage symptoms in patients with hydrocephalus secondary to cerebral metastasis (Fig. 1). The rate of complications we observed provides important context to consider during clinical decision making.

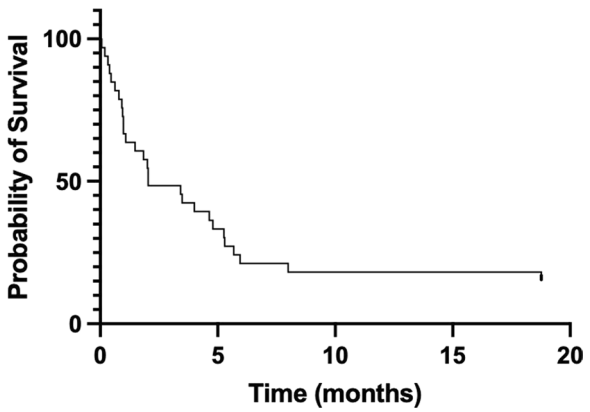

Fig. 1 A Kaplan–Meier Curve representing the survival rate of patients after ventriculoperitoneal shunts over time.

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Non-invasive fundoscopy as a tool to estimate intracranial pressure: an animal model

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Introduction: As monitoring of intracranial pressure (ICP) remains invasive, the demand for non-invasive modalities remains high. Several methods of non-invasive estimation of ICP have shown to be promising, but none have yet to be implemented. The relationship between the arteriole-venous-ratio (A/V-ratio) and ICP is well known but is not fully understood.
The purpose of this study is to investigate if non-invasive fundoscopy can estimate changes in ICP in pigs with controlled values of ICP.
Materials and methods: Six pigs were included. After sedation a burr hole was placed frontally on both sides of the skull. In one burr hole an intraparenchymal pressure monitor was placed for continuous ICP monitoring. In the other burr hole a catheter with a balloon was placed epidurally and the balloon was inflated to specific ICP-values. A fundoscopy video was obtained at baseline ICP and at specific values of ICP. A mixed-effect linear regression model with random intercepts was performed to assess association between ICP and A/V-ratio.
Results: Under 20 mmHg there was no significant change in A/V-ratio ($p = 0.987$). Over 20 mmHg there was a significant change in A/V-ratio with a coefficient of -0.0027 ($p < 0.001$). This makes it possible to distinguish relative changes in ICP. With an AUC of 0.659 it is currently difficult to estimate absolute values of ICP with this current version of the method.
Conclusion: Fast detection of elevated ICP is critical to avoid secondary brain injury. Fundoscopy is a cheap and easy to use modality that can be implemented outside of neuro intensive care unit. In poor countries it can serve as a tool for detection of raised ICP from infectious brain swelling with limited access to CT/MRI-scans. Further development of the method is required to estimate absolute values of ICP.
Keywords: ICP, Fundoscopy, Non-invasive, A/V-ratio, Intracranial pressure monitoring.

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Magnetic stability analysis of the SPHERA PRO programmable valve

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Introduction: Programmable valves enable personalized treatment for hydrocephalus patients. Bench tests have shown magnetic stability of the Sphera Pro valve when exposed to an electromagnetic field of up to 3T, without damage to the mechanism or deprogramming. The aim of this study is to analyze the magnetic stability of the valve concerning the maintenance of pressure programming in patients over a 2-year period.
Methods: 32 patients are being followed up with outpatient visits for a 2-year period. After valve implantation, regardless of the hydrodynamic diagnosis that prompted the surgery, patients were assessed at 10 days, 3 months, 6 months, 12 months, and 2 years. At each follow-up, the pressure setting of the valve is checked and confirmed using a specific mask and compass. A pressure elevation and reduction protocol is used to test the adjustment capability over time.
Results: From 2017 to 2024, 31 patients underwent valve implantation, comprising 14 males and 17 females. The mean age was 49.7 years. Regarding diagnoses, 11 had NPH, 12 IIH, and 8 acquired hydrocephalus. On average, each patient had 2.77 follow-up visits per year, with 6 undergoing MRI scans. No spontaneous or MRI-induced pressure adjustment alterations were identified in any patient.
Conclusions: The SPHERA PRO valve exhibits the necessary magnetic stability to maintain the programmed settings and adjustments, ensuring appropriate neurosurgical treatment for patients with cerebral hydrodynamic disorders.

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Evaluating the efficacy of blinded gait assessments to determine changes after shunt surgery in patients with iNPH – preliminary results

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Introduction: In the clinical assessment of idiopathic normal pressure hydrocephalus (iNPH), blinding during gait assessments is rare. Unblinded assessments can introduce biases, particularly when evaluating changes after shunt surgery. This study aimed to determine whether blinded assessments of gait could effectively detect changes in patients who have undergone shunt surgery and to compare its effectiveness with the Hellström iNPH-scale for motor symptoms. The study also sought to evaluate inter-rater agreement on gait patterns and perceived rates of improvement.
Methods: The study included 39 patients (mean age 79 years, $SD = 7.25$) diagnosed with iNPH who underwent shunt surgery. Patients were filmed walking before tap test and 3 to 12 months post-surgery. Videos were blinded regarding the timing of filming (pre- or post-surgery). Three raters evaluated gait patterns using the ordinal gait scale from the iNPH-scale and the difference (improvement or decline) between the films. Krippendorff's alpha was used to analyze inter-rater agreement for gait patterns and ratings of improvement. Spearman's rank correlation was used to compare scores from raters with changes in the iNPH-scale.
Results: Inter-rater agreement for gait pattern showed a moderate level of consistency ($\alpha = 0.504$), while the agreement for ratings of perceived improvement was strong ($\alpha = 0.824$). A strong positive correlation ($\rho = 0.646$ to 0.681, $p < 0.001$) was observed across all assessments, indicating that higher ratings of perceived improvement were consistently associated with greater positive changes on the iNPH-scale.
Conclusions: Blinded assessments of gait can effectively detect changes post-shunt surgery and show a strong correlation with the iNPH-scale for motor symptoms with high reliability between raters. Blinded gait assessment can reduce biases inherent in unblinded assessments, supporting that the method can be a useful tool for monitoring patients longitudinally and assessing outcomes in research studies.

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Natural history of syringomyelia: to treat or not to treat?

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Introduction: Knowledge on the natural history of untreated syringomyelia is limited, creating uncertainties on the optimal management of patients who present with syringomyelia. A better knowledge of the natural history of treated and untreated syringomyelia is desirable also to improve our ability to counsel patients. This study describes the clinical and imaging outcomes of patients with Chiari Malformation (CM) and syringomyelia.
Methods: Single-centre retrospective study. Patients attending a hydrocephalus-dedicated outpatient clinic were screened to identify subjects meeting the following inclusion criteria: (i)diagnosis of CM, (ii)syringomyelia identified on imaging study, (iii)serial MRI imaging of the spine (at least two MRI scans). The evolution of syringomyelia was classified as stable, worsening, or improving depending on neuro-radiology reports. Patients were divided into 2 groups: "treated" and "untreated" and the results of the two groups were compared.
Results: Forty-four patients met the inclusion criteria (30 females, mean age 42.5 ± 13.2 years). The average time interval between the baseline and follow-up imaging was 40.6 ± 44.9 months. Fourteen patients (32%) did not have any treatment and were monitored conservatively. Thirty patients(68%) received one or a combination of surgical treatments: ventriculoperitoneal shunt insertion(70%), foramen magnum decompression(56.7%), ventriculo-thecal shunt(13.3%) or syringo-pleural shunts(10%). Amongst patients who were conservatively managed, syringomyelia spontaneously improved in 21.4%, was stable in 57.1% and worsened in 21.4%. Amongst patients who were surgically treated, 30% had improvement of syringomyelia while it was stable in 56.7% and worse in 13.3%. Stratification of results by treatment types and clinical outcomes will be presented.
Conclusions: The evolution of syringomyelia over time is unpredictable. These results suggest that worsening of syringomyelia occurs in between 13% of the patients who receive surgical treatment and 21% of untreated patients. In 57% of patients, independent of whether they received surgical treatment or not, syringomyelia remains stable. Larger prospective studies will be needed to confirm these findings.

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Utility of the dot counting and rey-15 item recognition performance validity tests in cognitive assessment of patients with suspected idiopathic normal pressure hydrocephalus

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Introduction: Cognitive assessment is increasingly utilised to support the diagnostic process in iNPH. Professional guidance recommends consideration of invalid performance as an intrinsic component of test interpretation (BPS, 2021); however, in cognitive impairment, there may be a higher false positive rate. We reviewed the rate of performance validity test (PVT) failure in patients with suspected iNPH, and whether PVT failure has any relationship to diagnostic outcome.
Methods: We completed a retrospective review of patients who attended an iNPH diagnostic clinic (February 2023-March 2024) and had completed the Rey-15 Item Recognition Test (RFIT-R; Rey, 1964) and Dot Counting Test (DCT; Boone et al., 2002) during cognitive assessment. The patients were classified into iNPH/not iNPH, based on decision to shunt, and valid/invalid score on PVTs. The cutoff score determined for invalid performance was ≤ 22 on the RFIT-R (Poynter et al., 2019) and ≥ 22 on the DCT, using the mild dementia category (Boone, 2002). A chi-square test for independence was used to explore the relationship between performance validity and diagnosis.
Results: Forty-three patients were identified (female $n = 13$, male $n = 30$; age M = 76yrs). Of those with iNPH (37.21%, $n = 16$), 6.25% ($n = 1$) failed the DCT, and 81.25% ($n = 13$) failed the RFIT-R. Of those without iNPH (62.79%, n = 27), 29.63% ($n = 8$) failed the DCT, and 74.07% ($n = 20$) failed the RFIT-R. Effect size was not significant for the relationship between performance validity and diagnosis (DCT, 0.278, p = 0.121; RFIT-R, 0.0821, p = 0.719).
Conclusions: We found most patients included in this study failed the RFIT-R, whereas most patients passed the DCT. However, neither of the PVTs showed a relationship with diagnostic category. These findings highlight the complexity of interpretation of PVTs in the cognitive assessment of patients with suspected iNPH. Further research may be warranted to determine the value of routinely including PVTs in cognitive assessments for this patient group.

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Assessment of non-invasive ICP dynamics for shunted normal pressure hydrocephalus patients

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Introduction: Normal Pressure Hydrocephalus (NPH) arises from changes in intracranial compliance. The widely practiced treatment is Ventriculoperitoneal shunt (VPS) surgery, draining excess cerebrospinal fluid. This research evaluates the P2/P1 intracranial pressure waveform ratio, captured non-invasively, as an accessory assessment and diagnostic method for NPH.
Methods: The study encompassed seven NPH patients, assessing the P2/P1 ratio, TTP, confidence intervals for P2/P1 ratios, and valid waveforms pre and post-VPS surgery. Intracranial compliance evaluation was conducted in various postures: lying, sitting, 30-degree inclination, and upright. Pre- and post-surgery ICP waveform dynamics, such as P2/P1 ratio and time-to-peak, were scrutinized.
Results: Our study's results indicate that all patients experienced improvement in at least one parameter after VPS, with 67% showing enhanced P2/P1 ratios and 44% showing improvements across all evaluated parameters. Although a direct correlation between the number of symptoms improved and the number of parameters improved was not established, the majority of patients with more symptoms improved also showed improvements in more parameters. A significant limitation of our work is that patients were also monitored once before and after shunts and not all patients were monitored in the same positions, which may cause variations.
Conclusions: nICPw dynamics may serve as an additional non-invasive diagnostic and monitoring criterion for NPH. Despite evident pre and post-shunt disparities, refining monitoring routines remains essential to discern optimal cut-off values. Expansive research and clinical trials are imperative to further delve into the potential of non-invasive waveform analysis in the management of NPH patients.

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Combined endoscopic third ventriculostomy and biopsy of a rare case of papillary tumor of the pineal region: a case report

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Introduction: Pineal Gland is an extra-axial encapsulated organ that occupies the center of the brain. Mass that originates in the pineal region is one of the most complex neoplastic areas in the brain both anatomically and pathologically. Different cell types that comprise the pineal gland account for the diverse pathology of pineal region tumors. Papillary tumor of the pineal region (PTPR) is a very rare entity with only a few case reports available in the literature particularly in our local setting. There is little data regarding the natural history and definitive treatment for these patients. Further accumulation of reports will assist with defining this case and may provide further insight into the management of such patients.
Methods: We report a case of a 42-year-old male with a long-standing headache and dizziness. Imaging studies showed a pineal mass with secondary obstructive hydrocephalus. Simultaneous endoscopic third ventriculostomy (ETV) and tumor biopsy to achieve both diagnosis and treatment were done using a rigid lens endoscope via a single pre-coronal burr-hole.
Results: ETV was initially successful in relieving hydrocephalus and the diagnostic tumor biopsy yield was successful and confirmed PTPR with no significant intraventricular bleeding occurred. However, one-week post-operative period, ventriculoperitoneal shunt was inserted after the patient showed gradual signs of increased intracranial pressure, and radiographic evidence of hydrocephalus was noted.
Conclusions: Management of pineal region tumors is often complex; a histologic diagnosis is necessary to guide varied management decisions. Rigid endoscopy has made neuroendoscopic biopsy a more alternative option allowing surgeons to perform a third ventriculostomy and biopsy through the same bur hole in one sitting. It is a relatively safe and minimally invasive procedure.
Note: Consent to publish has been obtained by the patient.

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Non-invasive ICP waveform of patients with shunts and no symptoms

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Introduction: While shunts play a crucial role in managing hydrocephalus, the lack of noninvasive assessment tools for patients with shunts remains a challenge. In this study, we aimed to delve into the dynamics of noninvasive intracranial pressure waveform (nICPw) among patients with asymptomatic or oligosymptomatic shunts.
Methods: We gathered data on the P2/P1 ratio, time-to-peak (TTP), and confidence intervals from a cohort of 12 patients who had been living with their shunts for over a year without major symptoms or complaints. All patients had fixed-pressure valves and ventriculoperitoneal shunts (VPS). Data collection occurred in three positions: lying down, at a 30-degree incline, and standing.
Results: The P2/P1 ratios while lying down, at a 30-degree incline, and standing were 1.02 (±0.15), 1.06 (±0.18), and 0.99 (±0.21) respectively. TTP values in patients with shunt dysfunction were 16.87 (±7.67), 18.75 (±6.28), and 16.54 (±6.74) while lying down, at a 30-degree incline, and standing respectively.
Conclusions: Our findings suggest that nICPw data from this patient population could serve as a valuable tool for establishing baseline values. A crucial next step would involve comparing these measurements with those of healthy individuals lacking shunts. It's important to note that while our study revealed similar overall readings, the establishment of baseline values should be tailored to each patient.

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Comparing non-invasive ICP waveform analysis in shunt dysfunction patients pre and post-operatively

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Introduction: Shunt dysfunction may manifest as hypodrainage or blockage poses a significant threat to shunt-dependent patients with hydrocephalus. It may also manifest as hyperdrainage that causes significant disturbance to patients due to intense headaches and may also cause complications such as subdural effusions. Hence, we sought to analyze non-invasive ICP waveform (nICPw) dynamics in patients with hypodrainage and hyperdrainage before and after shunt revision surgery to understand further this tool's value for diagnosing shunt malfunction.
Methods: The following parameters were analyzed in patients presenting with hypodrainage and hyperdrainage before and after shunt revision surgery: P2/P1 ratio, time-to-peak (TTP), confidence intervals, and number of valid waveforms. Data was collected in 3 different positions: lying, sitting, 30 degrees incline, and standing. Five patients' data were analyzed: 2 patients with hypodrainage and 3 patients with hyperdrainage.
Results: Our results show that, while patients with hypodrainage seem to present with overall higher P2/P1 ratios and TTP, hyperdrainage patients present a significant variation between P2/P1 ratios in different positions pre-operatively. Post-operatively, hypodrainage patients tend to show a decrease in P2/P1 and TTP values, and hyperdraninge patients tend to have a decrease in the P2/P1 range (minimum and maximum values) and the variation between positions.
Conclusions: Our study suggests that nICPw monitoring can be a useful tool in the management of shunt dysfunction presenting with either hypodrainage or hyperdrainage in patients with hydrocephalus and other CSF disorders. It can aid in the diagnosis and assessment of patient improvement. Future studies should focus on improving monitorization routines and better characterizing these changes pre- and postoperatively.

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Almost 2 decades of Normal Pressure Hydrocephalus referrals: trends of clinical and imaging characteristics

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Introduction: The increasing awareness of Normal Pressure Hydrocephalus (NPH) has resulted in a change in the quantity and quality of referrals for this condition. This retrospective study analyses the

characteristics of the referrals for suspected NPH to a tertiary/quaternary neurosurgical centre.
Methods: Single-centre retrospective study. Patients referred for suspected NPH were identified through a database and were included in the study if the original referral was available. Data on the patients' demographics, clinical presentation and imaging report was collected and summarised by years. The data was then split in two "cohorts" (2006–2014 and 2015–2023) and the results compared.
Results: 468 patients were identified (64.5% male, mean age 74 ± 7 years). Most patients suffered mobility disturbances at the time of referral (98%), cognitive and urinary disturbances were less common (79% and 73% respectively). Most patients were referred by neurologists (59%) or geriatricians (12%). We identified 108 referrals in the first "cohort" and 360 referrals in the second "cohort" (2015–2023). Demographic characteristics did not differ between the two periods. There was a significant increase in the proportion of referrals coming from neurologists in the second "cohort" (from 50 to 62%, Fisher's exact $p = 0.03$). The proportion of patients presenting with the complete triad of symptoms has decreased (from 66 to 58%, n.s.). Patients referred in the second cohort were more likely to have acute callosal angle reported on imaging (20% versus 4%, $p = 0.002$) and to have DESH sign (45% versus 44%, $p < 0.001$), compared to patients referred in the first cohort.
Conclusions: In recent years patients are more likely to be referred for suspected NPH even in the absence of the complete triad of symptoms. In addition, recent referrals are more likely to present the typical imaging signs of NPH on radiology reports, raising the suspicion that referring teams may be reluctant to refer patients without these imaging features.

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Impact of different diagnostic techniques in the management of hakim disease

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Introduction: Hakim disease (HD) has a complex diagnosis. The indication for surgery is based on a combination of clinical (lumbar tap-test (TT)), radiological (DESH score, phase contrast MRI (pcMRI) analysis) and barometric (infusion test) parameters. In our institution, these diagnostic assessment tools have been implemented progressively (TT since 2015, pcMRI since 2017, infusion study since 2019, DESH score since 2021). Our objective was to assess the impact of these diagnostic tools on our clinical practice and patient outcomes after surgical treatment.
Methods: We retrospectively analyzed a population of all HD patients operated on for ventricular shunting in our center between 2016 and 2023. 87 patients (73.5 years ± 7.4) were included. 7 patients were treated by endoscopic ventriculocisternostomy and 80 by ventriculoperitoneal or atrial (since 2021) shunt (pressure-regulated valve). We analyzed patient progress according to the *iNPH grading scale* and preoperative clinical and paraclinical data.
Results: The number of surgical treatments increased from 5 to 26 surgeries between 2016 and 2023. The rate of patients improved at 6 months postoperatively was 92% (± 7.74) (max: 100%; min: 80%). The postoperative improvement rate appeared to increase between 2016 (85%) and 2023 (95%). Among patients improved after surgery, 87% showed improvement after TT, 84% an infusion test in favor of HD, 82% a pcMRI in favor of the diagnosis and 76% of patients presented a DESH score in favor of the diagnosis. 43% of patients had secondary deterioration, with a time to onset of 25 months (± 13), including 7.5% with valve dysfunction.
Conclusions: Plurimodal diagnosis has led to an increase in the number of shunt surgery indications associated with an unimpaired or even higher rate of post-operative improvement. No single diagnostic technique has sufficient negative predictive value to formally exclude a patient from a surgical indication. No single pathophysiology could explain all the HD.

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Ventriculoperitoneal shunt for the treatment of hydrocephalus after posterior fossa tumors: a systematic review and meta-analysis

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Introduction: Patients with intracranial tumors are predisposed to persistent hydrocephalus, often requiring a permanent CSF diversion procedure with shunts. Although the shunt procedure is rather simple, secondary complications frequently happen with all currently used shunt devices. One of the options for managing hydrocephalus after posterior fossa tumor (PFT) is the use of a ventriculoperitoneal shunt. Therefore, we conducted a systematic review and meta-analysis to assess the efficacy and safety of using VPS in the treatment of hydrocephalus caused by PFT.
Methods: Following PRISMA guidelines, we searched Medline, Embase, and Web of Science databases. Single proportion analysis with 95% confidence intervals under a random-effects model, I^2 to assess heterogeneity, and Baujat and sensitivity analysis to address high heterogeneity. Eligible studies included those with ≥ 4 patients, focused on patients with hydrocephalus caused by PFT treated with VPS, and outcomes included postoperative infection, postoperative ventricular blood, postoperative CSF leakage, and mortality.
Results: Thirteen studies were selected, involving a total of 605 patients. Among these patients, improvement in hydrocephalus was observed in 222 out of 256, representing a rate of 94%. Additionally, in the analysis, 26 out of 146 patients experienced overdrainage, resulting in a rate of 17%. Among the 231 patients analyzed, 25 had infections, resulting in a rate of 10% (95% CI: 6% to 14%). Regarding postoperative ventricular blood, it was observed that 11 of the 53 patients presented, obtaining a rate of 19% (95% CI: 0% to 44%). Analyzing the CSF leak, we found 22 cases of 109 patients, with a rate of 17% (95% CI: 1% to 34%). The mortality rate was 2% (95% CI: 1% to 3%), with 8 of the 380 patients analyzed.
Conclusions: This systematic review and meta-analysis revealed that VPS demonstrates promising efficacy and safety in the treatment of hydrocephalus following PFT, with minimal complications.

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Impact of prenatal care and Zika virus on congenital hydrocephalus prevalence in the Brazilian Amazon

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Introduction: The Zika virus, typically transmitted by *Aedes aegypti* mosquitoes, poses a notable health concern in the Americas, where it is associated with severe neurological disorders in fetuses and newborns, such as hydrocephalus. This condition may increase neurological risks during gestation. Effective prenatal care is essential for the early detection and potential management of these risks, underscoring the significant impact that the Zika virus can have on neonatal health.
Methods: An ecological study was conducted using data from the Brazilian Live Birth Information System (SINASC) spanning from 2019 to 2022 of Brazilian Amazonas. Prevalence and infant mortality due to congenital malformations (ICD Q00-Q99) in Amazon, overall congenital hydrocephalus, prevalence of Zika infection during pregnancy and number of pre-natal consultations were calculated. Trends were analyzed using simple linear regression, Pearson correlation conducted among the different age groups in GraphPad Prism 9.
Results: Among 1,213,851 births in the Brazilian Amazon, there were 355 cases of hydrocephalus. The mean incidence of Zika virus cases in pregnant women was 3,014. The prevalence of Zika virus at birth demonstrated a strong Pearson correlation with a coefficient of 0.9533 with the prevalence of hydrocephalus during the period from 2019 to 2022. Further analysis linking this to the prenatal care rate reveals a strong negative correlation (r = -0.7990) with the prevalence of hydrocephalus.
Conclusions: This analysis confirms the significant impact of Zika virus exposure during pregnancy on the incidence of congenital hydrocephalus in the Brazilian Amazon, illustrated by a positive correlation with hydrocephalus cases. Additionally, the inverse relationship between hydrocephalus prevalence and prenatal care underscores the effectiveness of thorough prenatal interventions in reducing this condition. These results advocate for reinforced prenatal health strategies and enhanced maternal support to mitigate hydrocephalus rates and improve newborn health outcomes in the region.

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Case report: the importance of performing intracranial monitoring and the tap test in patients with idiopathic normal pressure hydrocephalus

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Introduction: Idiopathic Normal Pressure Hydrocephalus (INPH), is a neuropsychiatric disorder characterized by Hakim's triad: dementia, gait apraxia, and urinary incontinence. The pathogenesis of INPH involves mechanisms such as glymphatic deficiency, abnormal pulsatility, and reduced cerebrospinal fluid drainage, leading to inflammation and injury in both white and gray matter.
Case report: A 62-year-old male with a medical history of spinocerebellar ataxia type III and epilepsy presented with symptoms of dementia and urinary incontinence. The patient underwent a TAP test in an outpatient setting, where approximately 40 ml of cerebrospinal fluid was collected using a 20 cm spinal needle. At post-test, a significant improvement in intracranial pressure was observed, indicating a positive response to the procedure. The TAP test, along with intracranial pressure monitoring, plays a vital role in diagnosing and managing patients with INPH, offering valuable insights into the patient's physiological response.
Discussion: Studies evaluating gait improvement in INPH patients and the efficacy of the TAP test have shown varying results. The sensitivity and specificity of the TAP test reduced up to 39% with subsequent patients, highlighting the importance of individualized assessment. Clinical and cognitive evaluations, including the P2/P1 ratio for quantifying intracranial pressure, are essential for monitoring post-TAP test outcomes and determining the need for further interventions. While immediate improvements in clinical conditions are often observed, long-term efficacy of the TAP remains a subject of debate.
Conclusion: use of the TAP test as a therapeutic measure in patients with INPH is limited. Its sensitivity and specificity are limited to the chronology of the disease. Thus, cases such as the one in this report invalidate this technique as a determinant in the treatment of INPH, but it presents a method with potential to define whether or not the patient is a candidate for shunt surgery.
Note: Consent to publish has been obtained by the patient.

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Post-traumatic hydrocephalus after decompressive craniectomy for patients with traumatic brain injury: a systematic review and updated meta analysis

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Introduction: Decompressive Craniectomy (DC) is a known cause of Post-Traumatic Hydrocephalus (PTH). A previous meta-analysis had addressed its incidence, bringing various insights into this complication. However, this study was published years ago, with an update being necessary. The authors conducted a systematic review and updated meta-analysis to address the incidence of PTH after DC.
Methods: Fulfilling PRISMA guidelines, the authors systematically searched the Embase, PubMed, and Web of Science databases to identify English articles reporting cohorts of more than four patients with Traumatic Brain Injury (TBI) that were submitted to DC and developed PTH. Single proportion analysis with 95% confidence intervals (CI) under a random-effects model was utilized to pool the data. Sensitivity analysis and Baujat plots were used to explore cases of high heterogeneity.
Results: A total of 44 studies and 6,881 patients were included in the final analysis. The etiology of Traumatic Brain Injury (TBI) varied from quotidian falls to violent cases and traffic accidents. Of all these patients, 1,769 developed PTH after DC at a rate of 0.23 (95% CI: 19%-27%; I2 = 97%). Heterogeneity remained high in every scenario after sensitivity analysis. The Baujat plot was used to identify

the main outliers. By visual analysis, the funnel plot showed a high asymmetry, with Egger's regression test confirming publication bias (p = 0.018). Subanalysis focusing on children, totaling 121 patients, found a rate of 29% (95% CI: 18%-40%; I2 = 45%). Heterogeneity dropped to 0% when omitting one of the included studies.
Conclusion: Despite the high rate, the high heterogeneity and confirmation of publication bias made the task of drawing a definitive conclusion inadequate. However, the heterogeneity was lower when analyzing only children, indicating more precise results. Nevertheless, studies with more methodological esteem are mandatory to better understand this complication.

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What is the best option for the initial pressure setting of the Sphera Pro programmable valve in the treatment of idiopathic normal pressure hydrocephalus?
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Introduction: The gold standard treatment for idiopathic normal pressure (iNPH) involves a ventriculoperitoneal shunt with a programmable valve. While lower pressure levels have been linked to improved neurological outcomes, albeit with a higher occurrence of overdrainage, the optimal initial pressure setting has not yet been established in the literature. This study aimed to identify the most effective and safest initial pressure level for a programmable pressure valve in the treatment of iNPH.
Methods: A prospective cohort of iNPH patients treated with an initial pressure of 6.5 cmH_2O was compared with a historical cohort of iNPH patients treated with an initial pressure of 3 cmH_2O, across two tertiary public hospitals. The Sphera Pro programmable valve with gravitational unit was used in both groups. The assessed outcomes were safety, evaluated by the incidence of subdural effusions measuring > 1 cm that required surgery, and efficacy, evaluated by the NPH Japanese Scale score during a one-year follow-up period.
Results: Nineteen patients were included in the group with an initial pressure setting of 3 cmH_2O, while 33 patients were included in the group of a setting of 6.5 cmH_2O. Demographic and clinical characteristics were similar between the two groups. Both groups demonstrated neurological improvement over time (p < 0.001), but no difference was seen between groups (p = 0.104). In the group with the 3 cmH_2O pressure setting, two patients (10.5%) experienced subdural effusions > 1 cm that needed reoperation, whereas no patients in the 6.5 cmH_2O pressure group required such intervention (p = 0.057).
Conclusions: In our study sample, no significant differences were noted in terms of efficacy between the two initial pressure settings. An initial pressure of 6.5 cm H_2O, however, showed a tendency to present fewer overdrainage complications than the initial pressure of 3 cmH2O.

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Comparative analysis of external ventricular drainage and ventriculoperitoneal shunt for the treatment of hydrocephalus caused by posterior fossa tumors: a meta-analysis and systematic review
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Introduction: Brain tumors located within the posterior fossa pose a significant concern for patients due to complications such as hydrocephalus. The aim of this study is to compare Endoscopic Ventricular Drainage (EVD) with Ventriculoperitoneal Shunt (VPS) as treatment options for hydrocephalus. Our objective is to evaluate the effectiveness and safety profile of EVD in comparison to VPS for the treatment of hydrocephalus.
Methods: Following PRISMA guidelines, we searched Medline, Embase, and Web of Science databases. Single proportion analysis with 95% confidence intervals under a random-effects model, I^2 to assess heterogeneity. Eligible studies compared EVD with VPS for hydrocephalus. Outcome measures included technical success, infection, CSF leakage, and mortality.
Results: Our analysis comprised 13 studies focused on EVD and an additional 13 studies centered on VPS, involving a total of 524 and 605 patients, respectively. The technical success rate was determined to be 60% for EVD and notably higher at 94% for VPS. Regarding infection incidence, we observed an 8% rate among patients treated with EVD, while a 10% rate was observed in those undergoing VPS. Upon examining the occurrence of CSF leakage, the analysis revealed an 11% rate among EVD recipients, whereas VPS patients exhibited a higher rate of 17%. Finally, our investigation unveiled a mortality rate of 14% for EVD recipients, contrasting with a lower rate of 2% among those who underwent VPS.
Conclusions: Both procedures have shown promising results in terms of efficacy and safety. VPS demonstrates slightly better technical success and lower mortality rates compared to EVD. On the other hand, EVD exhibits a lower rate of infection and CSF leakage compared to VPS. The selection between these procedures should be guided by the surgeon's expertise and the patient's anatomical considerations.

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Effectiveness and safety of endoscopic third ventriculostomy with choroid plexus cauterization compared to ventriculoperitoneal shunt for hydrocephalus: a systematic review and meta-analysis
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Introduction: Hydrocephalus presents a common therapeutic challenge, traditionally managed through the insertion of a ventriculoperitoneal shunt (VPS). However, an emerging alternative, endoscopic third ventriculostomy (ETV) combined with choroid plexus cauterization (CPC), has attracted attention. We aimed to assess the efficacy and safety profile of ETV + CPC when compared to VPS for hydrocephalus.
Methods: We conducted a systematic search of Medline, Embase, and Web of Science databases in accordance with PRISMA guidelines. We

pooled odds ratios (OR) with 95% confidence intervals was applied using a random-effects model, I^2 to assess heterogeneity. Eligible studies compared ETV + CPC with VPS for hydrocephalus. Outcome measures included success, complications, infection, and mortality.
Results: Nine studies involving a total of 987 patients met the inclusion criteria. In technical success, 622 patients received treatment with ETV + CPC, while 365 underwent VPS, resulting in an OR of 0.70 (95% CI: 0.38 to 1.28), suggesting no statistically significant distinction between the two approaches. When evaluating complications, we found 254 in the ETV + CPC compared to 185 in the VPS, resulting in an OR of 0.83 (95% CI: 0.39 to 1.75), though this difference did not reach statistical significance. Subsequent subanalysis focusing on infection rates revealed 356 in the ETV + CPC and 283 in the VPS, with an OR of 0.43 (95% CI: 0.18 to 1.0), indicating a higher likelihood of infection associated with VPS. Regarding mortality, we documented 342 in the ETV + CPC and 255 in the VPS, resulting in an OR of 0.89 (95% CI: 0.39 to 2.05), also without reaching statistical significance.
Conclusions: This meta-analysis revealed that ETV + CPC showed superiority only in terms of infection rates compared to VPS. Additionally, we found no significant differences in technical success, complications, and mortality.

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Effectiveness of subtemporal decompression in managing slit ventricle syndrome: a systematic review and meta-analysis

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Introduction: Slit Ventricle Syndrome (SVS) is characterized by reduced ventricular volumes and intermittent symptoms such as headaches and vomiting. Among the available therapeutic approaches, subtemporal decompression (STD) stands out, indicated when previous treatments, such as shunting, fail to alleviate persistent SVS symptoms. Although promising, the efficacy of STD lacks robust evidence on its outcomes. In this context, this systematic review and meta-analyses aim to fill these gaps, providing safe and effective guidance for the practice of this procedure.
Methods: We conducted a systematic search of Medline, Embase, and Web of Science databases in accordance with PRISMA guidelines. Single proportion analysis with 95% confidence intervals were applied using a random-effects model, I^2 to assess heterogeneity, and Baujat and sensitivity analysis to address high heterogeneity. Eligible studies encompassed those with a minimum of four pediatric patients with SVS who underwent STD. Outcome measures included infection, resolution of symptoms, shunt revision, complications, mortality, and related mortality.
Results: From the initial pool of 89 identified studies, we selected 8 studies involving 141 patients. The combined analysis of the studies revealed the following results: 30 complications were recorded out of a total of 122 patients, resulting in a complication rate of 24.6%. The resolution symptoms were observed in 64 cases out of 71 patients with SVS, resulting in a rate of 90.1%. Regarding infection, 17 cases were identified out of a total of 80 patients, resulting in an infection rate of 21.25%. The shunt revision occurred in 22 out of 44 patients, with a rate of 54%. The mortality rate was 4 deaths out of a total of 68 patients, resulting in a mortality rate of 5.9%. No deaths related to the procedure were reported.
Conclusions: This systematic review and meta-analysis highlight the efficacy and safety of STD in treating symptoms derived from SVS.

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Efficacy of the external ventricular drain in the treatment of hydrocephalus caused by posterior fossa tumors avoiding the shunt: a systematic review and meta-analysis

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Introduction: Acute obstructive hydrocephalus is a common presentation in children with a posterior fossa tumor (PFT) that occurs as due to its mass effect on the IV ventricle blocking CSF circulation. Ventricular External Drain (EVD) is one of the strategies used to treat obstructive hydrocephalus in children with PFT and avoid shunt. Therefore, a systematic review and meta-analysis was performed to evaluate the effectiveness of the use of EVD in the treatment of hydrocephalus caused by posterior fossa tumors to avoid the need for shunt.
Methods: Following PRISMA guidelines, we searched Medline, Embase, and Web of Science databases. Single proportion analysis with 95% confidence intervals under a random-effects model, I^2 to assess heterogeneity, and Baujat and sensitivity analysis to address high heterogeneity. Eligible studies included those with ≥ 4 patients, focused on children with hydrocephalus caused by posterior fossa tumors treated with EVD. Outcomes included were postoperative success, required shunt, infection, postoperative CSF leakage, and mortality.
Results: Thirteen studies involving 524 patients were selected. The success rate of EVD placement during the perioperative or postoperative period was found to be 60%. Regarding the required shunt, it was observed that 54 of the 216 patients needed it, obtaining a rate of 25%. In relation to infection, it was observed that 43 of the 443 patients presented obtaining a rate of 8%. Analyzing the CSF leak, we found 16 cases of 136 patients, with a rate of 11%. The mortality rate was 14%, with 27 of the 174 patients analyzed.
Conclusions: This systematic review and meta-analysis identified EVD as an effective option for treating hydrocephalus caused by posterior fossa tumors, yielding favorable clinical outcomes and a low need for CSF drainage and infection after the procedure.

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Endoscopic third ventriculostomy for the treatment of hydrocephalus caused by posterior fossa tumor: a systematic review and meta-analysis

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Introduction: Endoscopic third ventriculostomy (ETV) emerges as a prominent choice among the array of surgical options available for the initial management of obstructive hydrocephalus stemming from posterior fossa tumors. Therefore, to evaluate the efficacy of ETV in addressing hydrocephalus associated with posterior fossa tumors, a systematic review and meta-analysis were conducted.
Methods: Following PRISMA guidelines, we conducted a comprehensive search of the Medline, Embase, and Web of Science databases. We employed single-proportion analysis with 95% confidence intervals, utilizing a random-effects model. Heterogeneity was assessed using I2 statistics, with Baujat and sensitivity analyses applied to address high levels of heterogeneity. Eligibility criteria included studies with a minimum of four patients, focusing on hydrocephalus caused by posterior fossa tumors treated with ETV. Outcomes of interest encompassed ETV success, infection, CSF leakage, hemorrhage, intraoperative complications, mortality, and related mortality.
Results: Eighteen studies involving a total of 606 patients met the inclusion criteria. The success rate of ETV was reported in 211 out of 286 patients, yielding a success rate of 76%. Regarding infection, 9 out of 204 patients were observed to have developed infections, resulting in a rate of 3%. Analysis of CSF leakage revealed 14 cases among 253 patients, equating to a rate of 4%. Hemorrhage occurred in 7 out of 329 patients, representing a rate of 2%. Intraoperative complications were noted in 4 out of 166 patients, accounting for a rate of 1%. Mortality and related mortality were both reported at a rate of 0%.
Conclusions: This systematic review and meta-analysis ascertain ETV as an effective therapeutic option for managing hydrocephalus induced by posterior fossa tumors. It demonstrates a high success rate and minimal incidence of complications and mortality.

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Endoscopic third ventriculostomy in chiari malformation type i: a systematic review and meta-analysis

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Introduction: Chiari Malformation Type I (CM-I) involves cerebellar tonsil herniation, often necessitating posterior fossa decompression. However, when cerebrospinal fluid flow remains obstructed, additional interventions like endoscopic third ventriculostomy (ETV) or ventriculoperitoneal shunts (VPS) may be required. Despite the common use of ETV, its efficacy in CM-I cases lacks sufficient literature. To bridge this gap, we conducted a systematic review and meta-analysis focusing on ETV outcomes in CM-I patients.
Methods: We searched Medline, Embase, Web of Science databases following PRISMA guidelines. We used single proportion analysis with 95% confidence intervals under a random-effects model, I^2 to assess heterogeneity, and Baujat and sensitivity analysis to address high heterogeneity. Eligible studies included those with ≥ 3 CM-I patients treated with ETV. Studies had to assess symptom improvements, ETV success, and complications. Good outcomes were defined as symptom improvement post-ETV.
Results: From 502 initially identified studies, 12 were selected, involving 128 patients, including 35 children across 7 studies, with a median follow-up of 42 months. The combined analysis showed a 98% (95% CI: 93%—100%, $I^2 = 10\%$) good clinical outcomes rate. Specifically, symptom improvement related to hydrocephalus was observed at 97% (95% CI: 0.88—1.00, $I^2 = 16$), and syrinx improvement at 64% (95% CI: 32%—97%, $I^2 = 74\%$). Complication rates were 3% (95% CI: 0%—8%, $I^2 = 0\%$) overall and 0% (95% CI: 0%—7%, $I^2 = 0\%$) in the pediatric population. The success rate was 82% (95% CI: 71%—93%, $I^2 = 65\%$).
Conclusions: ETV shows promising efficacy in treating hydrocephalus and syringomyelia with minimal complications. Its potential as a less burdensome alternative to shunts underscores the significance of our study.

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Gomes coil: an inventive neuroplastic solution for bone growth deformities caused by arachnoid cysts

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Introduction: Untreated arachnoid cysts that are superficially located may cause bone deformities due to remodeling if not treated in due time. Usually, techniques such as craniectomies or reconstruction-cranioplasties are employed, although these may be relatively invasive and morbid.
Methods: We report a case in which a 7-year-old girl with hydrocephalus and associated right temporal arachnoid cyst with a significant right temporal deformity that caused distress to the patient, who requested surgery. Adapting the "coil" technique from craniosynostosis repair, a coil-shaped osteotomy was performed on the temporal bone and fixed with absorbable plates.
Results: The patient presented a completed resolution of the deformity in a minimally invasive process with significant bone sparing, without the necessity for a complete craniotomy with significant reconstruction or craniectomy.
Conclusions: The "Gomes Coil" technique may be used to repair bone deformities of varied causes, as highlighted in our example of a deformity caused by an arachnoid cyst. This neuroplastic technique could be valuable in a neurosurgeon's armamentarium to resolve similar cases.
Note: Consent to publish has been obtained by the patient.

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Good clinical outcomes and CSF drainage in patients undergoing simultaneous Biopsy and endoscopic Third Ventriculostomy in tumors of the pineals region: a Systematic Review and Meta-analysis

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Introduction: Due to their delicate and deep-seated location, tumors in the pineal region of the brain pose exceptional challenges in neurosurgical management. To address these complexities, highly precise procedures, such as the simultaneous performance of biopsy and endoscopic third ventriculostomy (ETV), have become crucial. Our aim was to assess the feasibility, safety, and efficacy of simultaneous biopsy and ETV for treating patients with pineal region tumors.
Methods: Medline, Embase, and Web of Science were searched for English studies from January 2000 to February 2024, adhering to the PRISMA guidelines. Single proportion analysis with 95% confidence intervals was conducted under a random-effects model, employing the I^2 statistic to assess heterogeneity and Baujat and sensitivity analysis to address high heterogeneity. Eligible studies encompassed a minimum of four patients and examined at least one of the following outcomes: good clinical outcomes and cerebrospinal fluid (CSF) drainage.
Results: Eighteen studies comprising 390 patients were included after a meticulous selection. Good clinical outcomes overall in 131 out of 147 patients, representing a rate of 92%. In a subgroup analysis, children demonstrated a high rate of good clinical outcomes reaching 100%. Additionally, when analyzing the CSF drainage, out of the 356 patients, only 39 required CSF drainage, resulting in a rate of 8%. Subanalyses revealed that children and adults had CSF drainage rates of 12% and 3%, respectively. In a specific analysis for adults, with a rate of 84%. Notably, no major complications were recorded in adults, resulting in a rate of 0%. Additionally, low rates of related mortality were observed in adults, resulting in a rate of 1%.
Conclusions: The technique of simultaneous biopsy and ETV shows promise in the neurosurgical treatment of pineal region tumors, yielding favorable clinical outcomes and a low need for CSF drainage after procedure.

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Enhancing the quality of evidence, comparability, and reproducibility in ventriculoatrial shunt research for normal pressure hydrocephalus: a systematic review and VAS-NPH reporting guideline

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Introduction: Ventriculoatrial shunt (VAS) is an important treatment option for normal pressure hydrocephalus (NPH). However, clinical studies reporting the use of VAS for NPH lack sufficient standardization for meta-analytic comparisons that could provide robust evidence regarding its use. This study aims to assess the quality of reporting in these studies and develop a reporting guideline checklist to standardize terminology, concepts, and reporting while reinforcing the essential elements to ensure comparability and reproducibility.
Methods: This is a systematic literature review that followed the PRISMA guidelines with the search in Medline, Embase, and Web of Science databases, with no timeframe restriction. The level of evidence of the studies was assessed using the GRADE system. The EQUATOR Network Group guidelins were followed. Furthermore, the studies were scrutinized focusing on eight domains: (1) Characteristics of the included studies and baseline characteristics of the patients; (2) Reporting methodology; (3) Pivotal concepts definition; (4) Adverse events assessment; (5) Data writing and reporting; (6) Detailed outcomes reporting; (7) Specific clinical outcomes assessment and reporting; and (8) Complications reporting.
Results: A total of 14 studies with 734 patients and 753 shunts were included in this review, and the assessment exposes notable deficiencies in reporting, specifically in baseline patient details, methodology, and outcome assessments. Only two studies followed reporting guidelines, prompting concerns about comprehensive reporting of adverse events and intraoperative complications. Variable reporting completeness existed for shunt-related issues. The absence of standardized definitions for key concepts and insufficient intervention details were observed. A VAS-NPH reporting guideline, encompassing 36 items across eight domains, was developed to address these shortcomings.
Conclusions: This systematic review reveals significant deficiencies in methodological rigor and reporting quality. The proposed VAS-NPH Reporting Guideline covers all essential aspects and is a potential solution to rectify these shortcomings and increase transparency, comparability, and reproducibility.

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Enhancing the Quality of Evidence, Comparability, and Reproducibility in Normal Pressure Hydrocephalus Research: A Systematic Review and NPH Reporting Guideline Study Protocol

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Introduction: Normal Pressure Hydrocephalus (NPH) predominantly affects older adults and is marked by a triad of symptoms: gait disturbances, urinary symptoms, and cognitive impairments, which collectively degrade the patient's quality of life. Despite its clinical significance, the research landscape is plagued by inconsistencies and non-standardized studies, making meta-analyses and the progression

of coherent research challenging. This protocol, after completion, aims to improve the quality of reporting within NPH literature and establish a comprehensive checklist to guide future research. This guideline will propose standardization of concepts, terminology, and outcome reporting.
Methods: Utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a systematic search will be conducted across *PubMed*, *Embase*, and *Web of Science*. Selected articles will be evaluated using the GRADE system to determine evidence levels. Compliance with the guidelines set forth by the EQUATOR Network Group will also be assessed. The study will examine the reproducibility of NPH-related concepts, definitions, and clinical and surgical outcomes. Following the systematic review, a Reporting Guideline will be crafted, utilizing a modified Delphi method to reach a consensus among the authors.
Results: The study protocol has been developed and the research is currently being evaluated.
Conclusion: The NPH-Reporting Guideline aims to standardize research publications in the field of NPH to enhance the consistency and reproducibility of data. It serves as a useful and flexible tool for researchers, laying the groundwork for the methodological planning of future clinical studies and clarifying key terms related to NPH. By doing so, the guideline is poised to improve the organization, implementation, data handling, and dissemination of findings in clinical trials and related research, thereby advancing the field of NPH.

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Which Different neuropsychological assessments are the most useful for Normal pressure hydrocephalus in combination with the Tap-test? A systematic review

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Introduction: Normal pressure hydrocephalus (NPH) presents as a complex and often underestimated condition, with cognitive impairments such as attention, psychomotor speed, and memory difficulties at early stage, suggesting frontal involvement. As the disease progresses, overall cognitive deterioration becomes more apparent. The diagnosis of NPH relies on both clinical and neuroimaging data, but its complexity, potential comorbidities, and overlap with other neurodegenerative diseases, particularly Alzheimer's disease (AD), make differential diagnosis challenging.
Methods: PubMed, Embase and Cochrane Library databases from 13 April 2024 were systematically searched for studies reporting neuropsychological assessment tools in combination with the tap-test. After the search, duplicate studies were removed, and subsequently, all articles that met the inclusion criteria were included.
Results: In this analysis, we screened 764 articles and 9 prospective studies comprising 432 patients with idiopathic normal pressure hydrocephalus were included. We have seen a significant improvement after the tap-test in RAVLT-A1 and B1 (results be for A1 3.1 (4.1) B1 2.7 (1.7) after Tap-test (A1 3.4 (1.7) B1 2.7 (1.5), we observed improvement in sematic and phonemic verbal fluency especially in the Stroop color trail test part 2. The MoCa have shown us significant changes for responders (0.62 points) and non-responders (0.22 points). Patients demonstrate an improvement in sematic and phonetic verbal fluency after TT post CSF tapping. RAVLT-L was the sole test to significantly improve post-TT or post-VPS, correlating with each other. CSF tapping positively impacted memory, executive function, and verbal abilities, with variations between responders and non-responders.
Conclusions: The inclusion of the MoCa Test, in addition to Neuropsychological assessments such as the RAVLT, Gooved Pegboard, and the Stroop test (color-naming and interference), allows for a comprehensive evaluation of cognitive function. These tests collectively provide a more thorough assessment of various cognitive domains, and differentiation of neurological conditions.

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Postoperative hydrocephalus in a Foramen Magnum Meningioma: case report and review of literature

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Introduction: Foramen Magnum Meningioma (FMM) is a rare and challenging intracranial tumor. Females are affected more commonly and generally present in the 6th decade. Post-surgical excision patients may develop hydrocephalus due to various reasons.
Methods: We present a 50-year-old female who complained of neck pain for six years and clinical features suggestive of cervical myelopathy. She was diagnosed to have enplaque FMM placed anterior, lateral, and posterior to the lower brain stem and spinal cord. It was calcified and was encasing the left vertebral artery partially.
A Simpson's Grade 4 excision could be achieved considering the calcified and plaque nature of the tumor. The medulla oblongata and spinal cord were adequately decompressed. She reported improvement in myelopathy features and reduced neck pain. However, she returned 40 days later with altered sensorium. Investigations revealed communicating hydrocephalus and pseudomeningocele. She successfully recovered after a ventriculoperitoneal shunt.
Results: Post-surgical excision of FMM, the patient made an excellent recovery with resolution of neck pain and myelopathy. Post ventriculoperitoneal shunt, she improved in sensorium and was doing well at her seven-month follow-up with Karnofsky's Performance Status at 80.
Conclusions: Post-surgical Hydrocephalus is a known complication following FMM excision. A procedure like ventriculoperitoneal shunt helps to address both hydrocephalus as well as pseudomeningocele. In this presentation, we will review similar literature and discuss potential reasons for post-surgical hydrocephalus.
Note: Consent to publish has been obtained by the patient.

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Non-invasive techniques versus invasive techniques for diagnosing shunt-responsive patients with normal pressure hydrocephalus: a systematic review

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Introduction: Accurately diagnosing normal pressure hydrocephalus (NPH) is a challenging endeavor, primarily focusing on the crucial distinction between shunt-responsive and non-responsive patients. This challenge arises due to the common clinical presentation of NPH that often overlaps with the natural aging process and other neurodegenerative conditions, such as Alzheimer's and Parkinson's.
Methods: PubMed, Embase, Cochrane Library were systematically searched for studies evaluating invasive and non-invasive diagnostic techniques in distinguishing elderly NPH patients responsive to shunt and non-responders. After the search, duplicate studies were removed and, subsequently, all articles that met the inclusion criteria were included. Literature reviews, systematic reports, case reports, comments and editorials were excluded.
Results: A total of 10 studies, encompassing 398 patients with NPH, were included in this analysis. Among these studies, five employed Normal Power Variant (NPV)-encephalograms (EEG) for diagnosing responders and nonresponders. These studies found that cerebrospinal fluid (CSF) tapping affected cortical electrical activity differently in each group. Responders showed stabilized medial frontal cortical electrical activity, while non-responders experienced destabilization in the right dorsolateral prefrontal area. A study utilizing transcranial Doppler revealed that parameters of the middle cerebral artery were significantly higher for the tap test and decreased after the tap test in responders. Furthermore, one study demonstrated the usefulness of optical coherence tomography in diagnosing NPH. Significant differences in optic disc area before and after the tap test, along with nearly statistically significant higher ganglion cell layer thickness in NPH patients after the CSF tap test, were reported.
Conclusions: In summary, our review of NPH patients revealed significant differences in cortical electrical activity with NPV. EEG and NPV identified responders and non-responders accurately. Transcranial Doppler detected shunt-responsive patients effectively. Other modalities, like optical coherence tomography, produced mixed results, emphasizing the necessity for more targeted approaches in research and clinical practices.

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Lumboperitoneal shunt surgery following failed endoscopic third ventriculostomy in Hakim's Disease: flow rate through the aqueduct of sylvius as a potential factor associated with failure

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Introduction: Hakim's disease (HD) is a type of non-obstructive hydrocephalus. According to the literature, while endoscopic third ventriculostomy (ETV) is traditionally employed for obstructive hydrocephalus, it has displayed potential in managing HD, particularly in cases involving functional aqueductal stenosis. Despite this, our four patients diagnosed with HD experienced no improvement following ETV and subsequently underwent lumboperitoneal shunt (LPS) surgery as a salvage procedure. This report explores the factors contributing to failed ETV and assesses the effectiveness of LPS as a secondary treatment option.
Methods: We performed ETV on four patients (two males and two females) who exhibited HD without aqueduct stenosis. They underwent CSF dynamic MRI to assess the presence of CSF flow through the aqueduct of Sylvius, and their CSF flow rates were very low (n = 2) or absent (n = 2). Functional aqueductal stenosis was suspected, prompting the initial performance of ETV.
Results: All four patients exhibited progression within one year after undergoing ETV, prompting a subsequent CSF dynamic MRI. Additionally, this revealed persistently low CSF flow through the fenestration. LPS surgery was then performed as a salvage procedure, resulting in clinical improvement in all cases. A review of the literature and our patient data suggested that CSF flow rate through the aqueduct of Sylvius prior to ETV could influence outcomes. It appears ETV may be ineffective in patients with diminished aqueductal flow, especially in the chronic stages of HD. This may be related to lower stroke volume of CSF by brain pulsations.
Conclusions: It is cautiously suggested that CSF flow rate through the aqueduct of Sylvius may be related to the outcome of ETV surgery. If this relationship is further quantified, ETV could play a significant role in HD surgery. Additionally, even in cases of failed ETV, LPS surgery could serve as an effective salvage surgery option in the future.

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Transient intracranial pressure elevations (B-waves) are associated with sleep apnea

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Introduction: Repetitive transient intracranial pressure waveform elevations up to 50 mmHg (ICP B-waves) are often used to define pathological conditions and are used to assess the need for ICP-reducing treatment. We recently reported that nocturnal transient ICP elevations are present in patients without structural brain lesions or hydrocephalus, in whom they are associated with sleep apnea. However, whether this signifies a general association between ICP macropatterns and sleep apnea remains unknown.
Methods: We included 34 patients with hydrocephalus or idiopathic intracranial hypertension (IIH) who were referred to the Neurosurgical Department, Copenhagen, Denmark, from 2017 to 2021. Every patient underwent diagnostic overnight ICP monitoring for clinical indications, with simultaneous polysomnography sleep studies. All transient ICP elevations were objectively quantified in all patients. Three patients were monitored with continuous positive airway pressure (CPAP) treatment for an additional night.
Results: All patients had transient ICP elevations associated with sleep apnea. The mean temporal delay from sleep apnea to transient ICP elevations for all patients was 3.6 s (SEM 0.2 s). Ramp-type transient ICP elevations with a large increase in ICP were associated with REM sleep and sinusoidal-type elevations with NREM sleep. In three patients treated with CPAP, the treatment reduced the number of transient ICP elevations with a mean of 37%. CPAP treatment resulted in insignificant changes in the average ICP in two patients, but elevated the average ICP during sleep in one patient by 5.6 mmHg.
Conclusions: These findings suggest that sleep apnea causes a significant proportion of transient ICP elevations, such as B-waves, and that sleep apnea should be considered in ICP evaluation. Treatment of sleep apnea with CPAP can reduce the occurrence of transient ICP elevations. More research is needed on the impact of slow oscillating mechanisms on transient ICP elevations during high ICP and REM sleep.

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Lumboperitoneal shunt for treating hydrocephalus: a systematic review and single-arm meta-analysis

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Introduction: Lumboperitoneal shunt (LPS) is often regarded as a secondary treatment option for various forms of hydrocephalus. While some studies have compared its results to conventional treatments, there is a lack of comprehensive evidence evaluating its outcomes.
Methods: According to PRISMA, the authors searched the *Embase, PubMed,* and *Web of Science* databases to identify articles including information on complications/revisions in a cohort of more than four patients submitted for LPS. A single proportion analysis with 95% confidence intervals (CI) was employed to combine the data. To evaluate the presence of heterogeneity, we utilized I^2 statistics.
Results: A total of 49 out of 3,091 retrieved studies involving 2,696 patients were included. Normal pressure hydrocephalus and communicating hydrocephalus accounted for 49.1% of shunt cases. The median follow-up period across 33 studies was 19.2 months (IQR = 25). Notably, headaches were reported in 91 patients, and radiculopathy in 46 patients, with minimal overall risk (0%, 95% CI: 0%-0%) and significant heterogeneity for headaches ($I^2 = 63\%$). Overdrainage was observed in 119 patients, showing high heterogeneity ($I^2 = 75\%$) but minimal risk (0%, 95% CI: 0%-0%). Infections affected 68 patients [1% (95% CI: 1%-2%, $I^2 = 25\%$)]. Tonsillar herniations were observed in 19 patients at a 0.7% rate with significant heterogeneity (0%, 95% CI: 0%-0%, $I^2 = 51\%$). Three patients died from shunt-related complications (0.1%), and the risk of requiring shunt revision was 25% (95% CI: 18%-32%, $I^2 = 93\%$). Revisions in Japan demonstrated lower rates (22% (95% CI, 10%-34%) than in the USA (30% (95% CI, 18%-43%)).
Conclusions: LPS was demonstratedto be a safe and effective procedure with low mortality and complication rates. Although there is heterogeneity and future trials are required, the rates of revisions and complications seem similar to those of other shunts.

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Analysis of trends and outcomes in congenital hydrocephalus: implications for neonatal health in Brazil

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Introduction: Hydrocephalus manifests as abnormal cerebrospinal fluid accumulation in brain ventricles, leading to ventricular dilation and increased intracranial pressure. Left untreated, it leads to significant infant morbidity and mortality.
Methods: An ecological study utilizing Brazilian Live Birth Information System (SINASC) data (2000–2023). Prevalence and infant mortality rates for congenital malformations (ICD Q00-Q99) were calculated. Analysis involved simple linear regression, Pearson correlation, and ANOVA variance testing among age groups using GraphPad Prism 9.
Results: During the study period, 18,484 cases of hydrocephalus were recorded, representing 29.22% of nervous system malformations (Q00-Q07), with a prevalence of 2.65/10,000 live births. A significant negative correlation was found between prevalence and year ($r = -0.47$, $p = 0.0179$), with simple linear regression suggesting an average decrease of 11 cases per year. There were 6,501 infant deaths recorded during the study period, representing a mortality rate of 35%. The post-neonatal age group was the most affected, with 3,532 deaths. ANOVA testing among the mortality rates of the three infant age groups indicated a statistically significant difference between the means of early neonatal, late neonatal, and post-neonatal mortality due to congenital hydrocephalus in Brazil ($p < 0.0001$). The majority of the variation in the data could be explained by the difference between the groups ($R^2 = 0.6942$). Additionally, there were significant differences in variances between the groups ($p < 0.05$).
Conclusion: The analysis suggests a decreasing trend between early neonatal and late neonatal mortality, more pronounced in the post-pandemic period, which may be attributed to a decrease in reporting efficiency during this time and a decrease in the number of births. Furthermore, the data suggest inadequate treatment of hydrocephalus, as mortality in children receiving appropriate treatment within three years is only 10% according to studies. These results stress the critical need for ongoing monitoring and targeted interventions to decrease the incidence and mortality of congenital hydrocephalus, thereby significantly advancing neonatal health in Brazil.

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Update on the surgical treatment of post-hemorrhagic hydrocephalus in preterm neonates: a systematic review

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Introduction: Prematurity is the leading cause of infant mortality under 5 years of age, with subependymal and intraventricular hemorrhage being some of its comorbidities. The objective was to present different surgical approaches for addressing post-hemorrhagic hydrocephalus (PHH).
Methods: This PRISMA adherent systematic review included the following databases: BVS, PubMed, and SciELO. Inclusion criteria: clinical trials (including randomized trials), systematic reviews, and meta-analyses, in Portuguese or English, published from 2019 to 2024 and related to the theme.
Results: In total, 2,948 articles were found. After the selection process, 17 articles were included. 13–60% of patients with subependymal and intraventricular hemorrhage developed hydrocephalus, with 40% requiring treatment. Regarding ventriculoperitoneal shunt (VPS), obstruction and infections are the main causes of failure in children under 2 years of age, occurring in 40.8% and 17.2% of cases, respectively. Antibiotic-coated catheters showed a lower infection rate (subdistribution hazard ratio 0.38, 97.5% CI: 0.18–0.80), while standard catheters had a significant infection rate (specific cause hazard ratio 0.99, 97.5% CI: 0.56–1.74). Concerning Endoscopic third ventriculostomy (ETV), its success rate was 63%, with a median event-free survival of 14 months. In a study with 399 patients, 10% had postoperative complications, such as postoperative fever (10.25%), cerebrospinal

fluid leak (6.15%), meningitis (4.10%), among others. When compared to shunt, ETV has a lower risk of infection during the procedure (OR: 0.15; 95% CI: 0.04–0.52; I2: 0%).
Conclusions: PHH is frequent in premature infants, leading to high rates of morbidity and mortality. Despite the absence of a standardized protocol and consensus, it is known that the earlier the intervention, the better the outcomes. In conclusion, VPS with antibiotic action seems the most effective and safe method, presenting a lower risk of infection and failure.

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Comparative evaluation of shunt-related complications in normal pressure hydrocephalus: a meta-analysis
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Introduction: Normal pressure hydrocephalus (NPH) is predominantly managed through the implantation of various shunt systems, characterized by variations in design and functionality. Despite numerous studies addressing the benefits and drawbacks of different shunt types, a comprehensive synthesis comparing complication rates remains elusive. This meta-analysis aims to remediate this by evaluating the complication rates across different shunt types used in NPH treatment, providing a robust assessment of their clinical outcomes.
Methods: A comprehensive search was conducted on PubMed using Boolean operators and MeSH terms, covering publications from 1984 to 2024. This initial search yielded 190 articles, then refined to 138 after narrowing the period from 2004 to 2024. After screening by title, 60 papers were selected, and subsequently, 44 studies (30 adult and 14 pediatric) underwent full review. Only prospective and retrospective reviews were included, excluding case reports and series. Detailed manufacturer and shunt type information was mandatory for inclusion. Complications such as subdural hematoma, overdrainage, infection, migration, and underdrainage, were analyzed.
Results: Our analysis revealed significant variation in complication rates per shunt type. For instance, the ProGAV shunt demonstrated higher incidences of valve adjustments (10.73%) and shunt readjustments (1.26%). In contrast, the Orbis-Sigma system demonstrated higher rates of overdrainage complications (23.81%). Pediatric shunts, such as the Paedi-GAV, showed notable issues with infection (6.21%) and obstruction (3.85%). Each shunt system exhibited unique complication profiles, highlighting the need for tailored clinical strategies.
Conclusions: This meta-analysis offers a comprehensive evaluation of shunt-specific complications in NPH treatment. The findings indicate a considerable diversity in complication rates, underscoring the importance of shunt system choice based on individual patient characteristics and clinical circumstances. These insights are crucial for optimizing treatment in patients with NPH. Understanding shunt-specific complication profiles will assist clinicians in making more informed decisions regarding shunt selection and management, ultimately improving neurosurgical outcomes.

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Are ventriculopleural shunts the second option for treating hydrocephalus? A systematic review and single-arm meta-analysis
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Introduction: Some centers utilize ventriculopleural shunt (VPLS) for treating hydrocephalus when conventional approaches are not feasible. Nonetheless, the literature regarding this approach is scarce. The objective was to evaluate the outcomes of VPLS through a single-arm meta-analysis.
Methods: Following PRISMA guidelines, the authors systematically searched for articles utilizing the VPLS in a cohort with more than four patients. Outcomes included: mortality, pleural effusion, number of patients who underwent revisions, obstructions, shunt migration, emphysema and subdural hematoma. A single proportion analysis with 95% confidence intervals (CI) was employed to pool the data. To evaluate the presence of heterogeneity, we utilized I^2 statistics.
Results: A total of 404 articles were reviewed, resulting in the inclusion of 13 retrospective studies encompassing 543 patients, with the majority being children (62.6%). The median average follow-up period was 35.4 months (10–64.1). After analysis, results yielded a revision rate of 54% (95% CI: 44%-64%; $I^2 = 73\%$). The most common complication observed was pleural effusion, with a post-analysis incidence of 16% (95% CI: 11%-21%; $I^2 = 63\%$), followed by infections at 7% (95% CI: 4%-10%; $I^2 = 33\%$). Shunt obstruction occurred in 13% (95% CI: 4%-21%; $I^2 = 84\%$) of cases after analysis, while migrations, overdrainage, subdural hematoma, and cutaneous emphysema had minimal occurrence rates (0%, 95% CI: 0%-1%; $I^2 = 0\%$). Notably, there were no reported cases of shunt-related mortality.
Conclusions: VPLS can be considered when there are no other suitable options for placing the distal catheter. However, the notable rates of shunt revisions, pleural effusion, infections, and the inherent heterogeneity of outcomes currently limit the widespread adoption of VPLS. In this scenario, other alternatives should be given priority.

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