



## Original Article

# Cerebrospinal fluid closing pressure-guided tap test for the diagnosis of idiopathic normal pressure hydrocephalus: A descriptive cross-sectional study

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## ABSTRACT

**Background:** Tap test improves symptoms of idiopathic normal pressure hydrocephalus (iNPH); hence, it is widely used as a diagnostic procedure. However, it has a low sensitivity and there is no consensus on the parameters that should be used nor the volume to be extracted. We propose draining cerebrospinal fluid (CSF) during tap test until a closing pressure of 0 cm H<sub>2</sub>O is reached as a standard practice. We use this method with all our patients at our clinic.

**Methods:** This is a descriptive cross-sectional study where all patients with presumptive diagnosis of iNPH from January 2014 to December 2019 were included in the study. We used a univariate descriptive analysis and stratified analysis to compare the opening pressure and the volume of CSF extracted during the lumbar puncture, between patients in whom a diagnosis of iNPH was confirmed and those in which it was discarded.

**Results:** A total of 92 patients were included in the study. The mean age at the time of presentation was 79.4 years and 63 patients were male. The diagnosis of iNPH was confirmed in 73.9% patients. The mean opening pressure was 14.4 cm H<sub>2</sub>O mean volume of CSF extracted was 43.4 mL.

**Conclusion:** CSF extraction guided by a closing pressure of 0 cm H<sub>2</sub>O instead of tap test with a fixed volume of CSF alone may be an effective method of optimizing iNPH symptomatic improvement and diagnosis.

**Keywords:** Cerebrospinal fluid closing pressure, Cerebrospinal fluid drainage, Cerebrospinal fluid extraction, Closing pressure-guided, Idiopathic normal pressure hydrocephalus, Tap test

## INTRODUCTION

Idiopathic normal pressure hydrocephalus (iNPH) is the most common cause of hydrocephalus in the adult population and a major cause of reversible dementia with surgical management.<sup>[14]</sup> It is characterized by dilated cerebral ventricles (ventriculomegaly) and the classic triad of symmetric gait disturbance, urinary incontinence, and cognitive impairment, not associated with a specific

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background history.<sup>[1,6,14,18]</sup> Ventriculomegaly on MRI and the triad leads to clinical suspicion of iNPH.<sup>[1,6,18]</sup>

Different diagnostic methods have been described which include external lumbar drainage (ELD), infusion test, cerebral magnetic resonance imaging testing of elasticity, and cerebrospinal fluid (CSF) biochemical parameter testing.<sup>[15,18]</sup> At present, the gold standard is objective improvement of symptoms after shunt surgery (operational diagnosis); therefore, tap test (which simulates a shunt) has become a common, minimally invasive, and easily reproducible method.<sup>[2,4,7,8,13]</sup> Symptoms, imaging, and neurologic tests have a positive predictive value (PPV) of 50–61% which suggests a moderate improvement after shunt surgery.<sup>[8,9,16]</sup> Because the prognostic value of imaging is limited, other tests are needed to increase the probability of identifying patients with iNPH who will respond to shunt surgery.<sup>[11]</sup> The only effective treatment is a CSF shunt that derives fluid to either the peritoneum, right atrium or pleura and most patients (60–80%) improve after surgery.<sup>[18]</sup> Surgery has a complication rate of 30–50%,<sup>[12]</sup> highlighting the importance of adequately selecting patients.

CSF drainage during tap test, emulates the effect shunting surgery would have and theoretically predicts the outcome.<sup>[3]</sup> Patients with iNPH improve clinically after tap test, suggesting that shunt surgery may be beneficial.<sup>[18]</sup> The effect after CSF extraction is associated with increased activity in the medial aspect of the frontal motor cortex (considered essential for motor planning),<sup>[5]</sup> and gait is the clinical parameter that improves most frequently after this test. This procedure is minimally invasive and easily done as an outpatient procedure that allows objective evaluation of gait and cognitive function before and after CSF drainage.

However, tap test has a low sensitivity, so a negative result may not exclude the diagnosis and additional tests with higher sensitivity may be needed.<sup>[18]</sup> ELD was introduced due to a high false negative rate after tap test.<sup>[3]</sup> We suggest draining CSF until a closing pressure of 0 cm H<sub>2</sub>O is reached.

Volume of CSF within the spinal subarachnoid space is variable among individuals; therefore, pressure changes after CSF extraction is different for each patient. This is our rationale for extracting CSF until a closing pressure of 0 cm H<sub>2</sub>O is reached instead of a fixed volume. We hypothesize that this method guarantees an adequate quantity of drained fluid and we share here our experience. As there is no diagnostic test considered to be the gold standard, we gather all the available information including symptoms, MRI findings, and symptom improvement after CSF drainage.

## MATERIALS AND METHODS

This is a descriptive cross-sectional study, in which medical records of patients treated for NPH in our institution between January 2014 and December 2019 were studied.

The parameters of the procedure for each subject included: opening pressure, volume of CSF extracted, and closing pressure. We included patients with suspected NPH-defined as the classic triad of symptoms. All patients underwent standard brain MRI, gait, and neuropsychologic tests before and after lumbar puncture. During lumbar puncture, CSF was drained until a pressure of 0 cm H<sub>2</sub>O was reached using a manometer.

Data were collected in an Excel® spreadsheet and analyzed using STATA® version 14. We used a univariate descriptive analysis. Absolute and relative frequencies were used for qualitative variables; central tendency and dispersion measures for quantitative variables. We determined if a quantitative variable had a normal distribution with the Shapiro–Wilk test using a significance level of 5% ( $P < 0.05$ ). For variables with normal distribution, mean and standard deviations (SD) were used. For those without normal distribution median and interquartile ranges were used.

A stratified analysis was used to compare the opening pressure and the volume of CSF extracted during lumbar puncture, between the patients in whom the diagnosis of NPH was confirmed and those in whom it was discarded.

## RESULTS

A total of 93 patients with clinical suspicion of iNPH were evaluated using a modified tap test whereby CSF was extracted until a closing pressure of 0 cm H<sub>2</sub>O was reached. Of these, 92 patients were included in the study (one was excluded because the CSF opening pressure was not recorded).

The mean age at the time of evaluation was 79.4 years (SD 6.7) and it ranged from 52 to 96 years. Sixty-three patients (68.5%) were male. Regarding symptoms: 100% of them presented with gait disturbance at the moment of evaluation, 88 patients (95.7%) had cognitive disturbances, and 76 (82.6%) had urinary incontinence [Table 1].

Of the 92 patients that were included, 68 (73.9%) had a confirmed diagnosis of iNPH. The mean opening pressure was 14.4 cm H<sub>2</sub>O (SD 4.8) and average volume of CSF extracted was 43.4 mL (SD 10.8). When carrying out the analysis of patient characteristics, discriminating groups according to the diagnosis of iNPH, no statistically significant differences were identified between the groups [Table 2].

A stratified analysis of the opening pressure and the amount of fluid obtained during lumbar puncture was performed comparing patients with a confirmed diagnosis of iNPH and those without iNPH. Average values for opening pressure and extracted volume in the group with iNPH and those without iNPH were 14.0 cm H<sub>2</sub>O and 42.9 mL and 15.3 cm H<sub>2</sub>O and 44.6 mL, respectively. According to this, no significant difference was found between the groups [Table 2].

**Table 1:** Global patients' characteristics and according to diagnosis of iNPH.

	Total	Confirmed diagnosis of iNPH		P-value
	n=92 (%)	Yes	No	
		n=68 (%)	n=24 (%)	
Age-years (mean and SD)	79.4 (6.7)	79.1 (6.6)	80.3 (6.9)	0.42
Gender				0.82
Male	63 (68.5)	47 (69.1)	16 (66.7)	
Female	29 (31.5)	21 (30.9)	8 (33.3)	
Abnormal gait	92 (100)	68 (100)	24 (100)	
Cognitive impairment	88 (95.7)	67 (98.5)	21 (87.5)	0.053
Urinary incontinence	76 (82.6)	57 (83.8)	19 (79.2)	0.61
Evans' ratio (mean and SD)	0.34 (0.04)	0.34 (0.04)	0.34 (0.05)	0.98
BMI (mean and SD)	25.4 (4.29)	25.6 (4.51)	24.8 (3.63)	0.41
BMI				0.1
Normal weight	44 (47.8)	28 (41.2)	16 (66.7)	
Overweight	41 (44.6)	34 (50)	7 (29.2)	
Obesity	7 (7.6)	6 (8.8)	1 (4.2)	
Previous neurodegenerative disease	31 (33.7)	24 (35.3)	7 (29.2)	0.59
Type of neurodegenerative disease				0.9
Dementia	15 (48.8)	11 (45.8)	4 (57.1)	
Alzheimer	2 (6.5)	2 (8.3)	0	
Parkinson's disease	5 (16.1)	4 (16.7)	1 (14.3)	
Other	8 (25.8)	6 (25)	2 (28.6)	
No data	1 (3.2)	1 (4.2)	0	
High blood pressure	65 (70.7)	45 (66.2)	20 (83.3)	0.11
Diabetes	25 (27.2)	20 (29.4)	5 (20.8)	0.42
Smoker	13 (14.1)	10 (14.7)	3 (12.5)	0.79

iNPH: Idiopathic normal-pressure hydrocephalus. SD: Standard deviation, BMI: Body mass index

**Table 2:** Stratified analysis of opening pressure and amount of cerebrospinal fluid obtained according to the diagnosis of iNPH.

	Confirmed diagnosis of iNPH	Mean	95% CI	Minimum	Maximum
Opening pressure (MmH <sub>2</sub> O)	Yes (n=68)	14	12.9–15.2	3	30
	No (n=24)	15.3	13.3–17.2	7	25
	Total (n=92)	14.4	13.4–15.4	3	30
Amount of cerebrospinal fluid obtained (ml)	Yes (n=68)	42.9	40.1–45.8	7	74
	No (n=24)	44.6	41.3–47.9	30	60
	Total (n=92)	43.4	41.2–45.7	7	74

iNPH: Idiopathic normal-pressure hydrocephalus

## DISCUSSION

Diagnosis of iNPH was confirmed in 73.9% of patients using this modified tap test. High clinical suspicion along with the modified tap test might be an effective diagnostic method for this pathology. The specificities of tap test (33–100%) and ELD (80–100%) are comparable. Although infusion test, which determines CSF flow resistance, has a higher sensitivity compared to tap test (57–100 vs. 28–62%), they both have comparable PPV values.<sup>[11]</sup>

Although all tests have disadvantages, ELD is considered an exact method due to its high PPV and NPV and has been used for over 20 years; however, it is not as common. It requires a brief period of inpatient admission and the most frequent complication is meningitis, which is seen in 2–3% of patients.<sup>[5,12]</sup>

Kahlon *et al.* concluded that infusion test and tap test have a high PPV in predicting outcome after shunting. However, infusion test is more sensitive and tap test more specific. This means, the latter may indicate surgery when positive, but may require additional testing when negative.<sup>[10]</sup>

The optimal volume of CSF that should be extracted during the lumbar puncture for tap test has not been determined, much variation exists on the recommended amount, and there is no significant association between the volume of CSF removed and gait outcomes when extracted volume falls within the 28–50 mL range.<sup>[16]</sup> Later, the test was enhanced by increasing the amount of fluid extracted, given that extracting less than 25 mL had a lower sensitivity.<sup>[2,11]</sup> Wikkelso *et al.* and the 2005 guidelines for the management of NPH suggest a volume of 40–

50 mL.<sup>[12,16,17]</sup> In our study, the mean volume of CSF extracted was within the currently recommended range, which means that our modified tap test is in accordance with the current evidence. Our results also show that there is a wide range of variation in tap test parameters between individuals that may be more homogenous by a fixed closing pressure and false negative rates due to insufficient CSF volume might be reduced.

To the best of our knowledge, there is no such procedure such as the modified tap test we describe in this study, first proposed by Doctor Salomon Hakim and later corroborated.<sup>[10-12]</sup> Of course, the descriptive nature of this study is a major weakness that warrants larger prospective randomized controlled trials to evaluate current diagnostic procedures.

## CONCLUSION

The gold standard for the diagnosis of NPH is the clinical improvement after CSF drainage, assessed with tap test. Nevertheless, recommendations on the optimal volume of CSF that should be drained are inconsistent and variable. We propose a novel standardized procedure, to the best of our knowledge, not reported in the literature, based on a closing pressure of 0 cm H<sub>2</sub>O after lumbar puncture to assure enough and adequate volume of fluid extracted. Our approach is reproducible, and our results show that using this method, the number of patients diagnosed with NPH increases when compared with the published literature. This study warrants a diagnostic test study to confirm these results.

## Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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## Conflicts of interest

There are no conflicts of interest.

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