



## Cognitive and upper limb symptom changes from a tap test in Idiopathic Normal Pressure Hydrocephalus

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### ABSTRACT

**Objectives:** To determine which cognitive and upper limb assessments can identify change in patients undergoing a Cerebrospinal fluid (CSF) tap test (TT) diagnosed with idiopathic Normal Pressure Hydrocephalus (iNPH).

**Patients and methods:** Prospective observational study of 74 iNPH patients undergoing a CSF TT for consideration of a ventricular peritoneal shunt. Patients who were offered surgical intervention were classified as responders. Patients were assessed with a battery of cognitive and upper limb assessments prior to and following a CSF TT. The Timed up and go cognition (TUG-C), Montreal Cognitive assessment (MoCA) and 9-hole peg test were utilised.

**Results:** 40 patients were classified responders. Significant differences were identified for responders for the MoCA (0.62 points) and TUG-C (−6.02 s). Only the executive function and orientation sub scores of the MoCA showed significant changes for responders. The 9 hole peg test mean change of 4.33 s for responders was not significant. Non-responder change scores for the MoCA (0.22 points), TUG-C (0.3 s) and 9 hole peg test (2.58 s) were not significant.

**Conclusion:** The TUG-C has the potential to identify change in patients resulting from a CSF TT. While statistically significant change was found for the MoCA, a mean change of less than 1 point on this scale is unlikely to be clinically relevant. Similarly, the 9 hole peg test cannot be endorsed as an assessment tool for identifying changed performance in iNPH.

### 1. Introduction

Idiopathic Normal Pressure Hydrocephalus (iNPH) is a condition where patients present with a triad of symptoms of high level gait disorder, incontinence, and cognitive deficits [1]. A neurosurgical procedure, insertion of a ventricular peritoneal (VP) shunt, represents the gold standard treatment [2,3]. This implanted surgical device is designed to divert cerebrospinal fluid (CSF) from the brain ventricles into the peritoneal space. However, not all patients diagnosed with iNPH will benefit [4]. To identify who may benefit supplemental tests have been developed to mimic a shunt [1,3,5,6]. The CSF tap test (TT) aims to temporarily drain CSF [7]. The CSF TT drains between 30 and 60 mls of CSF and patients are assessed prior to and after CSF drainage to determine if changes in symptoms, typically gait and cognition, have occurred [3,7].

iNPH symptoms often overlap or coexist with Parkinson's disease (PD), Alzheimer's disease (AD), or frontal dementia [1,7]. Determining

iNPH cognitive deficits opposed to co-existing cognitive deficits can prove difficult [8–10]. Subtle differences have been demonstrated between iNPH and AD with frontal lobe dysfunction disproportionately severe in iNPH and memory impairment distinctly mild compared to matched AD sufferers [8,10,11]. Idiopathic Normal Pressure Hydrocephalus suffers score better orientation and delayed recall testing compared to AD patients but worse on arithmetic and digit symbol substitution tests [8]. Generally the cognitive deficits of iNPH are isolated to executive function impairment [10]. These differences facilitate the ability to assess for cognitive change from a CSF TT.

Extensive evidence supports the prognostic efficacy of the CSF TT to predict positive response post insertion of a VP shunt [4,6,12,13]. However, what degree of change constitutes a positive response and which tests quantify the change resulting from a CSF TT is not clear. Cognitive examination is routinely undertaken to identify patients who may benefit from VP shunt insertion [2,10].

A previous study investigated the Cognitive Assessment of

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Minnesota (CAM) to determine if changes could be identified after external lumbar drainage (ELD), an alternative CSF drainage technique showing it was sensitive in detecting differences between responders and non-responders to surgical intervention [14]. The Montreal Cognitive Assessment (MoCA) is a cognitive examination testing similar domains to the CAM which has been suggested for use in the iNPH population based on its use in other forms of dementia [15]. The MoCA is valid in assessing mild cognitive impairment [16].

Additionally counting backwards from 20 has been evaluated to assess executive function in patients undergoing VP shunt insertion [17]. Counting backwards has been shown to be accurate, valid assessment in iNPH. The Timed Up and Go Cognition (TUG-C) is a test combining a serial counting backwards test with a timed walking task. A combination of the Timed Up and Go with a serial counting backwards task could have potential to aid in identification of surgical candidates. The Timed Up and Go has been demonstrated an ability identify responders v non responders to the tap test previously [18].

Upper limb tests used to measure CSF TT response have been reported in large international iNPH trials [10]. The efficacy of upper limb assessments to detect changes in upper limb performance has been shown by a small body of evidence [19]. Upper limb function testing, using line drawing and tracing tasks, has been investigated to identify change from a CSF TT [19]. The authors suggest that simple upper limb tasks may identify CSF TT responders in addition to traditional gait based assessments [19]. Patients completed a line tracing task before and after a CSF TT. Responders were noted to have an average reduction of 12% in time to complete a tracing task [19]. The 9 hole peg test assesses dominant hand function by measuring the time taken to individually pick up 9 pegs, place them into a 9 slot peg board and remove them again [20]. The 9 hole peg test has been evaluated previously in iNPH and is valid in identifying upper limb dysfunction in PD [14,20]. The 9 hole peg test has been evaluated unsuccessfully previously in an ELD. It was not able to identify improvements in upper limb function from 5 days of ELD [14].

Attempts to identify CSF TT responders varies substantially clinically and within research as many different assessment tools are utilised. Confounding this, no research has focused on defining meaningful change by which a positive response can be identified. Currently arbitrary values of 5 or 10% improvement are listed as signs of positive response [10]. This study sought to answer 2 questions: 1. Identify cognitive and upper limb assessments which can detect change resulting from a CSF TT in patients with iNPH.

2. Identify differences present between patients who respond and don't respond to a CSF TT for cognitive and upper limb assessments.

This information is necessary to streamline and standardise the assessment process currently used by clinicians and to objectively guide decisions regarding patient's suitability to undergo VP shunt insertion.

## 2. Patients and methods

This prospectiveobservational study was conducted in a tertiary referral Neurological and Neurosurgical facility. Patients admitted to this facility for investigation of iNPH and scheduled to undergo a CSF TT between June 2013 and December 2016 were provided with written information explaining the aims of the study and written consent to participate in the study was sought. This study was approved by the Hunter New England human research ethics committee, reference: 13/06/19/4.02.

Patients were eligible for inclusion in the study if they were admitted for a CSF TT for iNPH, aged over 55 years and diagnosed with Ventromegaly on CT or MRI imaging with Evans index > 0.3. Patients were excluded if they could not walk 10 m with assistance. Mobility aids were permitted. Patients who were unable to consent to the study or did not have a next of kin available to consent were also excluded. Demographic data was collected from patients and their medical records.

### 2.1. iNPH diagnosis and Pre-Post CSF TT assessment

Diagnosis of iNPH by the admitting medical officer was in accordance with international guidelines on the diagnosis of possible and probable iNPH [2,21].

The Montreal cognitive assessment (MoCA), Timed up and go cognition (TUG-C) and 9-hole peg tests were selected for use based on available research and current clinical practice. The MoCA is routinely used at the participating facility to assess cognitive deficit and was utilised in iNPH prior to the commencement of this study. The TUG-C was selected based on its ability to assess gait and cognitive function.

The MoCA consists of 30 items assessing short term memory, abstraction, executive function, orientation, and language [22]. Three versions of the MoCA exist eliminating learned effect from completing the same test within several hours. Scores below 26 represent mild cognitive impairment and below 21, moderate impairment [16]. The MoCA has been found valid and reliable in PD, AD and cognitive decline [23]. The TUG-C requires patients to rise from a chair, walk 3 m, turn around walk back and sit while counting backwards serially from 100. The TUG-C is a multistep process relying on a level of executive function to correctly execute. The TUG-C has been validated in PD and falls patients [20,21]. The Timed Up and Go has been demonstrated an ability to identify responders v non responders to the tap test previously [22]. The 9 hole peg test is a timed test requiring patients to individually pick up 9 pegs, place them into a board and remove them again.

A Physiotherapist and Occupational Therapist involved in the clinical care of the patient completed the above tests prior to the CSF TT which was conducted by the admitting medical officer (AMO). The assessments were re-administered within 4 h of the CSF TT by the same Occupational therapist and Physiotherapist. Different versions of the MoCA were used on pre-and post CSF TT assessment to eliminate potential for learned affect to confound results.

### 2.2. Tap test method

One Neurosurgeon inserted Rickman's reservoirs, a subcutaneous CSF reservoir linked to the lateral ventricles by a catheter, to facilitate a CSF TT. Lumbar puncture CSF TT's were completed by all other Neurologists and Neurosurgeons. Each CSF TT aimed to drain 30 mls of CSF.

### 2.3. Determination of response

Gait, balance, radiological examinations, cognitive and upper limb examinations were provided to the AMO. Patients were classified as responders where the AMO determined improvement in symptoms had occurred across all testing parameters and surgical intervention was offered to the patient. Patients not offered surgery were labelled non-responders.

### 2.4. Statistical analysis

Patients were dichotomized by response status for analysis. Pre Post scores were analysed by response status. Pre and post CSF TT scores along with change scores were analysed by response status to determine if differences were present.

Stata 13(Statacorp) was utilised for analysis. Skewness-kurtosis testing on data determined if data was normally distributed. Mann Whitney *U* and Wilcoxon sign rank tests were utilised to compare all pre post CSF TT data and demographic data except for the MoCA total where paired *t*-tests were utilised. Chi square tests assessed differences between responders and non-responders for gender and triad symptoms. Significance levels for all tests were set at a *p* = 0.05.

Recruitment numbers for this study were based on power calculations for a separate arm of this research investigating gait and balance

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