PREDICTIVE VALUE OF LUMBAR INFUSION TEST IN NORMAL PRESSURE HYDROCEPHALUS

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ABSTRACT

Introduction: *To detect the ability of the lumbar infusion test to predict the outcome of shunt surgery in patients with suspected normal pressure hydrocephalus.*

Methods: *Twenty patients with suspected normal pressure hydrocephalus were studied. Preoperative CT and/ or MRI of the brain was done in all cases. The absence of preceding history indicated idiopathic disease. All patients were assessed with walking and psychometric tests before lumbar infusion test and tap test assessments. Tap test was done in all cases because it is the standard test used in these cases. The lumbar infusion test was done using a constant infusion rate (0.80 ml/min) using a syringe pump and regarded as positive if the steady state CSF plateau pressure reached levels of > 22 mm Hg (16 cm H2O). The tap test was regarded as positive if two or more of three different test items improved after CSF removal. Walking and psychometric tests were used to assess patients postoperatively.*

Results: *The results of the CSF tap test and the lumbar infusion test agreed in only 40% of cases. Of all cases in the study, 18 (90%) had positive test results and were operated on; 16 (80%) of patients reported subjective improvement, and postoperative assessments verified the improvements in 15 patients (75%). Improvements were highly significant in walking and memory. Most of the patients improved by surgery (90%) were selected by a positive lumbar infusion test, and only 67% by a positive tap test.*

Conclusions: *Both the lumbar infusion test and the tap test can predict a positive outcome of shunt operations in patients with suspected normal pressure hydrocephalus. Lumbar infusion test has a higher predictive value than the CSF tab test. The two tests are complementary and should be used together for a better patient selection.*

Key Words: *- Normal pressure hydrocephalus - Lumbar infusion test - Tap test*

INTRODUCTION

Normal pressure hydrocephalus (NPH)

Normal pressure hydrocephalus is a chronic type of communicating hydrocephalus whereby the increase in intracranial pressure (ICP) due to accumulation of cerebrospinal fluid (CSF) becomes stable and that the formation of CSF equilibrates with absorption.(1) The ICP maintains a slightly elevated level and the CSF pressure reaches a high normal level of 150 to 200 mmH_2O. Measurements of CSF, therefore, are not usually elevated above normal values. Because of this equilibration, patients do not exhibit the classic signs of increased intracranial pressure such as headache, nausea, vomiting, or altered consciousness (though some studies have shown pressure elevations to occur only intermittently).(2) However, patients do exhibit the classic triad of gait difficulties, urinary incontinence, and mental decline as first described by Hakim and Adams in 1965.(3) It is often misdiagnosed as Parkinson's disease, Alzheimer's disease, and senility due to its chronic nature and its presenting symptoms.(4) Although the exact mechanism is unknown, normal pressure hydrocephalus is thought to be a form of communicating hydrocephalus with impaired CSF absorption at the arachnoid villi.(5)

There are 2 forms of normal pressure hydrocephalus. The secondary form which is due to subarachnoid haemorrhage, head injury, cranial surgery, or CNS infection, and the idiopathic form where the cause is at present unknown.(6)

Recent population-based studies have estimated the prevalence of NPH to be about 0.5% in those over 65 years old, with an incidence of about 5.5 patients per 100,000 of people per year.(7)

As regards to patients with dementia that are confined in a nursing home and have undiagnosed NPH may become again independent if treated, so far only one study was able to evaluate the prevalence of NPH, both diagnosed and undiagnosed, among residents of assisted-living facilities, that ranged between 9 to 14% of the residents.(8)

Diagnosis of NPH is usually first done by a lumbar puncture, followed by the evaluation of clinical response to removal of CSF. Other methods for diagnosis include continuous external lumbar CSF drainage during 3 or 4 days.(9)

Infusion test is a test with higher sensitivity and specificity than a lumbar puncture. The outflow plataue pressure of the cerebrospinal fluid (CSF) system is a parameter considered to be predictive in selection for hydrocephalus surgery.(10)

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NPH may be relieved by surgically implanting a ventriculoperitoneal shunt to drain excess cerebrospinal fluid to the abdomen where it is absorbed.[10]

METHODS

Patients

Twenty patients with assumed normal pressure hydrocephalus were included in the study. All patients suffered from either gait disturbance or cognitive dysfunction alone, or from both symptoms combined, or from one or both of them combined with urinary incontinence. Symptom duration was less than eight years. Computed tomography (CT) (Fig.1) or magnetic resonance imaging (MRI) showed widening of the ventricular system relative to the age matched ventricular index. Postoperative CT brain was done in all cases (Fig.2). A lumbar infusion test and a tap test were done in all patients.

Procedures

Lumbar infusion test

The lumbar infusion test was done with the patient in the lateral recumbent position; two cannulas (diameter 0.9 mm) were inserted in the lower lumbar region (L3–4 or L4–5). One of these was connected to a let down infusion device on a scaling ruler and the other to an infusion pump. The initial steady state CSF pressure was recorded for at least five minutes before starting an infusion of Ringer solution (NaCl 8.6 g/l, KCl 0.3 g/l, CaCl 0.33 g/l; 290 mosm/kg). The constant infusion rate was 0.8 ml/min. The CSF pressure was recorded continuously during a period of at least 45 minutes, to establish a steady state pressure plateau representing the pressure level at which absorption balanced infusion. A plateau pressure level exceeding 22 mm Hg (16 cm H2O) was considered pathological (a positive test result). Alternatively, if the CSF pressure increased steadily to greater than 40 mm Hg (29 cm H2O) without a plateau the infusion was stopped and the test was regarded as positive. After completion of the infusion test the lumbar puncture cannulas were left in place until the CSF pressure had returned to the initial preinfusion resting value and had been stable for 10 minutes.

CSF tap test

The CSF tap test was done directly after the lumbar infusion test and involved assessing the effect on a series of functional tests of removing 50 ml of CSF through one of the cannulas used for the infusion test. We had previously obtained baseline data for walking ability and psychometric tests on two separate occasions at the same time of day. After CSF removal and a rest period of one to three hours, these tests were repeated for comparison with the baseline data.

The test battery included the following:

• *Walking test*: The patient was asked to walk for a distance of 20 ms as fast as possible. The test was repeated three times and the number of steps as well as the performance time was recorded. The average of the three attempts was calculated and used as the test result.

• *Reaction time*: The patient was asked to raise his arm up in the air and the estimated response time was calculated. This was done for twenty times and alternating between the right and left arms and the average time for the response was calculated.

• *Memory test*: The patient was told a number of six figures and was asked to recall the number after five minutes. This was repeated for three times and an average score was given.

Surgery

Surgery was undertaken if either the lumbar infusion test or the tap test or both tests were positive. The patients received a low pressure ventriculoperitoneal shunt. If both tests were negative, surgery was not done.

Evaluation of Outcome

All patients were evaluated at a follow up visit after one, three and six months using the same test battery as at baseline. As in the tap test criteria, the patients were considered objectively improved if two or more of the test items showed improvement compared with the better of the two baseline results. Patients and relatives were also asked for their subjective opinion as to whether or not there had been an improvement.

RESULTS

The study included 8 men and 12 women (table I), mean age was 70 years (range 50 to 76) (table II). Two patients had an earlier history of spontaneous intracranial haemorrhage (more than five years before, including one patient with subarachnoid haemorrhage), and one of the patients had an earlier history of central nervous system infection (> 5 years before). One patient had an earlier history of severe head trauma (> 5 years before). In the majority of cases (80%) there was no evidence of earlier neurological disease to explain the development of normal pressure hydrocephalus. (table III)

Disturbance of gait was the most common preoperative symptom (90%), while fewer patients suffered from cognitive impairment (70%) or incontinence (60%). In most patients, different combinations of symptoms were found. Of 12 patients who had all three symptoms of the classical triad, 11 (90%) had either a positive lumbar infusion test, a positive tap test, or both, while of 3 patients with one symptom, one had a positive test result (33%), and of 5 with two symptoms, 3 had a positive

result (60%).

Complications and Assessment of Shunt Function

There were no complications or side effects related to the lumbar infusion test or the tap test. In one patient the shunting procedure was complicated by a subdural haematoma. In this patient, the haematoma was managed surgically. All operated patients who did not show objective improvement at the follow up evaluation had a plain skull *x*-ray, CT of the brain, and a repeat lumbar infusion test. In all cases, shunt placement, continuity, and function were found to be adequate.

Variability of the baseline tests

In order to study and compensate for spontaneous variations in the patients' ability to perform the different tests, we used the mean values of different measurements for the walking and reaction time evaluations, and repeated all tests twice.

Lumbar Infusion Test and the Tap Test Related to the Outcome:

In 10 patients (50%), the tap test and the lumbar infusion test showed a positive result. The 2 patients not operated upon (because both the tap test and the lumbar infusion test were negative), were both objectively and subjectively improved at follow up. These two patients did not have any history of head trauma or intracranial hemorrhage and were likely to be ischaemic. Eighteen patients fulfilled the criteria for surgery and underwent the shunting procedure. Sixteen (80%) of these patients showed an objective improvement and 15 patients (75%) reported a subjective improvement. Of the 16 patients with objective improvement, 13 (80%) had a positive lumbar infusion test but only 6 (35%) had a positive tap test. Only one of the two patients who were not improved had a negative lumbar infusion test, while both the two patients had a negative tap test.

In the operated group, walking, memory and reaction time tests showed improvements. Fourteen patients with a positive lumbar infusion test (90%) had significant improvements in walking, memory, and reaction time tests. Of 12 patients with a positive tap test, 9 patients (80%) had a significant improvement in memory and reaction time at the follow up evaluation. Only 8 patients were positive for both the lumbar infusion and the CSF tap tests, and all these were both objectively and subjectively improved postoperatively. In this group of patients the improvement was significant for walking and memory tests. In 6 patients a positive lumbar infusion test was an indication for shunt surgery, but the tap test was negative, while two patients had surgery because of a positive tap test but had a negative lumbar infusion test. The improvement in walking, reaction time, and memory tests after surgery was more in patients chosen by a positive lumbar infusion test than those with a CSF tap test. (table IV)

Degree of postoperative improvement:

In the majority of patients walking improved more than the reaction time. In 20% of the patients these tests were improved significantly. Fewer patients showed improvements in cognitive function.

Table I: The sex distribution of studied patients

Gender	Number of patients
Males	8 (40%)
Females	12 (60%)

Table II: The age distribution of studied patients

Age category	Number of patients
50 to less than 60	4 (20%)
60 to less than 70	7 (35%)
More than 70	9 (45%)

Table III: The distribution of patients according to the etiology

Category of patients	Number of patients
Idiopathic	16 (80%)
Intracranial hemorrhage	2 (10)
Meningitis	1 (5%)
Severe head trauma	1 (5%)

Table IV: The number of patients improved by different tests and the predictive value of tests used

Type of test used	Number of patients with positive test	Number of patients improved postoperatively of positive cases
Infusion test	16 (89%)	14 (88%)
Tap test	12 (67%)	9 (75%)
Infusion test only positive	6 (33%)	5 (83%)
Tap test only positive	2 (11%)	1 (50%)
Both infusion and tap tests positive	8 (44%)	8 (100%)

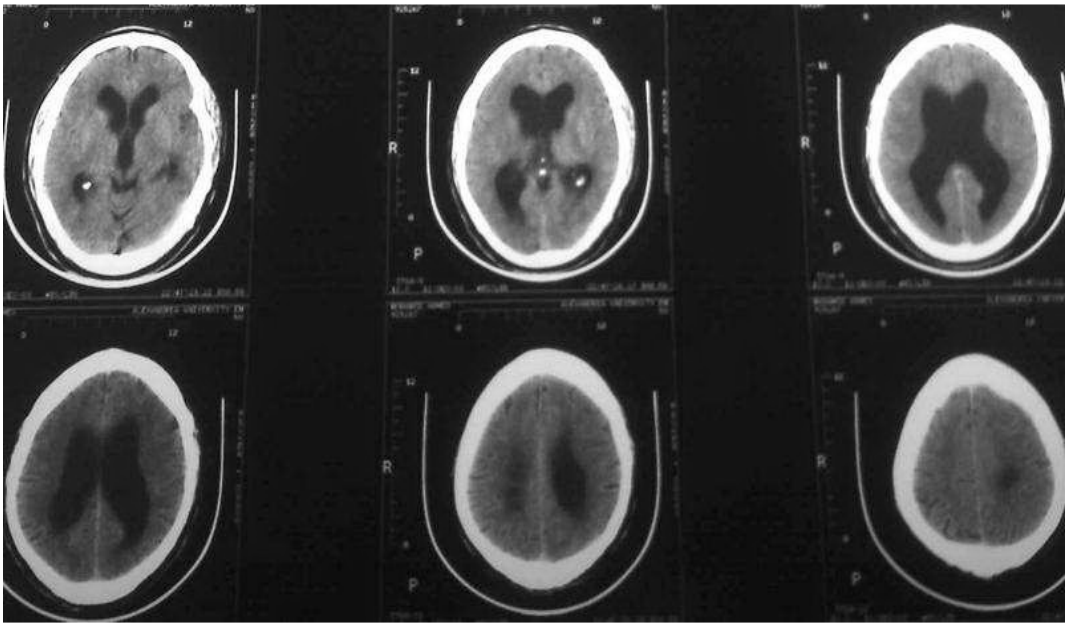

Fig. 1: Computerised scan of the brain, axial view, soft tissue window showing ventricular dilatation in one of patients suspected with normal pressure hydrocephalus

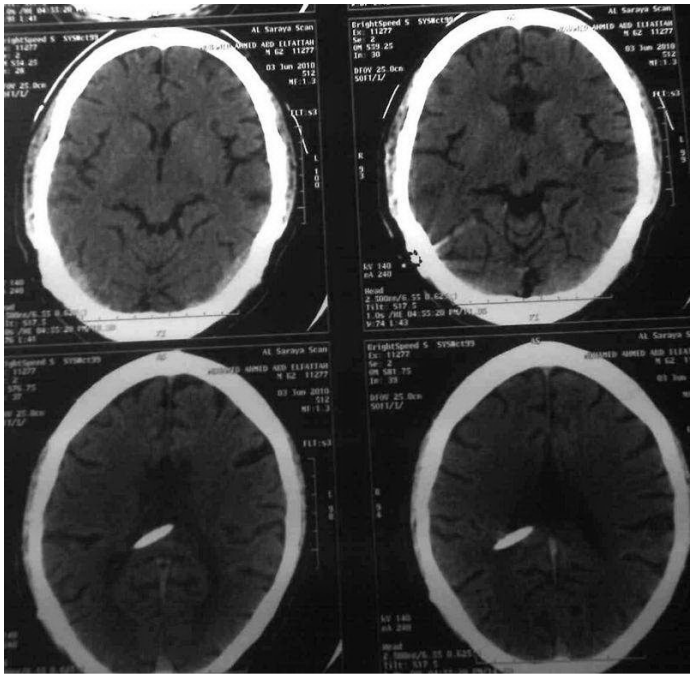

Fig. 2: Computerised scan of the brain, axial view, soft tissue window showing resolved ventricular dilatation in one of patients suspected with normal pressure hydrocephalus after ventriculoperitoneal shunting

DISCUSSION

Our aim in this prospective study was to establish how well the results of the lumbar infusion test and the tap test agree with each other and with the outcome after shunt treatment for suspected normal pressure hydrocephalus. The results show that both tests can predict a positive outcome after surgery, but there was agreement between the test results in only 50% of the patients. This was in accordance with most other studies.[11]

Methodological considerations

Both the tap test and the lumbar infusion test require lumbar puncture, and even though this can be done with small diameter needles it is difficult to exclude the possibility that repeated lumbar punctures within a limited time period may influence the test results. Thus if the tap test is performed first, a leak from the puncture may influence the result of a lumbar infusion test, at least for some weeks afterwards. On the other hand, a leak after a lumbar infusion test could influence the result of baseline test data before CSF drainage in the tap test.[12]

To circumvent these difficulties we chose to perform both tests on the same day, using the same lumbar puncture. We have earlier observed that patients may improve for a time after a lumbar infusion test and have interpreted this as being a possible effect of leakage of CSF after the lumbar puncture. If so, this effect is similar to the effect measured by the tap test and should not, therefore, influence the result a tap test performed directly after the lumbar infusion test using the same lumbar puncture.

Lumbar infusion test

For the lumbar infusion test, a pressure of 22 mm Hg was regarded as the cut off level above which the mean steady state plateau during the infusion was considered pathological.

CSF tap test

The CSF tap test has the advantage of being simple to perform without any specialised equipment. Drawbacks include the fact that the testing procedure needs active cooperation from the patients, and that unrelated diseases or deficits may interfere with the result.[13,14] This is at least partly compensated for by using different test items, with the requirement that improvement in only two of them is needed for a positive test result. More importantly, there may be spontaneous variation in the patient's ability to perform the tests. In fact our results confirmed a high spontaneous variation in baseline test results when repeated in the same patient. Most patients performed better when the baseline tests were repeated on the second day, indicating some learning effect.

Because we anticipated the possibility of spontaneous variation, we always used the better of the two baseline tests in comparisons with the result after CSF removal, as well as for evaluating the outcome at follow up.

In earlier studies of normal pressure hydrocephalus, using standardised tap test criteria, the baseline tests were performed only once before removal of CSF. The present results indicate that the baseline assessments should be repeated on different occasions and the best of at least two test procedures should be used to compare with the result after CSF removal. Of the 16 patients improved after shunting, the tap test predicted a positive result only in 75%.

Evaluation of outcome

In the present study, we used the patients' (and relatives') subjective impression of the clinical outcome was in good agreement with the test results. The subjective evaluations showed improvement in a greater number of patients than the objective tests, which may reflect the fact that more than one functional test had to be improved to classify the patient as objectively improved; however, it may also include a placebo effect.

Prediction of outcome

Both the CSF tap test and the lumbar infusion test were shown to predict a positive outcome of shunt surgery in patients with suspected normal pressure hydrocephalus.[15,16] We followed a strategy of not basing the decision for surgery on clinical symptoms and ventricular widening alone, so, patients with negative results in both the lumbar infusion test and the tap test were not operated on. [17]The positive predictive value was 75% for the tap test. The positive predictive value of lumbar infusion test was 88%. These data indicate that the lumbar infusion test is the more sensitive test than the tap test. Only in the small group of patients in whom both tests were positive did every patient improve after shunting. These results are in accordance with most other authors[18-20] However, 8 patients (50%) with postoperative improvement would have been missed if both tests were required to be positive before considering surgical treatment. Taken together, the data indicate that the tap test and the lumbar infusion test are complementary diagnostic tools.

Conclusions

In a patients with clinically suspected normal pressure hydrocephalus, most patients (88%) with improvement after shunt surgery were selected by a positive lumbar infusion test, while fewer (75%) were selected by a positive CSF tap test. There was only partial agreement between the two tests and they enhance the results of each other. We therefore suggest that both tests should be included in a preoperative evaluation, and one or both should be positive before recommending surgery.

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