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Clinical Study

Functional gait outcomes for idiopathic normal pressure hydrocephalus after primary endoscopic third ventriculostomy

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ABSTRACT

We evaluated if patients with idiopathic normal pressure hydrocephalus (iNPH) showed functional improvement after primary endoscopic third ventriculostomy (ETV). The efficacy of ETV for iNPH remains controversial. We retrospectively reviewed 10 consecutive patients treated between 2009 and 2011 with ETV for iNPH. Seven patients with a median age of 73 years (range: 60–80) who underwent a primary ETV for iNPH were included for analysis. Median follow-up was 39 months (range: 26–46). Post-ETV stoma and aqueductal and cisternal flows were confirmed via high resolution, gradient echo and phase contrast MRI. Post-ETV timed up and go (TUG) and Tinetti performance oriented mobility assessment scores were compared to pre- and post-lumbar puncture (LP) values. A second LP was performed if ETV failed to sustain the observed improvement after initial LP. Patients who demonstrated ETV failure were subsequently shunted. Compared to pre-LP TUG and Tinetti values of 14.00 seconds (range: 12.00–23.00) and 22 (range: 16–24), post-LP scores improved to 11.00 seconds (range: 8.64–15.00; $p = 0.06$) and 25 (range: 24–28; $p = 0.02$), respectively. ETV failed to sustain this improvement with slight worsening between pre-LP and post-ETV TUG and Tinetti scores. Improvement from pre-LP assessment was regained after shunting and at last follow-up with TUG and Tinetti scores of 12.97 seconds (range: 9.00–18.00; $p = 0.250$) and 25 (range: 18–27; $p = 0.07$), and 11.87 seconds (range: 8.27–18.50; $p = 0.152$) and 23 (range: 18–26; $p = 0.382$), respectively. Despite stoma patency, ETV failed to sustain functional improvement seen after LP, however, improvement was regained after subsequent shunting suggesting that shunt placement remains the preferred treatment for iNPH.

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1. Introduction

Idiopathic normal pressure hydrocephalus (iNPH) is a common and treatable neurological disorder that occurs in the elderly, and most often results in progressive gait impairment, urinary incontinence and cognitive deterioration [1,2]. Surgery is warranted in the majority of patients with symptomatic iNPH as cerebrospinal fluid (CSF) diversion results in symptomatic improvement in up to 80–90% of individuals [1]. Potential options for CSF diversion in iNPH patients include ventriculoperitoneal (VP) shunt placement and endoscopic third ventriculostomy (ETV).

Although ETV is considered a preferred treatment for obstructive hydrocephalus [3], its use in iNPH remains controversial with studies displaying contradictory outcomes [4]. Likewise, while the efficacy of ETV for obstructive hydrocephalus is easily understood as a means to bypass an obstructive lesion, the mechanism by which ETV may work in iNPH is not well understood. ETV is considered to be a safe and relatively simple procedure [5] with a lower risk of infection and delayed failure compared to VP shunts [6–8], however, careful consideration of the risk-benefit ratio related to each treatment option must be performed to determine the most appropriate modality for hydrocephalus management. As such, more data is needed regarding the outcomes in patients with iNPH following ETV compared to VP shunt placement.

Previous studies regarding the success of ETV in patients with iNPH were limited by the fact that often CT scan instead of MRI was used as the imaging modality and by the fact that third ventricle morphology was not used as inclusion/exclusion criteria [9–11] despite the significant association between third ventricle morphology and outcomes after ETV [12]. As a result, the majority of these studies likely included patients with obstructive etiologies with either triventricular enlargement (unrecognized aqueductal

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obstruction on CT scan) or tetraventricular enlargement such as infratentorial intracisternal obstructive hydrocephalus [13,14]. Therefore, prior studies have potentially included better results that are not applicable to patients with iNPH. It is essential, therefore, to ensure that only patients with clinically and radiographically confirmed iNPH are included in studies evaluating the efficacy of ETV for iNPH.

In the present study, we evaluated functional gait outcomes (as indicated by the change in timed up and go [TUG] and Tinetti performance oriented mobility assessment scores during follow-up) after primary ETV in patients with a confirmed diagnosis of iNPH and normal third ventricle morphology.

2. Materials and methods

2.1. Patients

Under an active Institutional Review Board approved protocol, the medical records of 10 consecutive patients treated with ETV for iNPH by the senior author between 2009 and 2011, were retrospectively reviewed. Of note, 107 new shunts were placed by the senior author for the treatment of obstructive hydrocephalus presenting as iNPH during the same time period. After discussion regarding the known treatment options for iNPH, 10 patients chose to undergo ETV instead of shunting. All patients were adults (>21 years of age). Seven patients (70%) with iNPH who received an ETV as their primary treatment were included for analysis (Table 1). A total of three patients (30%) were excluded, one (10%) because of secondary iNPH resulting from an intracranial infection, one (10%) with iNPH who had a history of previous shunt placement, and one (10%) with iNPH who was lost to follow-up after discharge. Preoperative high resolution, gradient echo MRI sequences were obtained to confirm the absence of an obstructive etiology, and displayed a normal third ventricle morphology in all patients (Fig. 1). All patients received a lumbar puncture (LP) prior to ETV and had a preoperative opening pressure <25 cm H_2O, supporting the diagnosis of iNPH.

Table 1
Idiopathic normal pressure hydrocephalus patient characteristics

Characteristics	iNPH patients (n = 7)
Age, years, median (range)	73 (60–80)
Sex, female, n (%)	3 (43)
Race, n (%)	
Caucasian	7 (100)
Symptoms at presentation, n (%)	
Gait impairment	7 (100)
Urinary incontinence	7 (100)
Cognitive dysfunction	5 (71)
Vision deficit	0 (0)
Headaches	1 (14)
Nausea	0 (0)
Dizziness	3 (43)
Duration of symptoms prior to ETV, months, median (range)	24 (5–60)
Complications, n (%)	
Intraoperative	0 (0)
Postoperative	0 (0)
Follow-up duration, months, median (range)	39 (26–46)
Pre-LP quantitative tests	**iNPH patients (n = 7)**
MMSE, median (range)	27 (25–29)
TUG, seconds, median (range)	14.00 (12.00–23.00)
Tinetti, median (range)	22 (16–24)
Evan's index, median (range)	0.36 (0.33–0.39)

ETV = endoscopic third ventriculostomy, iNPH = idiopathic normal pressure hydrocephalus, LP = lumbar puncture, MMSE = mini-mental state examination, Tinetti = Tinetti performance oriented mobility score, TUG = timed up and go.

Demographic information concerning sex, race, age at treatment, and previous shunting were collected. Baseline data concerning the duration of symptoms prior to ETV, Evan's index, and presenting symptoms were obtained. Baseline and post-LP TUG and Tinetti scores were reviewed prior to ETV. Quantitative, continuous data are expressed in median (range) for non-parametric variables, and categorical data are expressed as frequency (percentage).

2.2. Clinical and radiologic follow-up

All intraoperative and postoperative complications that occurred within 6 weeks postoperatively were recorded. Post-ETV TUG and Tinetti scores were compared to pre- and post-LP values prior to ETV. Higher values of mini–mental state examination (MMSE; 30 points) and Tinetti (28 points) and lower values of TUG indicate better performance. Recurrence free probability was determined by the time to symptom recurrence after ETV (Fig. 2). A second LP was performed if the ETV failed to sustain the observed improvement after initial LP, despite stoma patency. After ETV failure, patients who demonstrated improvement after a second LP were considered for repeat ETV or VP shunting. Postoperative ETV patency and aqueductal and cisternal flow were assessed by high resolution, gradient echo MRI and flow pulsatility through the stoma on phase contrast MRI.

3. Results

Three Caucasian women (43%) and four men (57%) with iNPH underwent ETV as their primary treatment modality. The median age at treatment was 73 years (range: 60–80). The median duration of symptoms prior to ETV was 24 months (range: 5–60). Preoperative Evan's index was 0.36 (range: 0.33–0.38). All patients presented with gait impairment and urinary incontinence and five (71%) displayed signs of cognitive dysfunction. Median baseline pre-LP MMSE, TUG, and Tinetti scores were 27 (range: 25–29), 14.00 seconds (range: 12.00–23.00) and 22 (range: 16–24), respectively. No intraoperative or postoperative complications occurred during the primary ETV or subsequent shunt placement.

After an initial LP, the TUG and Tinetti scores improved to 11.00 seconds (range: 8.64–15.00; $p = 0.06$) and 25 (range: 24–28; $p = 0.02$), respectively (Fig. 3). However, this improvement was not sustained after ETV with slight worsening observed between pre-LP and post-ETV TUG and Tinetti scores (Fig. 4). All patients also showed symptomatic ETV failure after a median of 9 months (range: 0–24; Fig. 2) despite evidence of a patent stoma on imaging. Patients were re-evaluated with a new LP after ETV failure and subsequently shunted after displaying improvement from pre-LP values following the second-LP. Improvement from pre-LP assessment was regained after shunting and at last follow-up with TUG and Tinetti scores of 12.97 seconds (range: 9.00–18.00; $p = 0.250$) and 25 (range: 18–27; $p = 0.07$), and 11.87 seconds (range: 8.27–18.50; $p = 0.152$) and 23 (range: 18–26; $p = 0.382$), respectively (Fig. 4). Follow-up duration was a median of 39 months (range: 26–46).

4. Discussion

Data from the present study suggests that primary ETV fails to improve mobility, assessed by TUG and Tinetti, in patients with confirmed iNPH and normal third ventricle morphology while subsequent shunt placement regained the improvement seen after a trial of CSF drainage via LP. As prior studies describing ETV use in