Journal of Clinical Neuroscience 29 (2016) 117–120

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Comparison of outcomes between patients with idiopathic normal pressure hydrocephalus who received a primary *versus* a salvage shunt

Dane Moran, Alice Hung, Sharif Vakili, Hugo Fialho, Lee Jeon, Eric W. Sankey, Ignacio Jusué-Torres, Jennifer Lu, C. Rory Goodwin, Benjamin D. Elder *, Daniele Rigamonti

Department of Neurosurgery, The Johns Hopkins University School of Medicine, 1800 Orleans Street, Baltimore, MD 21287, USA

ARTICLE INFO

Article history:
Received 8 December 2015
Accepted 17 December 2015

Keywords:
Normal pressure hydrocephalus
Reoperation
Shunt revision
Ventriculoperitoneal shunt

ABSTRACT

Placement of a ventriculoperitoneal (VP) shunt is the treatment of choice for communicating hydrocephalus; however, the extent to which VP shunting is able to relieve symptoms in patients who had previously been treated with cerebrospinal fluid diverting therapy at an outside institution remains unclear. A retrospective review of patients with idiopathic normal pressure hydrocephalus treated with VP shunts at a single institution between 1993 and 2013 was conducted. Patients were classified as having received a primary VP shunt if they had not been previously treated with a VP shunt, ventriculoatrial shunt, lumboperitoneal shunt, or endoscopic third ventriculostomy. Patients were classified as having received a salvage VP shunt if they had been previously treated by one of these four modalities at an outside institution prior to their presentation to our institution. There were 357 patients who received a primary shunt and 33 patients who received a salvage shunt. Patients who had a salvage shunt placed had significantly higher odds of requiring a future revision (54% *versus* 41%; odds ratio = 2.85; 95% confidence interval [CI]: 1.24–6.57; $p = 0.014$). Patients who received a salvage shunt had statistically significantly lower rates of gait improvement at 6 months in comparison to patients who received a primary shunt (relative risk = 0.35; 95% CI: 0.14–0.87; $p = 0.025$). Despite these findings, there was no significant difference at last follow-up in improvement in gait, continence, and cognition, indicating that outcomes for patients requiring a salvage shunt were comparable to patients receiving a primary shunt.

Published by Elsevier Ltd.

1. Introduction

Idiopathic normal pressure hydrocephalus (iNPH) is a form of communicating hydrocephalus associated with symptoms of gait instability, urinary incontinence, and cognitive decline – a constellation of symptoms referred to as Hakim's triad [1–3]. The prevalence of iNPH in the general population is about 1.3% in people aged over 65 years [4]. This increases to about 5.9% in people aged over 80 years [5]. The primary method of treatment for iNPH is shunting with a ventriculoperitoneal (VP) or ventriculoatrial (VA) shunt, but other methods such as lumboperitoneal (LP) shunting and endoscopic third ventriculostomy (ETV) have also been described; however, the success of ETV in iNPH is controversial [6–8]. Patients who receive substantial improvement from a high volume lumbar puncture tend to be good candidates for shunting, assuming there are no contraindications [9].

Of patients with iNPH who undergo cerebrospinal fluid (CSF) shunting, 67–75% experience an improvement in their symptoms [10,11]. In patients treated with a VP shunt for hydrocephalus, approximately 32.5% of adult patients require a revision surgery [12]. However, it is unclear how many patients would benefit from VP shunting after they have already failed previous treatment with a method of CSF diversion therapy, including treatment with a VP shunt, VA shunt, LP shunt, or ETV procedure.

The aim of our study was to compare the post-surgical clinical outcomes following the placement of a VP shunt in patients who received their first shunt at our institution (primary) *versus* those who received their first shunt at an outside institution and required revision (salvage). To our knowledge, there are no prior studies that have looked at how prior treatment has impacted the future success of placing a VP shunt.

* Corresponding author. Tel.: +1 410 955 2259; fax: +1 410 955 9126.
E-mail address: belder4@jhmi.edu (B.D. Elder).

http://dx.doi.org/10.1016/j.jocn.2015.12.009
0967-5868/Published by Elsevier Ltd.

2. Methods

Under an active Institutional Review Board approved protocol (NA_00044584), the records of 390 patients diagnosed with iNPH and treated with VP shunts were retrospectively reviewed. All patients were treated at a single institution by the senior author between January 1993 and December 2013.

Patients were classified as having received a primary VP shunt if they had not been previously treated with a shunt (VP, VA, or LP) or ETV. Patients were classified as having received a salvage VP shunt if they had been previously treated by one of these modalities at an outside institution prior to receiving a VP shunt at our institution.

Demographic information including age, sex, and race were collected. Data on co-morbidities were collected to allow the calculation of the Kiefer Co-morbidity Index [13]. Clinical data was collected from patients prior to their surgery, at 6 months post-operatively, and at last follow-up (LFU). Recorded symptoms included headache, dizziness, vision problems, gait disturbance, urinary incontinence, and cognitive decline. Performance on objective clinical tests included the Timed-Up-and-Go test, Tinetti test, and Mini-Mental Status Examination. Radiological data was also collected and the Evans' Index was calculated for each patient. Duration of symptoms and time of follow-up was recorded for each patient. The need for a revision, the number of revisions received, and complications were also recorded.

2.1. Statistical analysis

Statistical analysis was performed using Stata IC version 12 (StataCorp, College Station, TX, USA). Demographic and clinical characteristics were summarized using frequencies and percentages for categorical measures and medians and interquartile ranges for continuous measures because most of the continuous measures were not normally distributed. An independent-samples t-test was conducted to compare follow-up duration for patients with and without prior treatment, and simple logistic regression was done to compare duration of symptoms prior to surgery for patients with and without prior treatment. Simple logistic regression was used to assess the association between prior treatment and age, body mass index, and Kiefer Co-morbidity Index. The chi-square test was used to assess the association of prior treatment with sex and Fischer's exact test was used to assess the association of prior treatment with race. Simple logistic regression was used to assess change in symptomatology against prior treatment and the association between prior treatment and the occurrence of complications. Simple linear regression was used to assess the change in objective clinical and radiologic data against prior treatment. All reported p values were two-sided and statistical significance was set at $p < 0.05$.

Table 1
Patient baseline characteristics for patients receiving a primary or salvage shunt

Characteristic	Primary shunt (n = 357)	Salvage shunt (n = 33)	p value
Age (years)	74 (68–79)	61 (36–74)	0.000
Sex			0.043
Male	206 (57.7)	13 (39.4)	–
Female	151 (42.3)	20 (60.6)	–
BMI	28.3 (25.2–31.6)	28.9 (27.0–38.7)	0.058
Race			0.080
Caucasian	324 (90.8)	27 (81.8)	–
African-American	18 (5.0)	5 (15.2)	–
Other	15 (4.2)	1 (3.0)	–
Kiefer Co-morbidity Index	1 (1–3)	0 (0–2)	0.033

Data reported are median (interquartile range) or number (percent).
BMI = body mass index.

3. Results

Three hundred and fifty-seven patients received a primary VP shunt, whereas 33 patients in the study received a salvage VP shunt. Of the 33 patients in the salvage shunt cohort, 17 (52%) were previously treated with a VP shunt, four (12%) with a VA shunt, seven (21%) with an ETV surgery, and five (15%) with a LP shunt. The baseline characteristics of the patients in our study are reported in Table 1, and are stratified by prior treatment. Patients who received a salvage shunt were more likely to be younger (mean [M] 61 *versus* 74 years) and more likely to be female (61% *versus* 43%).

There was no significant difference in the follow-up duration for patients with a salvage shunt (M = 38.0 months, standard deviation [SD] = 31.4) *versus* a primary shunt (M = 40.7 months, SD = 38.6) (t [388] = -2.69, $p = 0.6984$). However, patients who received a salvage shunt had a significantly longer symptom duration prior to presentation at our institution (M = 135.6 months, SD = 262.2) compared to patients who received a primary shunt (M = 40.1 months, SD = 50.5; odds ratio [OR] = 1.007; 95% confidence interval [CI]: 1.003–1.011; $p = 0.001$).

Table 2, 3 contain information regarding change in symptomatology and results on objective clinical and radiological tests, respectively, at 6 months and at LFU for patients with and without prior treatment. The base outcome was set as no change following VP shunt placement for all variables examined. The relative risk of both having improvement and getting worse following the placement of a VP shunt was lower for gait, cognition, and urinary continence, although there was only a statistically significant difference in gait at 6 months ($p = 0.025$). Overall, patients who received a salvage shunt did not have statistically significant differences in rate of improvement in at least one of the three symptoms of the NPH triad at 6 month follow-up compared to patients who received a primary shunt (64% *versus* 76%; OR = 0.55; 95% CI: 0.23–1.29; $p = 0.167$). This was also the case at LFU (40% *versus* 47%; OR = 0.75; 95% CI: 0.33–1.72; $p = 0.495$).

Patients who received a salvage shunt were significantly more likely to require a future revision than those who had a primary shunt surgery (47.7% *versus* 29.7%; OR = 2.15; 95% CI: 1.14–4.06; $p = 0.018$), and if they needed a revision, they were significantly more likely to have more of them (2.46 *versus* 1.41; coefficient = 1.12; 95% CI: 0.75–1.50; $p = 0.000$). Table 4 outlines the

Table 2
Change in symptoms at 6 months and LFU comparing patients who received a salvage shunt *versus* a primary shunt

Change in outcome	Timing	RR (95% CI) for improvement	p value	RR (95% CI) for getting worse	p value
Gait	6 months	0.35 (0.14–0.87)	0.025	0.82 (0.26–2.62)	0.738
	LFU	0.45 (0.16–1.28)	0.135	0.78 (0.30–1.99)	0.596
Urination	6 months	0.76 (0.33–1.75)	0.522	0.40 (0.05–3.17)	0.382
	LFU	0.86 (0.34–2.14)	0.741	0.84 (0.26–2.67)	0.772
Cognition	6 months	0.42 (0.17–1.02)	0.055	0.43 (0.09–1.95)	0.273
	LFU	0.46 (0.15–1.45)	0.76	0.41 (0.29–1.94)	0.560

CI = confidence interval, LFU = last follow-up, RR = relative risk.