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Clinical Study

Outcomes of endoscopic third ventriculostomy in adults

Sandi Lam [a,*], Dominic A. Harris [a], Yimo Lin [a], Brandon G. Rocque [b], Sandra Ham [c], I-Wen Pan [a]

[a] Department of Neurosurgery, Baylor College of Medicine, Texas Children's Hospital, Department of Neurosurgery, 6701 Fannin St., Ste. 1230-01, Houston, TX 77030, USA
[b] Department of Neurosurgery, Section of Pediatric Neurosurgery, University of Alabama at Birmingham, AL 35294, USA
[c] University of Chicago, Center for Health and Social Sciences, Chicago, IL 60637, USA

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ABSTRACT

Endoscopic third ventriculostomy (ETV) is an alternative to ventriculoperitoneal shunting for treatment of hydrocephalus. Studies have reported favorable outcomes for up to three-quarters of adult patients. We performed the first ETV outcomes study using an administrative claims database, examining current practice for adult patients in the United States. We interrogated the Truven Health MarketScan® database for Current Procedural Terminology codes corresponding to ETV and ventriculoperitoneal shunt from 2003- to 2011, including patients over 18 years and data from initial and subsequent hospitalizations. ETV failure was defined as any subsequent ETV or shunt procedure. Five hundred twenty-five patients underwent ETV with 6 months minimum follow-up. Mean age was 45.9 years (range: 18–86 years). Mean follow-up was 2.2 years (SD: 1.6 years, range: 0.5–8.4 years). Etiology of hydrocephalus was 21.3% tumor, 9.0% congenital/aqueductal stenosis, 15.8% hemorrhage, and 53.9% others. ETV was successful in 74.7% of patients. Of 133 who failed, 25 had repeat ETV; 108 had shunt placement. Longer length of stay for index surgery was associated with higher risk of failure (hazard ratio (HR): 1.03, $p < 0.001$), as was history of previous shunt (HR: 2.45, $p < 0.001$). Among patients with repeat surgeries, median time to failure was 25 days. This study represents a longitudinal analysis of nationwide ETV practice over 9 years. Success rate in this large cohort is similar to that published by other single-center retrospective studies. Age and geographic variation may be associated with surgeon choice of ETV or shunt placement after failure of the initial ETV.

1. Introduction

Endoscopic third ventriculostomy (ETV) has been shown to be a safe and effective treatment for hydrocephalus of various etiologies [1–5]. Among children, there is evidence supporting that younger age is predictive of a worse outcome after ETV [1,2], and some evidence on the role of hydrocephalus etiology in outcomes after ETV [1,2,4,6,7]. The role of ETV in the management of hydrocephalus in adults is less extensively studied. Given the different physiology of cranial development, intracranial compliance, and cerebrospinal fluid (CSF) production and absorption, findings from pediatric studies may not be applicable to adults [8–10]. Woodworth et al. reported a single-institution series of 124 adult ETV patients with 55% success [11], while Dusick et al. reported another single-institution series of 108 adult patients with 77% success for shunt independence [10].

The purpose of this study was to use a large, nationally representative administrative database to examine national practice, correlates, and effectiveness of ETV in adult patients with hydrocephalus in the United States.

2. Methods

2.1. Data source

The Truven Health MarketScan database is a collection of health insurance claims for working adults and early retirees with employer-sponsored health insurance and their dependents. For the current project, we used the MarketScan Commercial Claims and Encounters database, constructed from paid claims for employee-sponsored health insurance between 2003 and 2011, representing 17 million enrollees in 2003 and up to 52 million enrollees in 2011. We utilized inpatient admission, inpatient service, outpatient service, and enrollment data tables. Within these tables, records from January 1, 2003, to December 31, 2011, were analyzed. The study received exempt status from the University of Chicago and Baylor College of Medicine Institutional Review Boards.

* Corresponding author. Tel.: +1 832 822 3950; fax: +1 832 825 9333.
E-mail addresses: sandilam@gmail.com, sklam@texaschildrens.org (S. Lam).

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2.2. Patient selection

For the initial procedure hospitalization, we queried inpatient service tables for all hospitalizations for patients 18 years and older from the following Current Procedural Terminology (CPT) procedure codes: (1) ETV codes 62200, 62201 or (2) shunt placement codes 62220, 62223. These codes and associated dates of procedures were used to determine the type and timing of index and follow-up surgeries. For each patient, the first occurrence of ETV in the database while aged 18 years or older was considered the index procedure.

2.3. Follow-up data

Patients with a minimum 6 months follow-up were included in the cohort. For these patients, we examined details of any subsequent hospitalization in the inpatient service and inpatient admission tables from the date of the index procedure until the end of the records in 2011. Analysis was then based on initial and subsequent hospitalizations for ETV or shunt.

ETV failure was defined as subsequent surgery for hydrocephalus after primary surgery (i.e. repeat ETV or placement of ventriculoperitoneal shunt [VP shunt]) [12]. Temporary CSF diversion measures, such as ventricular puncture, lumbar puncture, and external ventricular drain placement, were not included. Inpatient deaths were noted, but deaths in general were not included as ETV failure since outpatient deaths are not captured reliably in MarketScan.

To determine duration of postoperative follow-up, we used the enrollment table to obtain the final month of insurance enrollment for each patient. End of follow-up was defined as 1) the last day of the final month of enrollment, 2) the date of discharge with deceased status, or 3) the last date of data collection, December 31, 2011. Postoperative follow-up time was measured from the date of initial ETV to either ETV failure or end of follow-up.

2.4. Covariates

Age in years on the date of index admission was available in the inpatient admission tables. We retrieved from the inpatient admission tables and analyzed International Classification of Diseases-9 (ICD-9) diagnosis codes associated with the index hospitalization. Indication for ETV surgery was determined based on previously published methodology using administrative data to examine pediatric hydrocephalus and CSF shunts [13]. We reviewed these codes, focusing on those that occurred at a frequency of $\geqslant$ 1% of the study population. We assigned etiology at the time of ETV with the concurrent assignment of the following diagnosis codes: subarachnoid hemorrhage (430), intracerebral hemorrhage (432), central nervous system (CNS) tumor (191–194, 198.3–198.4, 225.0–2 and 225.8–9, 227.4, 237.0–1 and 237.5–7, 239.6, 239.7), meningitis (320–322, 326), trauma (767.4, 851.xx– 854.xx, 995.55), cerebral cyst (348), normal pressure hydrocephalus (331.5), and congenital hydrocephalus (742.3 [coding for aqueductal stenosis]). Due to limitations in ICD-9 coding, the indications were not mutually exclusive and did not describe the entire study population. Those with no indications or multiple indications were classified as other etiology.

History of previous CSF shunt was determined from diagnosis codes of inpatient and outpatient encounters from initial enrollment until the day prior to index ETV surgery. Codes considered to indicate history of CSF shunt include International Classification of Diseases-9, Clinical Modification (ICD-9-CM) procedure codes of shunt surgery (02.32–35, 02.42, 02.43); ICD-9-CM codes indicating the presence of or complications of shunt device (V45.2,

Table 1
Characteristics of the study sample undergoing endoscopic third ventriculostomy (n = 525)

Characteristic	Overall (n = 525) n (%)	Success (n = 392) n (%)	Failure (n = 133) n (%)	*p*-value
Median age (range)	47 (18–86)	48 (18–86)	45 (18–85)	
Mean age [SD]	45.9 [16.3]	46.9 [16.3]	43.2 [16.3]	0.03*
Age (years)				
18–39	174 (33.1)	126 (72.4)	48 (27.6)	0.40
40+	351 (66.9)	266 (75.8)	85 (24.2)	
Sex				
Male	234 (44.6)	176 (75.2)	58 (24.8)	0.80
Female	291 (55.4)	216 (74.2)	75 (25.8)	
Region				
Northeast	76 (14.5)	55 (72.4)	21 (27.6)	0.89
Midwest	143 (27.2)	105 (73.4)	38 (26.6)	
South	219 (41.7)	167 (76.3)	52 (23.7)	
West	87 (16.6)	65 (74.7)	22 (25.3)	
Payer type				
PPO/Comprehensive	365 (69.5)	272 (74.5)	93 (25.5)	0.91
HMO/Other	160 (30.5)	120 (75.0)	40 (25.0)	
Etiology				
Congenital	47 (9.0)	33 (70.2)	14 (29.8)	0.78
Tumor	112 (21.3)	87 (77.7)	25 (22.3)	
Hemorrhage	83 (15.8)	61 (73.5)	22 (26.5)	
Other	283 (53.9)	211 (74.6)	72 (25.4)	
History of prior shunt				
No prior shunt	433 (82.5)	340 (78.5)	93 (21.5)	<0.001*
Prior shunt	92 (17.5)	52 (56.5)	40 (43.5)	
Index length of stay, mean [SD]	9.9 [12.5]	8.5 [10.9]	14.2 [15.6]	<0.001*

* $p < 0.05$ was considered statistically significant.
HMO = health maintenance organization, PPO = preferred provider organization, SD = standard deviation.