

Ventriculoperitoneal shunt surgery in the pediatric age group: Experience from Misurata Medical Center - Libya

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Abstract:

Hydrocephalus is a notorious neurosurgical disease often associated with the adage "once a shunt, always a shunt." This study presents a retrospective analysis of hydrocephalic children who underwent ventriculoperitoneal (VP) shunt surgeries at Misurata Medical Center between February 2014 and February 2019. The study aimed to evaluate the etiology, clinical profile, and outcomes, including complications, in this pediatric age group. A total of 56 patients, aged 4 days to 10 years, were included. All patients were clinically diagnosed and radiologically confirmed using Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scans, and ultrasonography (USG). Patients were followed up and treated for any procedure-related complications. Key findings indicate that 34% of patients required shunt revisions, with 74% of these occurring in children younger than one year. The overall mortality rate was 3% for patients under one year and 1% for those older than one year. Congenital hydrocephalus due to aqueductal stenosis showed a better prognosis compared to other etiologies, while post-hemorrhagic and craniospinal dysraphism-associated hydrocephalus carried higher complication and failure rates. VP shunt surgery in children older than one year was associated with a significantly lower rate of morbidity and mortality. Children without preoperative brain insult or postoperative complications achieved normal or near-normal developmental milestones.

Keywords: hydrocephalus, ventriculoperitoneal shunt, neurosurgery, chiari malformation, head size.

الجراحة الدماغية التحويلية في فئة الأطفال في مركز مصراتة الطبي – ليبيا

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الملخص:

استسقاء الرأس (Hydrocephalus) هو مرض جراحي عصبي معروف غالبًا ما يرتبط بالقول المأثور "بمجرد تركيب تحويله، تبقى التحويلة دائمًا". تقدم هذه الدراسة تحليلًا بأثر رجعي للأطفال المصابين باستسقاء الرأس الذين خضعوا لجراحات التحويلة البطينية البريتونية (VP shunt) في مركز مصراتة الطبي بين فبراير 2014 وفبراير 2019. هدفت الدراسة إلى تقييم المسببات، والملف السريري، والنتائج، بما في ذلك المضاعفات، في هذه الفئة العمرية من الأطفال.

شملت الدراسة ما مجموعه 56 مريضًا، تتراوح أعمارهم بين 4 أيام و10 سنوات. تم تشخيص جميع المرضى سريريًا وتأكيد التشخيص إشعاعيًا باستخدام التصوير بالرنين المغناطيسي (MRI)، والتصوير المقطعي المحوسب (CT)، والتصوير بالموجات فوق الصوتية (USG). تمت متابعة المرضى وعلاجهم من أي مضاعفات متعلقة بالجراحة.

تشير النتائج الرئيسية إلى أن 34% من المرضى احتاجوا إلى مراجعة (إعادة جراحة) للتحويلة، وحدث 74% من هذه المراجعات لدى الأطفال الذين تقل أعمارهم عن سنة واحدة. بلغ معدل الوفيات الإجمالي 3% للمرضى الذين تقل أعمارهم عن سنة واحدة و 1% لمن هم أكبر من سنة.

أظهر استسقاء الرأس الخلقي الناتج عن تضيق القناة الدماغية (aqueductal stenosis) مآلاً أفضل مقارنة بالمسببات الأخرى، بينما ارتبط استسقاء الرأس التالي للزيف والناتج عن خلل الانشقاق القحفي النخاعي (craniospinal dysraphism) بمعدلات مضاعفات وفشل أعلى. ارتبطت جراحة التحويلة البطينية البريتونية لدى الأطفال الأكبر من عام واحد بمعدل أقل بكثير من الاعتلال والوفيات. حقق الأطفال الذين لم يعانون من إصابة دماغية قبل الجراحة أو مضاعفات بعد الجراحة مراحل نمو طبيعية أو شبه طبيعية.

الكلمات المفتاحية: استسقاء الدماغ، التحويلة البطينية البريتونية، جراحة المخ والأعصاب، متلازمة كيارى، حجم الرأس في الأطفال.

1. Introduction:

Hydrocephalus is one of the most common clinical conditions affecting the central nervous system, with an incidence ranging from 0.9-1.8 (reports vary from 0.2 to 3.5) per 1000 births for congenital hydrocephalus [1]. ReKate defined hydrocephalus as “an active distension of the ventricular system of the brain resulting from inadequate passage of cerebrospinal fluid (CSF) from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation” [2]. While not universally accepted, this definition has guided expert consensus, classifying most forms of hydrocephalus based on an identifiable anatomical site of CSF flow obstruction or impairment [3]. Currently, there is no definitive cure. Most patients are managed by shunting, involving a silicone tube and valve system that diverts CSF from the cerebral ventricles to another body site [4]. However, shunt treatment is associated with frequent complications, particularly obstruction and infection in young infants, which contribute to increased morbidity and mortality.

Two main functional forms of hydrocephalus are typically observed in the pediatric age group:

1. Obstructive (non-communicating): Characterized by a blockage of cerebrospinal fluid circulation proximal to the arachnoid granulations. Neuroimaging studies (CT, MRI) reveal enlargement of ventricles proximal to the block, as seen in aqueduct of Sylvius obstruction, which causes enlargement of both lateral and third ventricles, sometimes referred to as triventricular hydrocephalus (a frequent cause of hydrocephalus, accounting for up to 70% of cases [5]).

2. Communicating (non-obstructive): In this form, cerebrospinal fluid circulation is blocked at the level of the arachnoid granulations.

Despite these challenges, the advent of shunt surgeries has significantly improved the prognosis, allowing these children to achieve normal or near-normal neurological development.

2. Amis and objective of the study:

The purpose of this study is to evaluate ventriculoperitoneal shunt surgery and its complications as regards the age and the cause in pediatric age group and to try to reduce the most of complications related to this procedure.

3. Materials and Methods:

This retrospective study included 56 pediatric patients diagnosed with hydrocephalus who underwent ventriculoperitoneal (VP) shunt insertion at the

Neurosurgery Department of Misurata Medical Center between February 2014 and February 2019. Inclusion criteria comprised children with hydrocephalus due to congenital or acquired causes, with a minimum follow-up period of 14 months. A detailed record was maintained for each patient, documenting name, age, sex, etiology, clinical features, investigations (including neuroimaging studies), and treatment.

All children underwent initial ultrasonography (USG) of the brain (n=33) through the anterior fontanelle window to assess ventricular dilatation and ventricular-parenchyma thickness ratio. Older patients or those with suspected meningitis underwent computerized tomography (CT) scans of the brain (n=40). Magnetic resonance imaging (MRI) was performed in cases where a structural lesion was suspected as the cause of hydrocephalus.

Routine preoperative laboratory tests included complete blood count, serum electrolytes (sodium, potassium), blood urea, serum creatinine, blood sugar, and cerebrospinal fluid analysis (cell count, glucose, protein). All patients also received a chest X-ray, ECG, cardiological evaluation, and a general pediatric survey to identify any other congenital anomalies. The VP shunts used were primarily Medtronic and Integra medium-pressure slit and spring valve shunts, which were the most available types in Libya at the time. These shunts are radio-opaque and designed for pressure-regulated CSF flow.

All patients received general anesthesia and prophylactic intravenous ceftriaxone, dosed according to body weight. Postoperative management included intravenous fluids, analgesia, and vital sign monitoring. Detailed records of shunt complications, causes of revisions, and patient outcomes were maintained throughout the follow-up period.

Pediatric patients who underwent VP shunt surgery over the five-year study period were reviewed for shunt revisions. Variables analyzed included age at shunt placement, age at the time of revision, presence of infection, obstruction, and diagnosis (congenital, post-hemorrhagic, craniospinal dysraphism, and others including tumors, infection, and trauma). Multiple regression analysis methods were employed to determine independent risk factors for shunt failure and the number of shunt revisions. Statistical analyses were performed using SPSS software (Statistical Package for the Social Sciences), version 25.0. A p-value of less than 0.05 was considered statistically significant.

4. Results:

A total of 56 patients were included in the study, with an almost equal sex distribution (23 males, 33 females). The majority of patients (n=40, 71%) were less than one year old at the time of shunt placement, with 16 patients (29%) being older than one year. The etiologies of hydrocephalus were diverse: 27

patients (48%) had congenital hydrocephalus (aqueductal stenosis), 15 patients (26%) had craniospinal dysraphism, 9 patients had space-occupying lesions, 3 patients had post-meningitis hydrocephalus, and 2 patients had post-hemorrhagic (traumatic) hydrocephalus. The Medtronic and Integra medium-pressure slit and spring valve shunts were used in all 56 cases. A total of 19 patients (34%) required revision surgeries due to shunt failures from various causes; 74% of these revisions occurred in patients less than one year old, and 26% in older patients. The mortality rate was 3% for patients under one year of age and 1% for those older than one year. The 5-year survival rate and median 5-year survival time were significantly lower for patients with post-hemorrhagic and craniospinal dysraphism compared to the congenital or "other" groups. The shunt failure rate and number of revisions were significantly reduced in patients older than one year.

Table (1): Age and Gender Distribution of Patients (N=56)

N. Cases	Male	Female	<1 year	>1 year
56	23	33	40	16

Table (2): Etiology of Hydrocephalus (N=56)

Etiology	<1 Year	>1 Year
Aqueduct stenosis	21	6
Spinal dysraphism Chiari II	15	-
S.O.L (Space-Occupying Lesion)	1	8
Post-traumatic	2	-
Post-meningitis	1	2

Table (3): Age at Revision Surgery (N=19)

Etiology	Revision <1 Year	Revision >1 Year
Aqueduct stenosis	2	3
Spinal dysraphism Chiari II	10	1
S.O.L (Space-Occupying Lesion)	-	1
Post-traumatic	1	-
Post-meningitis	1	-

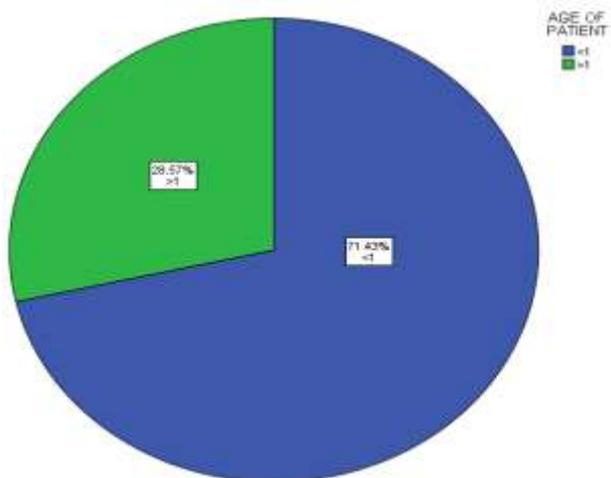


Figure 1:

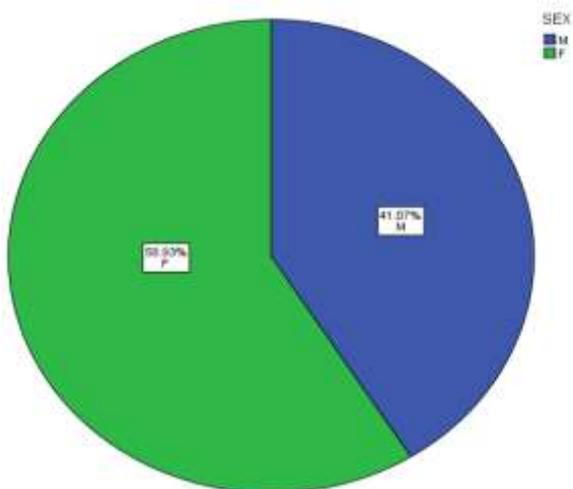


Figure 2:

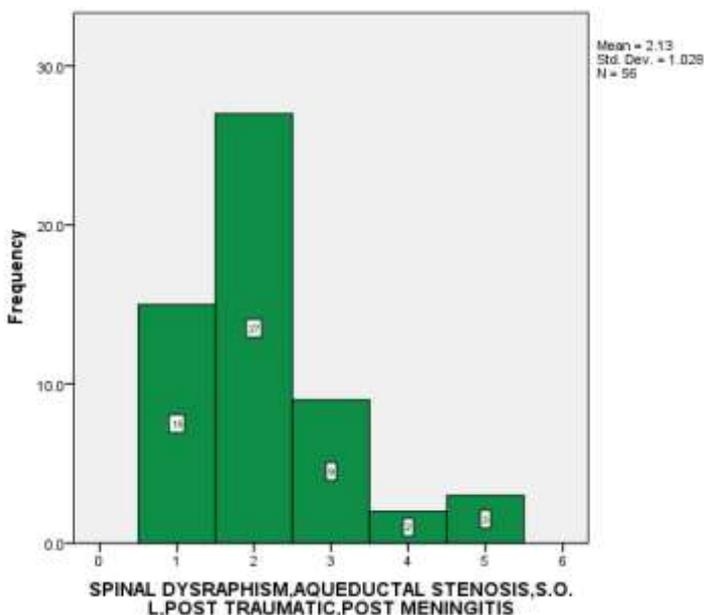


Figure 2:

5. Discussion:

Hydrocephalus is a prevalent neurological disorder in children [6], with the majority of affected patients being infants under one year, consistent with 71% of our study population. Congenital aqueductal stenosis is a leading cause, accounting for approximately 48% of all pediatric hydrocephalus cases [7]. In our study, aqueductal stenosis was indeed the most common etiology (n=27, 48%), closely followed by spinal dysraphism (n=15, 26%). The high prevalence of spinal dysraphism might be attributed to the socioeconomic strata of the study group. Hydrocephalus was detected in almost all cases of meningomyelocele in our cohort, developing either post-surgical repair of the defect or being primarily present. Hydrocephalus secondary to meningitis was observed in 5% of our cases, acknowledging bacterial meningitis as an uncommon but possible sequela. Complications often developed insidiously over weeks to months.

Increased head circumference was the most common clinical sign (85%), followed by a tense anterior fontanelle and splayed cranial sutures (70%). Sunset sign, indicative of upward gaze palsy due to compression or axial dislocation of the brainstem's tectal region [8], was noted in 30% of cases. Other

signs included splayed cranial sutures (39%), scalp vein distension (37%), vomiting (14%), refusal of feed (12%), and lethargy (7%).

Shunting cerebrospinal fluid from the brain ventricles to the peritoneal cavity, while life-saving, carries a multitude of complications. Mechanical obstruction is the most common, as observed in our study. Obstruction can occur at either the proximal or distal ends of the shunt. Proximal obstruction, typically involving the ventricular catheter due to entrapped choroid plexus tissue, intraventricular debris, or gliosis around the catheter tip, has an incidence of approximately 30%. This incidence is highest in the early postoperative period and decreases over time. Distal obstruction results from debris accumulation in the slit valve. Although slit valve distal catheters were associated with higher distal catheter failure rates in the late 1990s, leading to a decline in their use, the literature lacks surgeon-modifiable factors to reduce distal catheter failure rates [9]. Notably, the method of distal catheter placement (open peritoneal, trocar insertion, or laparoscopic) does not significantly impact distal catheter obstruction rates [10]. The dead space beneath the slit valve may favor debris accumulation, composed of acellular fibrin clumps surrounded by macrophages, lymphocytes, and fibroblasts. We observed one patient with peritoneal end blockage by tissue debris.

Infection is the second most common complication. Reported shunt infection rates in the literature range from 3% to 15% [11]. The proportion of shunt failures related to infection rapidly decreases after the first few months post-implantation, with 90% of infections occurring within the first 6 months [11]. Infections are typically a result of prior CSF infection or introduction during surgery. Postoperative manifestations include ventriculitis, meningitis, and local wound infection. Our study reported an infection rate of 15%. Infections are commonly caused by organisms of low virulence, primarily *Staphylococcus epidermidis* [12], followed by *Staphylococcus aureus*, Gram-negative bacilli, and mixed pathogens. *Staphylococcus* species were the predominant organisms cultured in our series. Shunt migration was observed in 7% of cases, with two instances of proximal migration into the lateral ventricle and one case of distal catheter extrusion per rectally. The overall incidence of shunt migration was 4%. Shunt malfunction also led to sequelae such as abdominal distension and abdominal pseudocyst in three cases, and cerebrospinal fluid varix in two cases. During a mean follow-up period of 14 months, 19 of the 56 cases (34%) required shunt revisions due to shunt-related complications. Five of these cases necessitated multiple shunt revisions, predominantly due to shunt infection. Shunt infection was managed by shunt exteriorization, external ventricular drain, intermittent CSF tapping, and intravenous antibiotics guided by CSF culture and sensitivity. Serial C-reactive protein (CRP) and erythrocyte

sedimentation rate (ESR) were monitored. Revision shunt surgery was performed once the infection was completely treated and confirmed by two consecutive infection-free CSF samples.

Thirty-seven of the 56 patients (66%) experienced no complications following shunt insertion, and an improvement in neurological/functional status was noted during follow-up. However, developmental milestones were delayed in 10 cases (20%). Hydrocephalus is a common central nervous system disorder in children, primarily caused by congenital aqueductal stenosis. Infections (tubercular, pyogenic) and spinal dysraphism represent potentially preventable causes of hydrocephalus, amenable to improvements in quality of life through better public health measures in developing countries. While increased head size is often the only sign of hydrocephalus in most children under two years, older children may present with the classical triad of headache, vomiting, and papilledema. The evolution of shunt surgeries has dramatically altered the outcome for these patients, offering better prospects for leading a normal life. Nevertheless, complications such as infection and obstruction, necessitating shunt revisions, continue to adversely affect outcomes. Infective causes of hydrocephalus are also more likely to result in adverse neurological outcomes, including delayed milestones and mental retardation.

6. Conclusions:

Congenital hydrocephalus resulting from aqueductal stenosis generally carries a better prognosis and outcome compared to other etiologies in patients younger than one year. Conversely, post-hemorrhagic and craniospinal dysraphism-associated hydrocephalus are linked to the most serious complications and higher failure rates. Ventriculoperitoneal shunt surgery in the age group older than one year is associated with a significantly lower rate of morbidity and mortality. Children without preoperative brain insult or postoperative complications can achieve normal or near-normal developmental milestones.

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