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RESEARCH ARTICLE

MANAGEMENT OF CONGENITAL HYDROCEPHALUS BY DIFFERENT AVIALABLE VENTRICULO PERITONEAL SHUNT DEVICES IN EGYPT: COMPARITIVE STUDY

*Samy M. Selim, Mohamad Soliman, Mostafa G. zahr, Gasser H. Elshyal and Usama Elshokhaiby

Lecturers of Neurosurgery AL-Azhar University, Egypt

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ABSTRACT

Hydrocephalus is a serious condition, result in impaired circulation and absorption of CSF. Ventricular shunting has been used successfully and have become the most common therapy in treatment of hydrocephalus, various types of shunt valves have been developed during the last 50 years. We compared between three shunt systems: Codman, Medtronic and Chhabra shunts,used in sixty patients divided in three equal groups and randomly selected.The end points of the study were shunt malfunction, shunt migration, wound complication, death, or no problem at 1 year. Of all patients, 5% died. The occurrence of complications in all patients were infection (10%), migration/disconnection (5%), wound complication (6.7%), valve malfunction (1.7%), ventricular catheter obstruction (8.3%), and peritoneal catheter obstruction (3.3%). There was no statistically significant difference in any outcome category for patients receiving the Codman, Medtronic or Chhabra shunt.

Abbreviation: CSF = Cerebrospinal Fluid, VP= VentriculoPeritoneal, TLC = Total leucocytic count.

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INTRODUCTION

Congenital hydrocephalus is built-up of excess cerebrospinal fluid (CSF) in the brain during intrauterine life. The extra fluid can increase pressure in the baby's brain, causing brain damage, mental and physical problems. Finding the condition early and treating it quickly can help limit any long-term problems (Hydrocephalus association, 2013). It is caused by an imbalance between how much CSF is produced and how much is absorbed. Excess CSF in the ventricles occurs for one of the following reasons:

- ***Obstruction**:* The most common problem is a partial obstruction of the normal flow of CSF, either from one ventricle to another or from the ventricles to other spaces around the brain.
- ***Poor absorption:*** Less common is a problem with the mechanisms that enable the arachnoid granulation and venous sinuses to absorb CSF.
- ***Overproduction:*** Rarely, the mechanisms for producing CSF create more than normal and more quickly than it can be absorbed (Hydrocephalus, 2004).

The management of hydrocephalus has challenged neurosurgeons, neurologists, engineers and medical device developers alike because of the unique nature of CSF dynamics in each patient. CSF diversion devices or shunts have been used successfully and have become the primary therapy for hydrocephalus treatment for nearly 60 years (Hydrocephalus association, 2013). Ventricular shunning is the most widely accepted form of treatment for hydrocephalus.Shunting has dramatically changed the outlook of children with hydrocephalus, with many of them having normal life expectancies and attaining normal intelligence as before shunts became available 50 years ago, hydrocephalus was either fatal or severely debilitating neurological condition (Ghotme and Drake, 2008).

Shunts Typically Consist of Three Major Components

1-An inflow (proximal or closer to the inflow site) catheter, which drains CSF from the ventricles or the subarachnoid space. 2-A valve mechanism, which regulates differential pressure or controls the flow.3-An outflow (distal or farther away from the inflow site) catheter, which runs under the skin and directs CSF from the valve to the abdominal (peritoneal) cavity (Hydrocephalus association, 2013).

Shunt devicesavailable in Egypt

- Codman Hakim
- Medtronic
- Chhabra

Corresponding author: Samy M. Selim,
Lecturers of neurosurgery AL-Azhar University, Egypt

Shunt malfunction may result from either under drainage or over drainage of C.S.F.

- Under drainage occurs if shunt becomes obstructed or disconnected. Obstruction may be in the proximal ventricular catheter, the valves, connectors or the distal end. Proximal occlusion is more common and occurring in approximately 80% of the time (Epstein, 2000).
- Over drainage may result in slit ventricles, intracranial hypotension and subdural hematoma. About 10-12% of long term shunts will develop one of these within 6.5 years of initial shunting (Pudenz and Foltz, 1991).

Shunt failure reaches its maximum within the first few months after surgery ranging from 25% to 40% at one year follow up. The risk of failure persists after this critical period and remains approximately 4-5% per year (Drake and Iantosca, 1994). In this study, we compared between different available shunt devices in Egypt that are used in management of congenital hydrocephalus (aquiductalstenosis), with focusing on the etiology of shunt malfunction and possible ways for its prevention and management.

MATERIAL AND METHODS

Shunt Systems: The Codman-Hakim Micro Precision Valve (Medos S. A. [Johnson & Johnson Co.], Switzerland) is a unitized shunt using the Hakim. Precision Valve. Medtronic shunt (Medtronic Co., Dublin, Ireland) is a unitized shunt using delta valve. The Chhabra shunt (G. Surgiwear Ltd., India) is a unitized shunt system that incorporates a proximal slit-inspring valve.

Patient selection: This study was done on 60 patients of congenital hydrocephalus through VP shunt by different types of devices (Codman, Medtronic and Chhabra) and analysis post-operative results during the period from 2013 to 2015, at the Neurosurgical Departments of AL-Azhar University Hospitals (20 patients of each shunt type).

Inclusion criteria: Age: 1 day –1 year, all patients had congenital hydrocephalus due to aquiductal stenosis, no history of perinatal intracranial hemorrhage or infection.We used available shunt devices in Egypt as Codman, Medtronic and Chhabra, for three of them, the valve was medium pressure. The patient's selection for each type of shunt device were done randomly, i.e. not influenced by clinical criteria and for Subjects who had shunt complications, were fully investigated and managed.

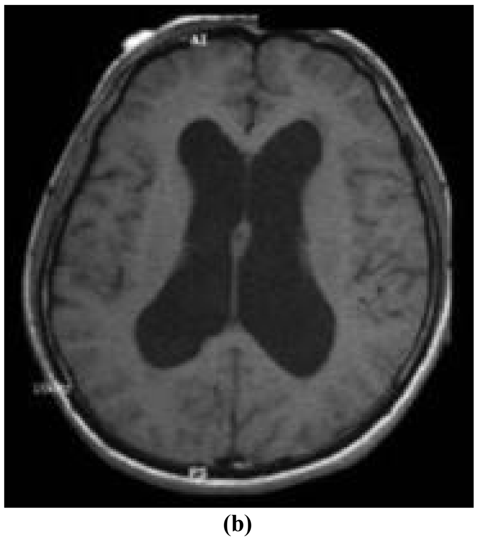
Exclusion criteria: Subjects with debilitating diseases and bad general condition, Multiple congenital anomalies, Compartmental (multiloculated) hydrocephalus and Hydrocephalus with brain tumor.

Database and Clinical Evaluation: Preoperative and postoperative data were collected prospectively and entered into a Microsoft Access database. Clinical information included patient history, neurological examination, head circumference, and character of the fontanel. Laboratory data included complete blood picture, blood sugar, liver and renal function tests, bleeding, coagulation time and results of cerebrospinal fluid analysis/culture. Radiological information included (1) cranial ultrasonography, performed in infants via the anterior fontanelle. Ultrasonography demonstrates lateral and third ventricle morphology, intraventricular masses and periventricular leukomalacia Fig (1).

Figure 1. Ultrasound scan of premature neonate, showing marked hydrocephalus with intraventricular hematoma

(2) CT/MRI brain fig, (2); hydrostatic hydrocephalus is suggested when either; temporal horns is ≥ 2 mm in width, the ratio between frontal horn and internal distance > 0.5, ballooning of frontal horns of lateral ventricles and third ventricle, periventricular edema.

(a)



(b)

Figure 2. (a) CT. brain with hydrocephalus, (b) MRI Brain (T1) axial view show dilated lateral ventricles

Operative Method

Patients were positioned for right frontal or right posterior parietal shunt placement. Standard surgical techniques were used, Small incisions were made in the scalp and in the right paramedian region of the abdomen. The shunt valve was flushed and tested to confirm an appropriate closing pressure, burr hole was done,the shunt was tunneled subcutaneously between the incisions. A pinpoint of dura was cauterized and punctured, and the ventricular catheter was passed. Flow was confirmed, a CSF sample was obtained, and the catheter was secured to the valve connector (for the Chhabra) or the integral reservoir connector (for the Codman and Medtronic) with a 2-0 silk tie. The valve construct was then secured to pericranial tissue with a 3-0 silk stitch.

Postoperative Follow Up

It was intended to assess patients at 1 week and at 1, 3, 6, months and every 6 months up to 2 years postoperatively. During follow-up examinations, head circumference, fontanel, symptoms, neurological examination, and developmental progress were assessed. CT brain was also performed to assess the ventricles.

Outcome Parameters

Clinical success was defined according to criteria that included a shift in head circumference growth to a normal or less than normal rate, decompression of the anterior fontanel, relief from symptoms of elevated intracranial pressure, such as irri¬tability and vomiting, decreased spasticity and or improved gait and resolution of eye findings, such as sun setting or sixth cranial nerve palsy.

The failure end points of the study included death at less than 1 month postoperatively from any cause (operative mortality), death at less than 1 year from any cause, shunt infection, wound dehiscence or skin breakdown over the track, ven¬tricular catheter obstruction, valve malfunction (obstruc¬tion), distal (peritoneal catheter) obstruction, and shunt migration or disconnection.

Statistical Analysis

Two-tailed probability values, as calculated by the Fisher exact test, were used to assess the significance of outcome differences between groups. A probability value less than 0.05 was considered significant.

RESULTS

The mean age of the patients was 3.233 months, the youngest patient age was 1 day and the oldest one was 7 months, male to female ratio was 3:2. Macrocephaly and tense fontanel is the commonest presentation in our patients. Preoperative CT brain showing ventricular dilatation in all patients and periventricular CSF permeation in about 60% of patients.Our patients were divided according to type of shunt into three equal groups. Shunt longevity in our study means the period between initial shunt insertion and occurrence of the malfunction. In group C which two Chhabra valve failures all occurred within two months of placement, the fifth VP proximal catheter obstructions of three groups occurred within 1 month of placement, one distal catheter obstruction of group C occurred in seven month. The infections in group A all occurred within 2 months of placement and four infections in group B and group C occurred between 1 and four months after placement.

Table 1. Pre-operative clinical presentation of three groups

Clinical present	Group A	Group B	Group C	Total	X^2	P-value
Refuse feeding	4 (20%)	6 (30%)	3(15%)	13(21.7%)	1.375	0.502
Vomiting	7 (35%)	6 (30%)	6 (30%)	19(31.67%)	0.154	0.925
Irritability	11(55%)	13(65%)	12(60%)	36(60%)	0.417	0.811
D.C	2 (10%)	1 (5%)	1 (5%)	4(6.67%)	0.536	0.764
Tens fontanel	11(55%)	12(60%)	9(45%)	32(53.33%)	0.938	0.625
Enlarged head	14(70%)	11(55%)	12(60%)	37(61.67%)	0.987	0.610
Sunset sign	10(50%)	9(45%)	13(65%)	33(55%)	1.741	0.418
6^{th} nerve palsy	6 (30%)	7(35%)	6 (30%)	19(31.67%)	0.154	0.925
Enlarged & engorged scalp veins	5 (25%)	4(20%)	3(15%)	12(20%)	0.625	0.731

Table 2. Complication of Shunt in three groups

	Group A		Group B		Group C		Fisher exact test	
	No.	%	No.	%	No.	%	Fisher	P-value
Valve malfunction	0	0%	0	0%	1	5%	3.407	0.182
Proximal obstruction	1	5%	2	10%	2	10%	0.115	0.944
Distal obstruction	1	5%	0	0%	1	5%	1.008	0.604
Wound complication	1	5%	2	10%	1	5%	0.903	0.637
Infection	2	10%	2	10%	2	10%	0.115	0.944
Migration	1	5%	1	5%	1	5%	0.049	0.976

Outcome: (60 cases)

Table 3. Outcome of three groups

	Group A		Group B		Group C		Chi-square test	
	No	%	No	%	No	%	X^2	P-value
Excellent	14	70.0%	13	65.0%	12	60.0%	0.44	0.802
Good	5	25.0%	5	25.0%	6	30.0%	0.17	0.9185
Poor	0	0.0%	1	5.0%	1	5.0%	2.034	0.361
Death	1	5.0%	1	5.0%	1	5.0%	0.000	1.000

Manual testing used to asses emptying and refilling and determine site of obstruction, examination of cranial and abdominal wounds and the tract for signs of infection. All cases were candidates for CT brain to evaluate postoperative ventricular size, sub ependymal permeation and intracranial complication. Plain x-ray Skull, chest and abdomen was done in (4 cases) suspected for distal obstruction, it showed disconnection in one case in each group and kinking in one case of group Aand abdominal U/S showed (1 case from group B) for intra-abdominal cysts. CSF samples are collected from the reservoir itself or by direct ventricular tapping after shunt removal and insertion of external ventricular drain (EVD) for suspected causes of infection and sent for chemistry, culture and sensitivity and total leucocytic count in CSF (10 cases). 2 cases showed negative results for culture and sensitivity due to the use of antibiotic previously.

All cases of exposed shunt or necrosis and sloughing are managed as shunt infection together with true shunt infection (10 cases). 2 cases of skin necrosis were managed by repeated dressing and antibiotics for two weeks after confirming TLC <10 and negative culture and sensitivity. 6 cases, shunt systems were removed and external ventricular drain (EVD) was inserted to drain CSF where repeated CSF simples were obtained and sent for examination, TLC was done and according to culture and sensitivity 1case showed positive results. 2 cases were respond to appropriate administered intravenous antibiotics sensitive to the organisms. The appropriate intravenous antibiotics sensitive to the organisms isolated were administered together with intra-ventricular amikin through the EVD. 2 cases with negative culture, vancomycin (40 mg twice daily) and amikin (intraventricular through the EVD) was administrated till TLC was <30 then a whole new shunt was inserted. The criteria for cure from infection based on the clear aspect of CSF through the EVD and TLC declining <30 with negative culture and sensitivity test in repeated two samples of CSF consequently. 3 case died in the pre-operative before reshunting from severe septicemia and ventriculitis while the other cases a new shunt was inserted. Due to mechanical dysfunction as kinking, disconnection and inappropriate position of catheter end, shunt revision was done for nine patients (15%), three patients in each group.

DISCUSSION

Hydrocephalus is a common but complex condition caused by physical or functional obstruction of CSF flow that leads to progressive ventricular dilatation. Though hydrocephalus was recently estimated to affect 3.5 in 1,000 infants (Hannah *et al.,* 2014). Despite the proven effectiveness of VP shunts in treating hydrocephalus, complications related to shunt failure, continue to occur (Stewart *et al.,* 2006). Anothony and his collegues in (2009) studied 647 patients and found that a total of 248 shunts were judged to have failed (38%), and 55 were judged specifically to have failed by infection (8.5%). Bulging fontanel, fluid collection along the shunt, depressed level of consciousness, irritability, abdominal pain, nausea and vomiting, accelerated head growth, and headache were strongly associated with shunt failure. Fever and gross signs of wound infection was strongly associated with shunt infection (Anothony *et al.,* 2009). In another two studies performed by Marcus and his colleagues (2006); Garton et al. (2001) it was found that lethargy and shunt site swelling were predictive of shunt malfunction especially when present in the first several months following surgery; however, one must maintain a high index of suspicion when evaluating children with an intracranial shunt because the presentation of malfunction is widely varied. A missed diagnosis can result in permanent neurological sequelae or even death (Marcus Voth *et al.,* 2006; Garton *et al.,* 2001). Benjamin Ware (2005)Compared 1-year outcomes for the Chhabra and Codman-Hakim shunt systems in 195 children.The occurrence of complications in all patients were, Infection (9.7%): (Chhabra 11% and Codman 9.3%). Migration/disconnection (6.3%): (Chhabra11% and Codman 9.3%).Wound complication (5.7%) (Chhabra 5.7% and Codman 8.3%). Valve malfunction (3.4%): (Chhabra 4.2% andCodman 0%). Ventricular catheter obstruction (2.8%): (Chhabra 2.9% & Codman 2.7%) and peritoneal catheter obstruction (1.1%): (Chhabra 1.9% and Codman 0%). There was no statistically significant difference in any outcome category for patients receiving the Codman or Chhabra shunt (p =0.2463-1.0000) (Benjamin, 2005).

In our study, we compared three shunt devices (Codman, Medtronic and Chhabra) in 60 patients, irritability, refusal of feeding, vomiting, underweight and tense fontanel were the most common clinical presentations with obstruction. Fever, anemia, chest infection and complications related to the underlying pathology of hydrocephalus were present in almost all cases of infection (For all type of shunt). The end points of the study were shunt malfunction, shunt migration, infection, wound complication, death, or no problem at 2 year. The only concern that emerged was the possible trend toward a higher rate of valve malfunction in the Chhabra system, and indeed, this might have been the anticipated outcome if a difference in performance was to be found. This differ¬ence did not reach statistical significance. In this study the result is nearly comparable with those of Benjamin C Ware (2005) who comprise between tow type of shunt (Chhabra and Codman) but our study compare between three type of shunts (Chhabra, Medtronic and Codman). Our inten¬tion was simply to confirm the safety of a commonly used shunt device in the developing world, and this seems to have been accomplished. The outcome is, perhaps, not surprising given the conclusions of previous authors that the type of shunt used has no bearing on outcome (Drake *et al.,* 1998). The failure rates may be attributed to other factors including poor general condition of the patients; negligence from their families and unawareness of such complication together with lack of pre-operative preparations to correct general conditions of the patient and the presence of associated underlying pathology as operation for tumor removal or infected spinal dysraphism.

Conclusion

Shunt operation is a long commitment between the neurosurgeon and the patient. From this point of view, we can say that for a shunt operation to succeed or to fail this requires the integration of the three main factors, the surgeon, the patient and the device. Insertion of a VP shunt for treatment of hydrocepha¬lus can be performed in the context of an developing coun¬try with results like those reported for developed na¬tions. The inexpensive Chhabra shunt performed as well as the expensive Medtronic or Codman shunt, with no statistically signifi¬cant difference in any outcome category. The ongoing high mortality rates of children in developing country who are treated for hydrocephalus by shunt insertion is likely increased by multiple factors that are based on the economic, cultural, and political realities of their society.

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