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Comparison of 1-year outcomes for the Chhabra and Codman-Hakim Micro Precision shunt systems in Uganda: a prospective study in 195 children

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Object. The author investigated the 1-year outcomes for shunt treatment of hydrocephalic children in Uganda, comparing the results using the inexpensive Chhabra shunt ($35 US dollars), widely used in East Africa, with those using the Codman-Hakim Micro Precision Valve shunt ($650).

Methods. The results in 195 consecutive children (mostly infants) in whom shunts were placed were studied prospectively. In Group 1, 90 patients randomly received either the Chhabra or Codman shunt as primary treatment for hydrocephalus. In Group 2, 105 patients received the Chhabra shunt when endoscopic third ventriculostomy could not be performed or had failed. The end points of the study were shunt malfunction, shunt migration, wound complication, death, or no problem at 1 year. Of all patients, 9.7% were lost to follow up and 15.9% died before 1 year. The occurrence of complications in all patients were infection (9.7%), migration/disconnection (6.3%), wound complication (5.7%), valve malfunction (3.4%), ventricular catheter obstruction (2.8%), and peritoneal catheter obstruction (1.1%). There was no statistically significant difference in any outcome category for patients receiving the Codman or Chhabra shunt ($p = 0.2463–1.0000$).

Conclusions. Ventriculoperitoneal shunt insertion for treatment of hydrocephalus can be performed in a developing country with results similar to those reported in developed countries. No difference in outcome was noted between the two shunt types. No advantage was found in using a shunt system that, in this setting, is prohibitively expensive.

KEY WORDS • hydrocephalus • shunt • developing country • outcome • pediatric neurosurgery

MANAGEMENT of hydrocephalus throughout sub–Saharan Africa is made difficult by economic constraints and the difficulties patients and families face regarding transportation and access to proper care. Shunts, as well as the expertise to place them, are not available to most children. When shunts are available, most people cannot afford one. Even when the placement of a shunt is possible, it is more dangerous in this context than in developed countries because complications and shunt malfunctions are less likely to be properly addressed in a timely fashion, if at all. This is especially concerning in light of the prospective multicenter North American study in which a 43.6% incidence of shunt failure (which included an 8.1% infection rate) was found within the first 2 years of placement.[4] Avoiding shunt dependency in an environment such as ours is an important goal. I have reported elsewhere that ETV can be used successfully in this environment to avoid shunt dependency in many patients.[9] Nonetheless, ETV will not be successful in some patients, and more importantly, the expertise and equipment to perform ETV is presently unavailable for most children.

Shunt placement remains the primary method of treatment in the majority of children for the foreseeable future. Typically, shunts manufactured by companies in the West are prohibitively expensive for use in emerging countries; the cost of a single shunt exceeds a year's income for many families. This poses an obstacle not only to families but also to nonprofit organizations that might hope to underwrite the care of such children. Less expensive alternatives are commonly used in Africa. These range from the "home-made" shunts of simple silastic tubing as reported in a series from Zimbabwe and Malawi[1] to the inexpensive Chhabra shunt manufactured in India, which can be purchased for $35 (all monetary units are given as US dollars). A prospective study of shunt placement outcomes in a developing country that formally compares one of these inexpensive alternatives to a shunt system commonly used in the West has, as far as I am aware, never been published.

The CURE Children's Hospital of Uganda, a Christian nonprofit referral hospital for pediatric neurosurgery, opened in January 2001. At that time, we were initially pro-

Abbreviations used in this paper: ETV = endoscopic third ventriculostomy; VP = ventriculoperitoneal.

vided with 50 Codman-Hakim Micro Precision Valve shunt systems, which cost $650 each. Given the large number of children with hydrocephalus whom we were treating, our ability to continue sustaining the cost of placing these shunts would soon be exhausted. Because we could place Chhabra shunts in almost 20 children for the price of one Codman shunt and because Chhabra shunts were available to us through a grant from the International Federation for Spina Bifida and Hydrocephalus, we decided to make a formal comparison of clinical outcomes when using this shunt system with those when the more expensive shunt system was used. We regarded this as an important undertaking not only to assure ourselves of being able to use a "cheap" shunt with confidence but also to be able to provide this information to the many centers throughout the developing world that are using this same shunt system.

Clinical Material and Methods

Shunt Systems

The Chhabra shunt (G. Surgiwear Ltd., India) is a unitized shunt system that incorporates a proximal slit-in-spring valve. The Codman-Hakim Micro Precision Valve (Medos S. A. [Johnson & Johnson Co.], Switzerland) is a unitized shunt using the Hakim Precision Valve.

Patient Selection

Prior to its opening, our hospital had been supplied with 50 Codman-Hakim Micro Precision Valve and Integral Reservoir shunt systems, at a total cost of $32,500. This was initially the only shunt system available for our use. We then became aware of the opportunity for an ongoing supply of free Chhabra VP shunts through the International Federation for Spina Bifida and Hydrocephalus program. Until these became available all patients received the Codman shunt. Once the Chhabra shunts were received, patients were randomly selected by coin toss for placement of either a Codman or a Chhabra shunt at the time of surgery. This random selection process was used until no more Codman shunts were available, following which the Chhabra shunt was used uniformly. Therefore, the type of VP shunt selected for use was random, based on either coin toss at the time of operation or availability and was in no way influenced by clinical criteria. For both systems, a valve with a closing pressure in the medium range was used and valve function and closing pressures were checked manometrically prior to placement in every case. The distal slits in the peritoneal tubing were routinely cut away prior to insertion.

There were two study groups. Group 1 was composed of 90 consecutive patients who underwent VP shunt placement during the first 6 months after the hospital opened. This was prior to performing ETV as the primary treatment for children with hydrocephalus presenting to our institution.[9] These patients received either a Chhabra or a Codman VP shunt with all but five undergoing occipital placement of the ventricular catheter. Group 2 consisted of 105 consecutive patients in whom only Chhabra shunts were placed over the course of 9 months (period ending March 2002); no Codman shunts were available during this period. In contrast to the first group, these patients all received frontal placements, usually after abandonment of an attempted ETV or when an ETV had failed. Data from these two groups were evaluated separately, given the distinctions between them.

The end point of the study was repeated operation for shunt failure, infection, or wound complication; death; or completion of 1 year of follow up without repeated operation.

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 (when present). Laboratory data included status of human immunodeficiency virus and results of cerebrospinal fluid analysis/culture. Radiological information included cranial ultrasonography (performed by the author in the majority of patients). When ultrasonography could not be performed, a computerized tomography scan was obtained in Kampala (a 6-hour round trip) at no cost to the patient.

Operative Method

Patients were positioned for right frontal or right occipital shunt placement. In Group 1, an occipital approach was used with placement of the catheter in the occipital horn, with the exception of four Chhabra and one Codman shunts, which were placed frontally in the frontal horn. Patients in Group 2 underwent a right frontal 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. The shunt was tunneled subcutaneously between the incisions. A pinpoint of dura was cauterized and punctured after removing bone, when necessary, and the ventricular catheter was passed. In Group 2, in which shunt placement usually followed either ETV abandonment or failure, the dural opening was closed around the ventricular catheter with a stitch when necessary. Flow was confirmed, a cerebrospinal fluid sample was obtained, and the catheter was secured to the valve connector (for the Chhabra) or the integral reservoir connector (for the Codman) with a 2-0 silk tie. The valve construct was then secured to the dura or pericranial tissue with a 3-0 silk stitch.

Postoperative Follow Up

It was intended to assess patients at 1 week and at 3, 6, and 12 months postoperatively. This follow-up pattern was not always feasible, however, due to the difficulties of transportation for the majority of our patients. Follow up would sometimes occur off schedule when illnesses such as malaria prompted a patient's return. Patients lost to follow up were aggressively sought with home visits, often deep in the village, by our social work staff. During follow-up examinations, head circumference, fontanel, symptoms, neurological examination, and developmental progress were assessed. Cranial ultrasonography 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, as plotted on a standard growth chart; decompression of the anterior fontanel; relief from symptoms of elevated intracranial pressure, such as irritability, vomiting, and headache; decreased spasticity and/or improved gait; and resolution of eye findings, such as sunsetting 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, ventricular catheter obstruction, valve malfunction (obstruction), distal (peritoneal catheter) obstruction, and shunt migration or disconnection. Patients with no known problem but who were lost to follow up prior to 1 year postoperatively were eliminated from analysis.

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.

TABLE 1

*Group 1 outcomes**

Variable	No. of Patients (%)			p Value
	Chhabra	Codman	Total	
no. of patients	47	43	90	—
lost at <1 yr	4	7	11	0.3402
total patients followed	43 (91)	36 (84)	79 (88)	—
dead at <1 mo	1 (2)	0	1 (1.1)	1.0000
no problem 1st yr	22 (51)	21 (58)	43 (54)	0.6508
dead by 1st yr	6 (14)	6 (17)	12 (15)	0.7628
infection	4 (9.3)	4 (11)	8 (10)	1.0000
wound complication	3 (7)	2 (5.6)	5 (6.3)	1.0000
valve malfunction	3 (7)	0	3 (3.8)	0.2463
proximal obstruction	1 (2.3)	1 (2.7)	2 (2.5)	1.0000
distal obstruction	1 (2.3)	0	1 (1.3)	1.0000
migration	3 (7)	3 (8.3)	6 (7.6)	1.0000
randomized by coin toss	5	13	18	—
randomized by availability	42	30	72	—

* — = not applicable.

Results

Group 1: Chhabra Compared With Codman Shunts

The mean age for patients receiving Codman shunts was 7.4 months (range 0.25–32 months), with 49% of patients younger than 6 months of age and 88% 1 year or younger. The mean age of patients receiving Chhabra shunts was 13.3 months, but the two oldest patients (96 and 144 months) were lost to follow up and are not included in the analysis. The mean age for this group excluding those two patients was 8.8 months (range 0.75–84 months). Among all the Chhabra patients 63% of patients were 6 months of age or younger and 84% were 1 year or younger.

Hydrocephalus was due to the following: 64% of Codman and 49% of Chhabra patients had postinfectious hydrocephalus, according to previously reported criteria;[9] 7% of Codman and 14% of Chhabra patients had hydrocephalus related to myelomeningocele; and 29% of Codman patients and 37% of Chhabra patients had non-postinfectious hydrocephalus from other causes (such as, congenital). Using head circumference as a reflection of the severity of hydrocephalus, the two groups were similar. The mean head circumference was 54.9 cm (range 41–77 cm) for those receiving Codman shunts and 53.1 cm (range 40–71 cm) for those patients receiving Chhabra shunts.

There was no statistically significant difference between the two shunts for any outcome parameter (Table 1). The category of failure that came closest to suggesting a possible difference was valve malfunction, with three Chhabra valves and no Codman valves failing in the 1st year; however, this did not reach significance ($p = 0.2463$).

The three Chhabra valve failures all occurred within 2 months of placement (mean 1.67 months). The two VP catheter obstructions (one in each shunt type) both occurred within 1 month of placement (0.25 and 1 month). The four infections in Codman shunts all occurred within 2 months of placement (mean 1.88 months), and the four infections in Chhabra shunts occurred between 1 and 4 months after placement (mean 2.4 months). For the Codman group, all shunt complications occurred within 2 months of placement. For the Chhabra group, all shunt complications occurred within 3 months of placement, except for the one in which infection was present at 4 months postoperatively.

Group 2: Chhabra (Frontal Placement)

The mean age for patients in Group 2 was 7.5 months, with 63% of patients being 6 months or younger. Regarding cause, 50% were due to postinfectious hydrocephalus, 28% non-postinfectious hydrocephalus, and 22% myelomeningocele. The mean head circumference of the group was 53 cm. These values were quite similar to those in Group 1.

In comparing the outcome parameters for Group 2 with those of the Chhabra shunts placed in Group 1, there was no statistically significant difference in any category (Table 2). This suggests that the population of patients in Group 2 had the same likelihood of shunt failure or infection in the 1st year. Because the majority of these patients underwent shunt placement either at the time of ventriculoscopy (when ETV was abandoned) or at some time following ventriculoscopy when ETV had failed, this suggests that the ventriculoscopy procedure did not increase the risk for subsequent shunt infection. Although Group 2 had a higher postoperative (< 1 month) mortality rate, this did not achieve statistical significance ($p = 0.4348$). Also of interest is the fact that no advantage in outcome was apparent for the frontal compared with occipital placements in Groups 2 and 1, respectively, particularly with regard to VP catheter obstruction ($p = 1.0000$).

Comparison of Combined Outcomes for all Chhabra Shunts With Those for Codman Shunts

In comparing the combined outcome for all Chhabra patients (in Group 1 and Group 2) with that for the Codman patients in Group 1, again, there was no significant difference in any category (Table 3).

TABLE 2

Chhabra (Group 1) and Chhabra (Group 2) outcomes

Variable	No. of Patients (%)			p Value
	Chhabra Group 1	Chhabra Group 2	All Patients	
no. of patients	47	105	152	—
lost at <1 yr	4	8	12	1.0000
patients followed to end point	43 (91)	97 (92)	140 (92)	—
dead at <1 mo	1 (2)	7 (6.7)	8 (5.3)	0.4348
no problem 1st yr	22 (51)	53 (55)	75 (54)	0.7173
dead by 1st yr (total)	6 (14)	16 (21)	22 (15.7)	0.8050
infection	4 (9.3)	9 (9.3)	13 (9.3)	1.0000
wound complication	3 (7)	5 (5.2)	8 (5.7)	0.7011
valve malfunction	3 (7)	3 (3.1)	6 (4.2)	0.3711
proximal obstruction	1 (2.3)	3 (3.1)	4 (2.9)	1.0000
distal obstruction	1 (2.3)	1 (1)	2 (1.4)	0.5215
migration/disconnection	3 (7)	5 (5.2)	8 (5.7)	0.7011

Discussion

The occurrence of hydrocephalus in children is very common in East Africa, although its incidence and prevalence are not known. I have reported elsewhere that central nervous system infection is the most common cause of hydrocephalus in our practice in Uganda, accounting for 60% of cases.[9] The access to treatment of hydrocephalus for children in many African countries is inhibited by economic factors, with treatment only being possible in most instances by using inexpensive shunt systems. Although some centers have reported using home-made devices,[1] the simple and inexpensive slit-in-spring valve Chhabra shunt system is commonly used throughout East Africa.

No previously published report has prospectively compared the results of using this shunt system with those when using one of the more "sophisticated" expensive shunt systems that are typically used in North America or Europe. Given that we were embarking on the treatment of hydrocephalus in hundreds of infants per year at our hospital, it was important for us to gauge the relative safety and efficacy of the shunt system most readily available to us and economically feasible.

Economic imperatives aside, this study suggests no clinical reason *not* to use the inexpensive Chhabra shunt. 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 difference did not reach statistical significance, however, even when all patients receiving Chhabra shunts were compared with those in whom Codman shunts were placed ($p = 0.3448$). This is reassuring news to those of us working in emerging countries. It means that in the particular case of the two shunt systems compared here, nearly 20 children can be treated for hydrocephalus with equivalent safety and efficacy for the price of treating one child with the expensive shunt. These results also provide evidence to government agencies charged with regulating health care that an expensive product from the North is not a priori safer or more effective. These results might also be of interest to the so-called developed world in which the cost of health care is also a concern.

This study was not performed so that we could advocate for a particular shunt system or manufacturer. Our intention 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.[4] Those comparisons were among expensive shunts commonly used by neurosurgeons in North America and did not include an inexpensive alternative.

The results of this study also demonstrate that shunting of hydrocephalus can be performed in the context of an emerging country with results similar to those in developed countries. Young age has previously been identified as a major risk factor for shunt infection, and our infection rate of 10% for Group 1, more than 80% of whom were younger than 1 year of age, is in line with published results for infants.[5,6] An overall infection rate of 5 to 10% without regard to risk factors is considered acceptable, being the range commonly reported in the literature.[5] Furthermore, our population differs in that the additional risk factors of malnutrition, poor skin integrity (contributed to by severe macrocephaly), and generally poor physical condition are routinely seen in our patients.

Similarly, the incidence of shunt malfunction in the 1st year is comparable with results from developed countries. Among 148 1-year survivors in the total study group, 84% had no type of primary shunt failure in the 1st year. This compares favorably with published North American studies showing 1-year shunt survivals in the 60 to 80% range.[2,3,7] If one includes all repeated operations for any problem, including infections and wound complications, 65.5% of survivors had been free of all problems during the course of the 1st year. The majority of repeated operations for shunt malfunction or infection were performed at less than 3 months from the initial shunt placement.

The notable disparity between the results of this study and the experience in developed countries lies in our overall 16% mortality rate in the 1st year. The UNICEF statistics for 2003 in Uganda reveal an infant mortality of 8.1% (81 of 1000 infants born will die before their 1st birthday) and a 5-year mortality of 14.9% (140 of 1000 infants born will die before their 5th birthday).[8] It is to be expected that the 1-year mortality rate for any population of infants (and

TABLE 3

Combined results for all patients at 1-year follow-up review

Variable	No. of Patients (%)			p Value
	Chhabra	Codman	Total	
no. of patients	152	43	195	—
lost at <1 yr	12	7	19	0.1410
total followed	140 (92)	36 (84)	176 (90)	—
dead at <1 mo	8 (5.3)	0	8 (4.1)	0.3631
no problem 1st yr	75 (54)	21 (58)	96 (54.5)	0.7083
dead by 1st yr	22 (15.7)	6 (17)	28 (15.9)	1.0000
infection	13 (9.3)	4 (11)	17 (9.7)	1.0000
wound complication	8 (5.7)	2 (5.6)	10 (5.7)	1.0000
valve malfunction	6 (4.2)	0	6 (3.4)	0.3448
proximal obstruction	4 (2.9)	1 (2.7)	5 (2.8)	1.0000
distal obstruction	2 (1.4)	0	2 (1.1)	1.0000
migration	8 (5.7)	3 (8.3)	11 (6.3)	0.6982

perhaps especially those with a preexisting condition such as hydrocephalus) will reflect that for the general population, and will most certainly be higher than those in developed countries.

That the 1-year mortality rate following shunt placement exceeded that expected for the general infant population is distressing, although perhaps not surprising. One obvious potential explanation is that the physical condition of these children is already compromised by their preexisting conditions. This might render them more susceptible to death from the common childhood killers here, such as malaria, measles, upper respiratory infections, and gastroenteritis. Another factor may be the difficulty parents here have in quickly transporting a sick child to competent medical attention, combined with the fact that any fever in a child is often assumed to be malaria and treated empirically as such; thus, a shunt infection could easily go untreated and become fatal. With regard to shunt malfunction, a similar danger exists for shunt-dependent children with closed fontanels; however, this is less likely to have been a factor in the 1st year for this very young patient population. The foregoing argues for the avoidance of shunt dependency by the primary management of hydrocephalus with ETV when possible.[9]

It is also a fact that many of these children were in a debilitated condition at original presentation for treatment and, despite adequate treatment for hydrocephalus, we have found that many continue to suffer postoperatively from malnutrition and, occasionally, family neglect. The economic and cultural milieu in rural Uganda is such that when faced with meager resources, a family with many children will often be reluctant to invest any further in the health of a disabled child. All of these factors most likely converge to increase mortality rates in these children. Such is the environment of pediatric neurosurgical practice in this context.

Conclusions

1) Insertion of a VP shunt for treatment of hydrocephalus can be performed in the context of an emerging country with results similar to those reported for developed nations.

2) The inexpensive Chhabra shunt performed as well as the expensive Codman shunt, with no statistically significant difference in any outcome category.

3) The ongoing high mortality rates of children in an emerging 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.

Disclosure

The author has no financial interest that relates in any way to this report.

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