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ORIGINAL ARTICLE

Ventriculo-subgaleal shunts—broadening the horizons: an institutional experience

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Abstract

Objective Ventriculo-subgaleal shunt is an established treatment of hydrocephalus following germinal matrix haemorrhage in low birth weight neonates. It is also used in treatment of post-infective hydrocephalus in children. We intend to emphasise the impact of its extended use in multiple clinical conditions to reduce the number of permanent shunt implantation in infants.

Method Retrospective review of clinical cases in a single institution from medical records.

Results VSG shunts with low-pressure valve system were useful in variety of hydrocephalus in infants (post-haemorrhagic, post-infective, post-myelomeningocele, post-shunt block, post-traumatic, hydrocephalus associated with brain tumours). A significant number of infants especially those with post-haemorrhagic and post-myelomeningocele hydrocephalus could be made free of permanent shunt placement.

Conclusions Ventriculo-subgaleal shunt is an effective, less risky temporary solution of hydrocephalus in infants and can be used in a variety of hydrocephalus in children and helps in avoiding shunt dependency in some of them.

Keywords Ventriculo-subgaleal · Shunts · Infants

Introduction

Ventriculo-subgaleal (VSG) shunt is a simple surgical procedure that offers a passage between the dilated ventricle and the subgaleal pouch developed in the opposite side of the scalp through a small silicone tube as the conduit. It is presumed that in a recumbent child, raised intracranial pressure will force CSF flow from the ventricle to the tube and then to the avascular pocket from where it will be absorbed back through the walls of the pouch kept distended by the incoming CSF. It is most commonly used in treating neonates with germinal matrix haemorrhage, as these children have CSF with high RBC and protein content and also very low body weight, and are considered unsuitable for ventriculo-peritoneal (VP) shunt. In our institution, we have used this method of CSF diversion extensively in post-infective hydrocephalus, be it bacterial or tubercular. This form of diversion of infected CSF into an avascular subgaleal pocket has not given rise to any increased rate of shunt infection as compared to VP shunt. Furthermore, this avoids iatrogenic infection risk associated with external ventricular drain (EVD) or the risk of developing porencephalic cysts associated with repeated anterior fontanelle ventricular taps and avoids the risk of infection with insertion of a needle into the ventricular access device (VAD).

We have expanded the indication of VSG shunts—like in posterior fossa tumours, myelomeningocele at the time of primary repair, in shunt infections or in acute shunt blockage in very low birth weight infants. We have successively treated older infants with acute hydrocephalus with VSG shunts, routinely up to 3 months of age and also in some children up to 9 months age who present acutely (avoiding an EVD in those cases). In this retrospective study, we present our data regarding conversion of VSG shunts to permanent VP shunts and show that a significant portion of these children could be made shunt free.

Methods

This is a single centre retrospective study involving the data of 215 infants in the period between 2009 and 2018, who presented with hydrocephalus and were treated with ventriculo-

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subgaleal shunts. All the patients were screened for hydrocephalus clinically with serial head circumference measurements, looking for tense and bulged anterior fontanelle along with subtle signs like upgaze restrictions or sixth cranial nerve paresis. Head circumference measurements were used as clinical marker for the progression of hydrocephalus. All the patients underwent ultrasound scan of head at the time of presentation and ventriculomegaly more than 97th percentile for age was accepted as indication for CSF diversion. Also, progressive increase in ventriculomegaly in serial scans was accepted as indication for CSF diversion. MRI scans were done in all except premature neonates in NICU, to detail the anatomy, type of hydrocephalus and identification of loculations if present. Routine analysis of ventricular CSF was done in all the cases through anterior fontanelle tap to look for cell type, cell count, protein and sugar levels along with Gram stain and culture, and hence to distinguish between true aqueductal stenosis and post-infective hydrocephalus.

Our technique for VSG shunt placement (Fig. 1) is to make a curvilinear incision in the precoronal region, in line with ipsilateral pupil. The dura was opened in the lateral angle of the anterior fontanelle, which is normally open in the majority of infants. A ventricular catheter was used to tap the ventricle which was then attached to a low-pressure slit spring ball valve connected to a small segment of tubing with slits made on either side. A large subgaleal pocket was thereafter created on the opposite side of the scalp with a blunt dissector being run 270° in exactly the same plane from the coronal suture to the lamboid suture. The temporalis fascia and the forehead were avoided. The short distal tube was placed in this pouch after checking CSF flow with the valve tunnelled under the skin. Compression bandage of scalp was avoided to allow distension. Attempt was always made to place the shunt reservoir (with the slit valve) over the bony skull and not over the anterior fontanelle so that it could be manually compressed if necessary.

Filling up of subgaleal pouch was noted within 48 h. Close watch was kept on the reabsorptive capacity of the scalp, and if the reabsorption was not adequate, occasional tapping of the pouch was necessary. Initial follow-up was weekly, and then follow-up was done monthly. CT scans or MRI scans were done routinely after 3 months of insertion of VSG shunt or earlier if there were any signs of blockage or malfunction (Fig. 2). A final decision of conversion to VP shunt was taken at this juncture. In cases where there was significant CSF collection in the subgaleal pouch, the VSG shunt was left in situ while it continued to function and the infant was asymptomatic. In case it had been there for over 3 months, it was converted to a VP shunt provided ETV was not feasible (we do not do ETV below the age of 1 year). If the subgaleal pouch was empty, but head circumference was stable without clinical or radiological evidences of ventriculomegaly, the VSG shunt was removed. If there was increase in head circumference or clinical or radiological evidence of increasing ventricular size, a VP shunt was performed below the age of 1 year, and in case the child was over 1 year age, an ETV was done (Chart 1). While removing the VSG shunt, a suture of 1/0 silk was used percutaneously to tie up the distal catheter (procedure done under sedation), and if there were no clinical or radiological evidence of ventriculomegaly after 72 h, the VSG shunt was

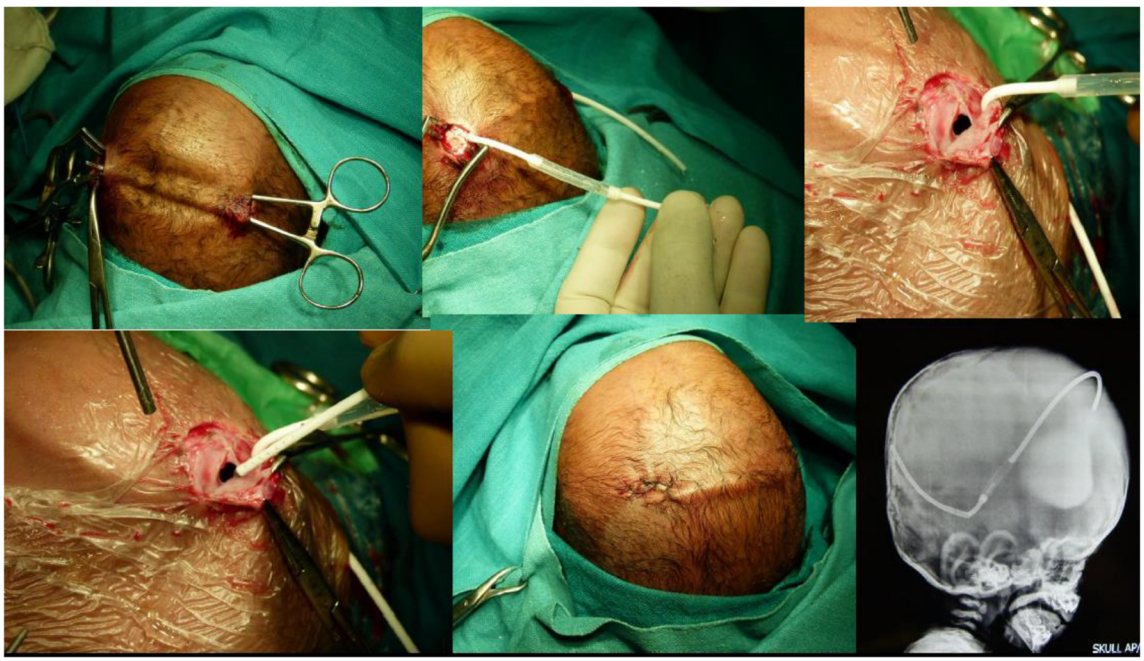

Fig. 1 Our technique of VSG shunt insertion

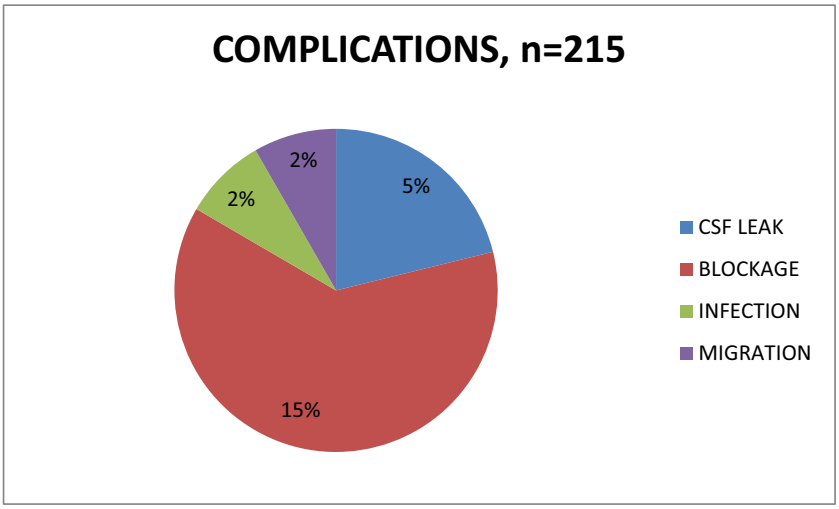

Fig. 2 Complications of VSG shunts

removed under general anaesthesia. Follow-up after removal was done upto 6 months to look for need for permanent shunt. Results were analysed graphically. Hospital ethics board approval was obtained although it was a retrospective analysis of records.

Results

Our series had 35 patients of post-haemorrhagic hydrocephalus (PHH) (Fig. 3) all of whom were in papile grade 3 and above who presented at the mean age of 36.5 weeks, out of

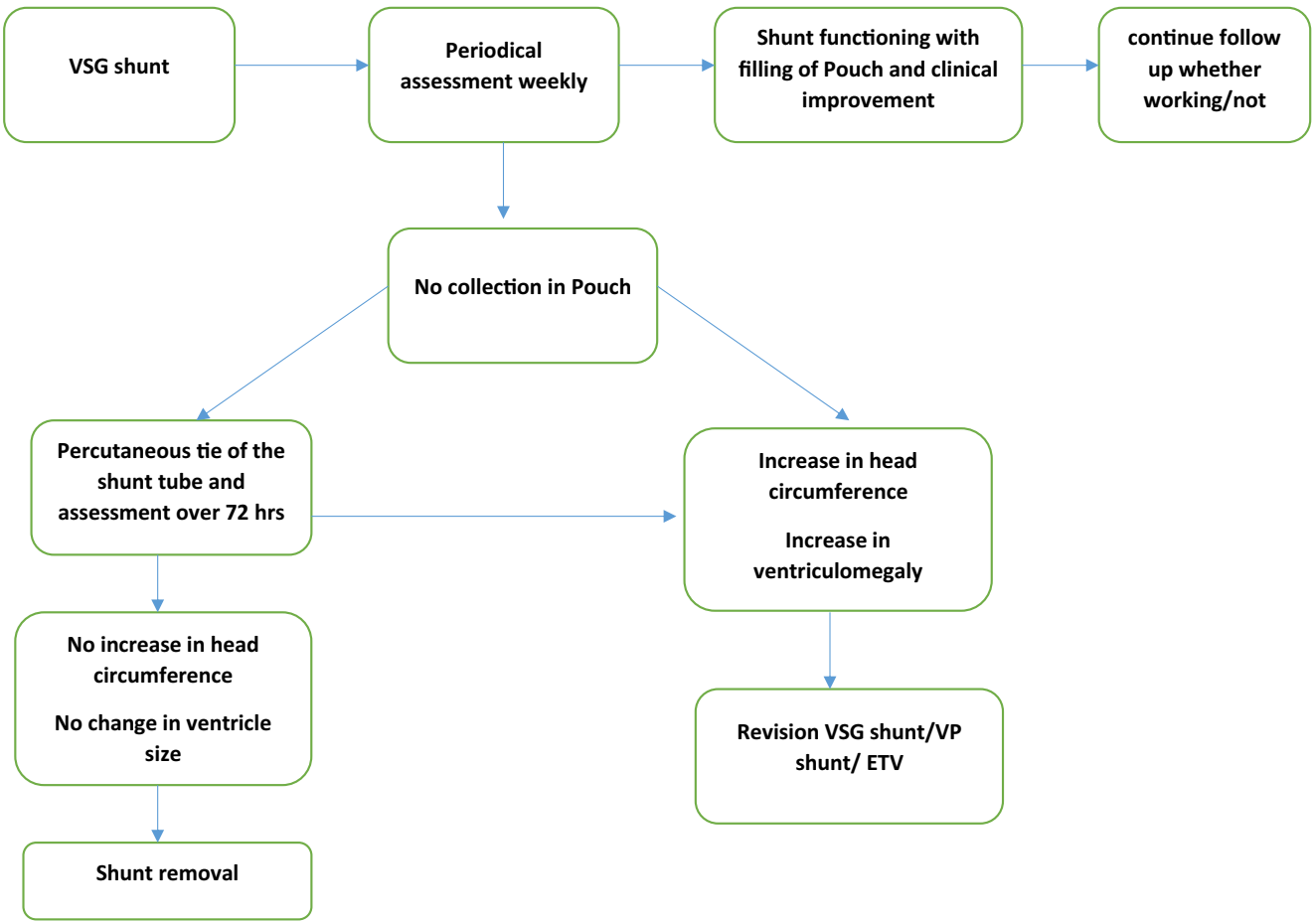

Chart 1 Flow chart of our protocol for VSG shunt followup

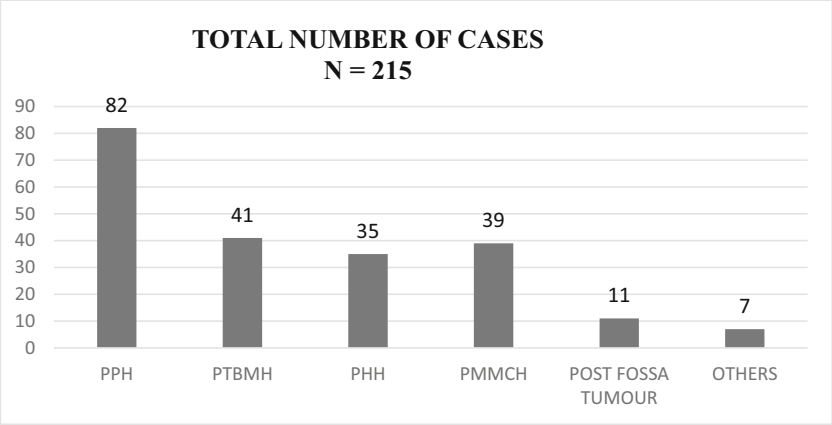

Fig. 3 Total number of cases and each etiological subgroup—'others' included acute hydrocephalus with VP shunt in situ and traumatic brain injury with severe comorbidities

which 32 underwent primary VSG shunts. Three patients had VP shunt done earlier and presented with distal blockage of the shunts (Fig. 4). These patients underwent VP shunt removal and secondary VSG shunts. Eight of them had evidence of CSF infection.

Amongst the 82 patients of post-pyogenic hydrocephalus (PPH) (Fig. 3), mean age was3.2 months. Thirteen patients had VP shunts inserted outside (Fig. 4).

A total of 41 patients of post-tubercular meningitis (PTBMH) hydrocephalus (Fig. 3) presented at the mean age of 5.6 months, out of which 9 patients were in MRC grade 4.

Thirty-nine patients presented with post-meningomyelocele (PMMCH) hydrocephalus (Fig. 3) of which 6 had failed VP shunt (Fig. 4).

Complications associated with VSG shunts were CSF leak (5%), blockage (15%), infection (2%) and migration (2%) (Fig. 2).This compares very favourably with the complication rate for infants with VP shunts. Mean duration of VSG shunts was 63 days in PMMCH, 60.1 days in PPH, 52 days in PTBMH and 40.6 days in PHH group (Fig. 5).

Our success was in that the primary outcome of VP shunt conversion rate was lowered. It was found that 39% of PHH group, 23% in PMMCH group were ultimately shunt free. However, permanent CSF diversions were required in 90.2% of PTBMH and 97% in PPH group (Fig. 6).

Besides these, in a significant number of PPH patients with multiloculated hydrocephalus, we used VSG shunts after multiple endoscopic fenestration procedures to reduce the number of loculations before putting in the final VP shunts.

We used VSG shunts in 11 cases of infantile hydrocephalus associated with posterior fossa brain tumours where the infants had significantly raised intracranial pressure at presentation and were not considered fit for definitive surgery (Fig. 3). It may be mentioned that in all these cases, the infants were in poor clinical state or had other congenital anomalies which precluded major

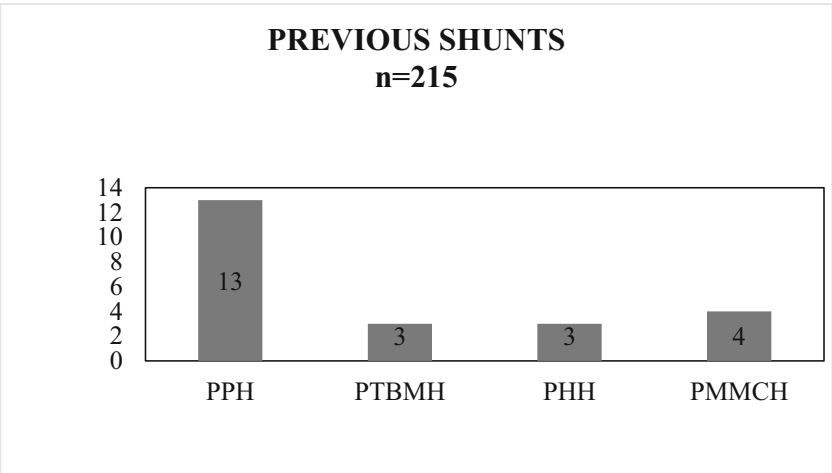

Fig. 4 Number of cases with previous shunts

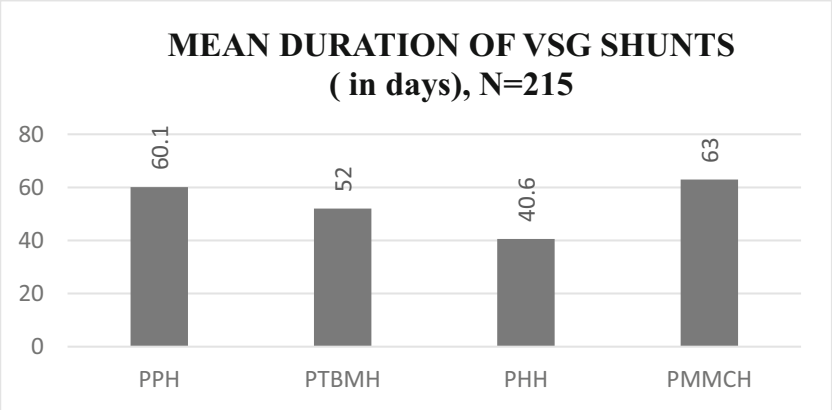

Fig. 5 Mean duration of VSG shunts

surgery. Here the procedure was performed as emergency. Conversion to VP shunt was necessary in 45% of these cases (Fig. 6).

Four children with acute hydrocephalus with precipitous shunt blockage due to peritoneal end infection or pseudocysts underwent VSG in lieu of EVD and were converted to formal shunts within a month (Fig. 3).

Lastly, 3 infants having hydrocephalus following traumatic brain injuries and associated with severe comorbidities (pneumothorax, hemoperitoneum and long bone fractures) (Fig. 3) respectively underwent VSG shunts as interim measures to avoid the longer surgical and anaesthetic procedure of insertion of a VP shunt.

Discussion

VSG shunt was first described in 1896 by von Mickulicz, followed by successive publications from Schramm (1899), Senn (1903), Horseley (1906) and Krause (1908). Renewed interest came in 1977 when Perret and Graf presented a series of 173 patients suffering from tumours and subdural fluid collections [11]. There are many options in treating a neonate with hydrocephalus. In those with open fontanelle, ventricular tap on a repeated basis can be a temporising measure especially in CSF laden with RBC or infection. But the disadvantages are that they are labour intensive, require strict aseptic protocol and environment, and repeated taps may lead to frontal lobe gliosis with resultant development of porencephalic cysts.

Lumbar puncture is an option in communicating hydrocephalus, but one must remember that CSF spaces are non-communicating (either at foraminal or at arachnoidal level) in a majority of our cohort and repeated lumbar taps may lead to focal arachnoiditis with subsequent tethering of the spinal cord. In fact, one published guideline [9] has level 1 evidence against use of serial lumbar puncture.

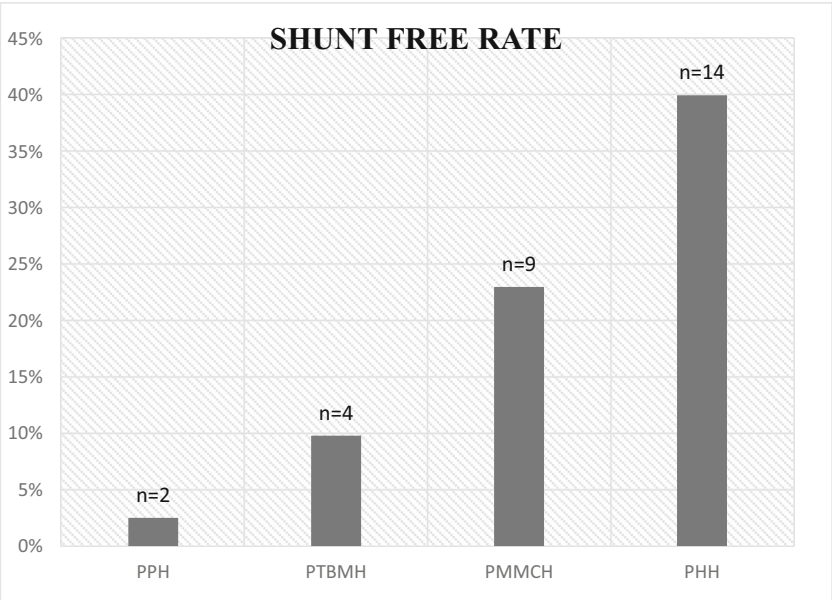

Fig. 6 Number of cases which did not require VP shunt (shunt free)

External ventricular drainage is the most direct method of quick relief of raised intracranial pressure but it carries a high rate of infection even in the best of the set-ups. Furthermore, it is difficult to maintain in non-neurosurgical set-up like a general NICU (neonatal intensive care unit) and runs the risk of disconnection, blockage or over drainage if not maintained correctly. Protein and electrolyte loss through EVD also require meticulous monitoring in a sick child.

VP shunt is a rational option but its use is limited in small neonates. Infants who have less than 2-kg body weight do not tolerate shunts and many of premature neonates have associated immature peritoneum and possible gut infections like necrotising enterocolitis negating the possibility of an abdominal procedure. In post-infective cases, highly protinaceous CSF leads to slow CSF flow making the shunt more prone to blockage and infection, and also causes irritation of the peritoneum leading to ileus. The cost of shunt procedure and revisions is quite high as compared to temporising procedures. Delaying the shunt procedure may lead to better survival and subsequent reduced number of repeat surgeries and cost. In patients with acutely raised intracranial pressure, the VSG shunt insertion requires less than 10 min of operating time.

Endoscopic third ventriculostomy (ETV) is not the procedure of choice in a neonate or in an acute setting. However, its use is also technically difficult if not impossible in cases of post-infectious hydrocephalus due to hazy CSF, multiple loculations, thick septum and hypervascularity increasing the possibility of intraoperative bleeding. In hydrocephalus, due to meningomyeloceles or posterior fossa tumours, though there are numerous reports of successful ETV procedures, but in our practice, we have found the space in front of the basilar artery to be very small in these cases. ETV is fraught with failures in small children with these problems.

VAD is a useful temporary measure wherein a small reservoir is placed subcutaneously connected to the ventricle. This will require frequent tapping as the reservoir fills in no time. Each tap carries a risk of introducing iatrogenic infection. In small neonates with thin skin, especially in a malnourished population, the reservoir tends to extrude through the skin causing CSF leak and this causes great difficulty in subsequent management.

VSG shunts offer the best of both worlds. It is a closed device thus negating the infection rate and fluid loss risk of an EVD. It is a short surgical procedure (even can be done at the bedside), having advantage in acute settings. It avoids the abdominal complications of the shunt and the risk of ETV in small infants. As compared to VAD, the shunt assembly is flatter and the receptive cavity (subgaleal pocket) is large, so chances of blockage, extrusion and CSF leakage are much lower. Compared with VAD, VSG shunt group had fewer taps (1.6 vs 10 taps) and longer time interval before placing VP shunt (80.8 days vs 48.8 days) [15]. Fountain et al. in his meta-analysis of 338 publications comparing the use of VAD and VSG found out that a significant proportion of patients with a VSG require less tapping [4].The pooled outcome of 9 studies with VSG shunts for post-haemorrhagic hydrocephalus described 9.6% as rate of obstruction and 9.2% rate of infection, but mentioned that there was arrest of hydrocephalus in 13.9%, 12.2% requiring revision and 58.7% leading to good neurodevelopmental outcome [1].

The golden advantage of VSG shunt is its longevity. The average duration of these shunts in our setting was 53.9 days that is almost 2 months. Seiff et al. in their review of 185 VSG shunts found an average longevity of 37.4 days in the primary group and 32.4 days in the secondary group [13]. Majority of the shunt dysfunctions were due to pocket problems and not due to catheter blocks. In the series of Fulmer et al., it was also observed that most of the failures were due to failed subgaleal CSF absorption (pouch too full or too empty) and not because of the catheter blockade [5].Tubbs group [14] had shown other complications of VSG shunts to be infection (5.9% vs 2% in our group), bleed (1.1% vs none in our group) and leak (4.7% versus 5% in our group due to increased prevalence of malnutrition in the cohort in our study group).

It may be pointed out that in spite of using a valved shunt instead of a valveless tubing as in other studies, our rates of shunt blockage were small. Our rationale in using a low-pressure valve instead of simple tubing has been that this ensures that there is no rapid drainage of the CSF causing a large accumulation of CSF in the subgaleal pouch. In our initial experience of using plain tubings, often the initial collection of CSF was so large that there was leakage through the skin or need for multiple aspirations, neither of which happen when a low-pressure valve is incorporated into the system. Also the shunt chamber offers a port for aspiration of CSF for analysis especially in follow-up of post-infective hydrocephalus infants. This particular shunt (Chhabra-G.Surgiwear Ltd., India) was chosen as the valve has very low resistance to flow in horizontal position but significantly prevents overdrainage on head turning.

In neonatal post-haemorrhagic hydrocephalus of prematurity, VSG offers a significant advantage over other methods of CSF diversion like EVD and VADs. Not only the internal diversion procedure is better from the point of the risk of infection but also the simple surgery puts very little stress on the premature child. There have been reports of subgaleal shunt being performed under local anaesthesia and sedation without intubation [8].Interestingly, in one series, the mean life span of VSG shunts placed at NICU was much longer than that placed at OR (73 versus 43 days) [6]. Our series showed 40% of the children in this subgroup required no further shunts, a much higher incidence as compared to other series [12].In some centres using VAD as alone temporising measure, the VP shunt conversion rate was as high as 95% [2].

In post-pyogenic group, our policy of routinely analysing all CSF before deciding about the need for shunts has been successful in isolating a fair number of asymptomatic patients

with CSF infection [3]—possibly due to partially treated meningitis, a very common finding in our population. VSG shunts offer a fantastic temporising tool allowing the CSF to recover, with a mean VP shunt conversion time of 60.1 days, though literature shows a much higher stay of upto 75.6 days in the Nagi series [10]. The conversion to VP shunt has been the highest in this group due to persistence of multiloculation, thick ventricular walls and failure of resorption at the level of arachnoid villi. However, in only 1 case, the subgaleal pouch got infected in this group, and this necessitated change of the VSG shunt to the opposite side.

With a single revision, the life of the shunt may be extended even further. Repeat VSG was required in 21% of post-pyogenic hydrocephalus patient comparable to 23.8% of the patients in another Indian series [7]. However, revision rates are high in post-tubercular meningitis probably because of very protineaceous CSF content.

In patients with temporary hydrocephalus, like post-haemorrhagic, post-traumatic and those associated with meningomyeloceles or brain tumours, VSG shunt can help the children to tide over the crisis period and a significant number of them can be made shunt free. This is our take home message in expanding the indications of this shunt in a wide variety of hydrocephalus in children.

Conclusions

VSG shunts already had a level II recommendation over VAD in post-haemorrhagic hydrocephalus [9]. We have done significant extension of this temporary procedure in other types of hydrocephalus in infants (post-meningocele hydrocephalus, post-traumatic hydrocephalus, post-acute shunt block hydrocephalus, hydrocephalus associated with surgically complete removable brain tumours). Also we demonstrate successful use of low-pressure shunt valve system for preventing huge subgaleal pouch collection and easy CSF reassessment. We have also shown that extending the length of stay of VSG shunts with revisions if necessary, thus delaying the permanent shunt placement until normal physiology can take over and thus were able to offer a shunt-free life in a significant number of our children. Even if one child can have a permanent shunt avoided, it is worthwhile.

Compliance with ethical standards

Hospital ethics board approval was obtained although it was a retrospective analysis of records.

Conflict of interest No external support or funding was utilised for this study. The authors deny any conflict of interest.

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