



# Thecoperitoneal Shunts—Our 20 Years Experience

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## Abstract

### Keywords

- thecoperitoneal shunts
- outcome
- complications
- idiopathic intracranial hypertension
- normal pressure hydrocephalus
- pseudomeningocele
- CSF leaks
- communicating hydrocephalus

**Introduction** The thecoperitoneal shunt is a modality of cerebrospinal fluid (CSF) diversion used to treat various clinical conditions such as idiopathic intracranial hypertension (IIH), normal pressure hydrocephalus (NPH), and CSF leaks. There is a wide variability in the data regarding the utility and complications associated with it. We thus reviewed the outcomes and complications of the shunt done in our setting.

**Methods** The study is a retrospective review of all the thecoperitoneal shunts performed at NIMHANS (National Institute of Mental Health and Neurosciences) from January 2000 to December 2020. The demographic details, clinical profile, indications for the shunt, magnetic resonance imaging, follow-up and complications, and shunt revisions were collected and analyzed.

**Results** Three-hundred twelve patients underwent shunt primarily at our institute. The mean follow-up of the patients was 5.2 years. The indications include pseudomeningocele in 31.4%, CSF leak from surgical site in 25.3%, IIH in 17.6%, and NPH in 7.3% patients.

The shunt was more effective in pseudomeningocele in up to 95% and CSF leaks in 91% compared to 64% in IIH, though it is not significant ( $p > 0.05$ ). The complication rate was 17% that included shunt block, wound CSF leak, infection, and subdural hygromas. The shunt malfunction was seen in 14.69% patients who underwent revision.

**Conclusion** Thecoperitoneal shunt is a useful treatment option for various pathologies including IIH, NPH, and wound CSF leaks. They have good clinical outcomes and acceptable revision rates especially in conditions with slit ventricle. The complications such as low-pressure headache can be overcome by using adjuncts as programmable valve or antisiphon device.

## Introduction

The thecoperitoneal shunt is a modality of cerebrospinal fluid (CSF) diversion whose popularity of usage in clinical medicine has waxed and waned since their introduction by Ferguson

100 years ago. They have been used to treat diseases such as idiopathic intracranial hypertension (IIH), normal pressure hydrocephalus (NPH), CSF leaks, and slit ventricles. These shunts come with the advantage of lack of cerebral cannulation, ability to use in slit ventricles, and decreased

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proximal obstruction by choroid plexus. However, complications such as infection, distal obstruction, arachnoiditis, nerve root pain, and unregulated CSF drainage have been reported with wide variability in the data. We, thus, have conducted this study to review the outcomes and complications associated with the shunt in the various clinical conditions.

## Methodology

The study is a retrospective review of all the thecoperitoneal shunts performed at NIMHANS (National Institute of Mental Health and Neurosciences) from January 2000 to December 2020. The demographic details, clinical profile, indications for the shunt, magnetic resonance imaging, follow-up and complications, and shunt revisions were collected and analyzed.

Two types of shunts were used in the study. Most of the shunts used were normal unidirectional shunts with or without a reservoir, while the programmable shunts were used in fewer cases especially in patients with diagnosis of NPH and IIH who could afford the shunt.

The IIH patients have been diagnosed by Modified Dandy criteria. The clinical outcome was assessed by the quality of headache, visual acuity in the form of World Health Organization grading. The NPH patients were by gait score by 30 feet step score and time score, and objective criteria such as Mini Mental State Examination (MMSE). The remaining diagnosis was assessed by clinical signs and symptoms.

Statistical analysis was done using commercially available software (SPSS version 20, IBM Inc., Armonk, New York, United States). The outcomes and complications were analyzed. A regression analysis was done to predict the

significant factors correlating with the complications and outcomes.

## Results

A total of 312 patients underwent shunt for the pathology primarily at our institute in the past 20 years. They were 149 (47.7%) males and 163 females (52.3%). The mean age of the patients was 38.46 years (1–89 years). Two-hundred ninety-five (95%) patients underwent regular valveless shunt, while remaining 17 (5%) patients underwent programmable shunt. The mean follow-up of the patients was 5.2 years. The various indications include pseudomeningocele, CSF leak from surgical site, IIH, NPH, and communicating hydrocephalus (►Fig. 1).

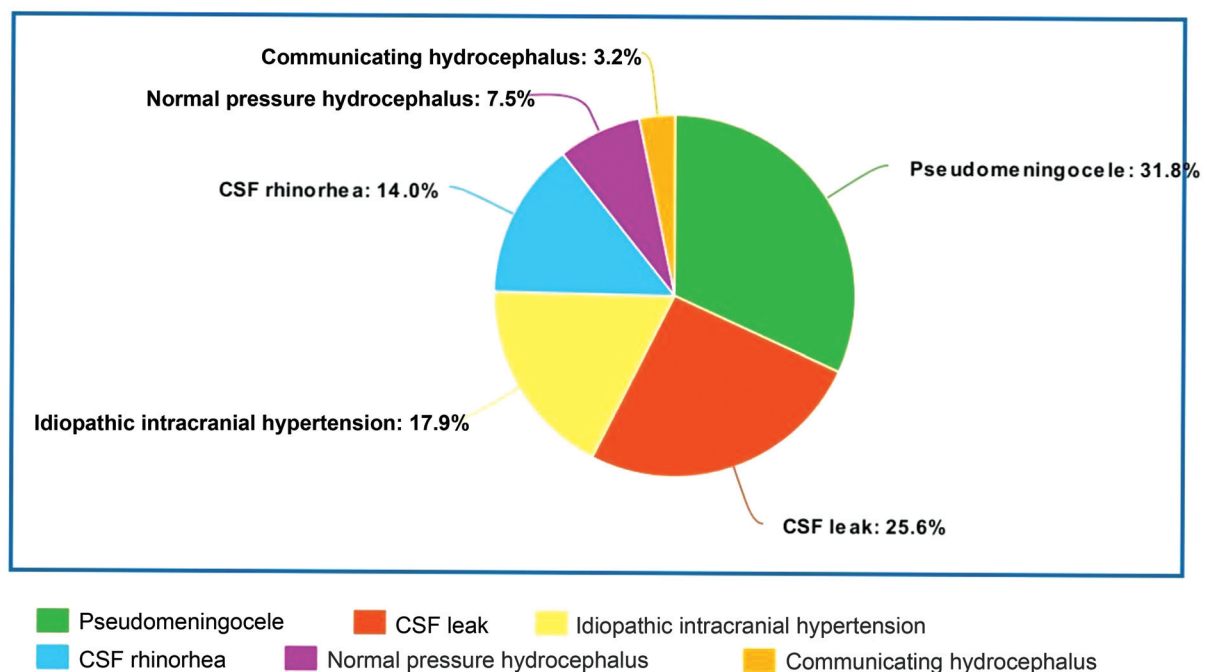
### Pseudomeningocele

A total of 98 patients (31.4%) had pseudomeningocele. All the patients were initially treated conservatively for 5 to 7 days and those who did not improve underwent shunt. The shunt was performed for supratentorial pathologies in 63% (62), infratentorial pathologies in 35% (34) and spinal in 2% (2) cases. Two patients (2%) underwent programmable shunt.

The swelling subsided in 96% patients (94) remained same and worsened in 2% (2) each. Two patients (1—supratentorial, 1—infratentorial) had undergone cranioplasty postshunt. Among the shunt failure patients, one patient underwent ventriculoperitoneal (VP) shunt, and three patients underwent revision of the entire thecoperitoneal shunt.

### CSF Leaks

Seventy-nine patients (25.3%) with CSF leak underwent normal valveless thecoperitoneal shunt. Among them,



**Fig. 1** Indications of thecoperitoneal shunts. CSF, cerebrospinal fluid.

50.6% (40) shunts were done for infratentorial pathologies, 36.7% (29) for supratentorial pathologies, and 12.7% (10) for spinal leaks. Sixty-five percent (26) of infratentorial pathologies were done for surgeries involving the cerebellopontine angle, while the remaining were distributed equally among 4th ventricular and decompressive craniectomies. The patients with spinal CSF leaks had equal distribution among extradural, intradural–extramedullary, and intramedullary pathologies. The supratentorial cases included trauma and skull base pathologies.

It was found that 8% (7) patients had shunt failure for which shunt revision was done in three of them and reinforcement of the dura was done in the remaining, all of them were infratentorial cases.

### CSF Rhinorrhea

Forty-three patients with CSF rhinorrhea underwent the thecoperitoneal shunts; majority of them done for postendoscopy for suprasellar pathologies (53.5%). The rhinorrhea had subsided in all the patients except in four patients (10%) including one primary spontaneous rhinorrhea patient and three postendoscopic patients, who underwent secondary reinforcement surgery within a mean time of 12 days, after which the CSF rhinorrhea subsided.

### Idiopathic Intracranial Hypertension

Fifty-five patients (17.6%) with IIH underwent the shunt procedure, among whom 11 (20%) underwent programmable shunt. All patients were started on medical management, and patients with acute vision deterioration or symptoms refractory to conservative management of 1 month were considered for the shunt procedure. Preoperatively, headache and nausea were present in 100 and 70% of patients. Seventy-three percent of patients had blindness preoperatively with the fundus showing papilledema in 85% (47) patients and optic atrophy in 15% (8) patients. The venogram found that sinus stenoses and

hypoplasia were seen in 40 and 24% of them, respectively. Postoperatively, 62% patients had improvement in visual acuity and 100% of them had improvement in headache and vomiting. Two patients with nonimprovement in vision had undergone optic nerve fenestration, which did not affect the outcome. The improvement in visual acuity after the shunt was significantly associated only with the presence of papilledema in the fundus preoperatively ( $p < 0.001$ ). On logistic regression analysis, the complications were not significantly associated with age, sex, preoperative symptoms, or visual acuity ( $p > 0.005$ ).

### Normal Pressure Hydrocephalus

A total of 23 NPH (7.3%) underwent lumbar-peritoneal shunt among which 78.3% (18) are males.

Four patients (18%) underwent programmable shunt. All the patients preoperatively underwent lumbar drainage with improvement in the symptoms, after which thecoperitoneal shunt was done. The ataxia, dementia, and urinary incontinence symptoms had improved postoperatively in 86, 87, and 89% patients, respectively, that were significant ( $p < 0.001$ ).

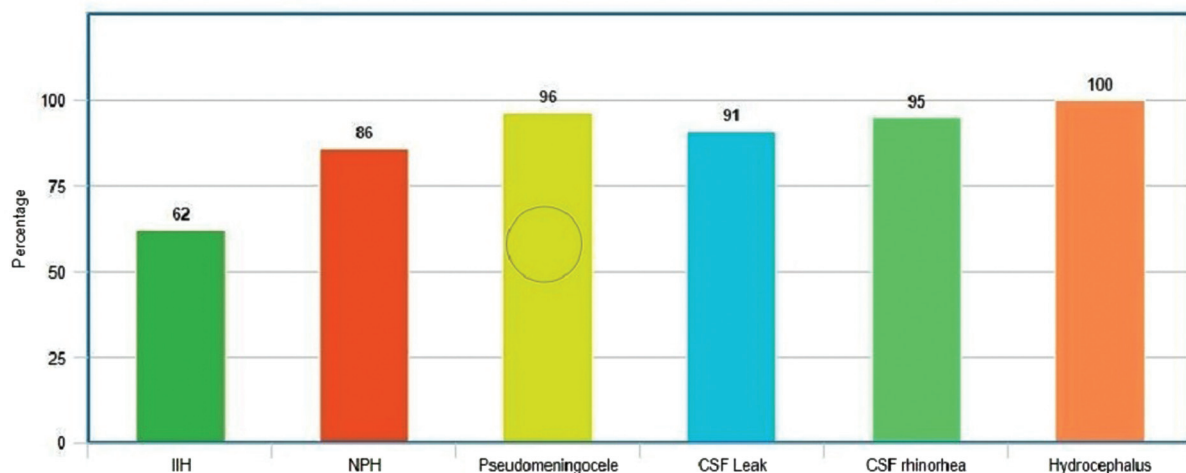
### Communicating Hydrocephalus

Among 14 patients, 71% (10) were posttraumatic, 21.4% (3) post-subarachnoid hemorrhage, and 7.1% (1) postinfectious.

Twelve (86%) patients underwent the procedure in first decade (2000–2010). The symptoms of drowsiness seen in 21% (3) and raised intracranial pressure in the remaining patients improved post-surgery.

### Efficacy of the Shunt

It has been found that shunt was effective more in the conditions of pseudomeningocele and CSF leaks compared to other pathologies, though it is not significant ( $p > 0.05$ ; ▶ Fig. 2).



**Fig. 2** Efficacy of thecoperitoneal shunts in various pathologies. CSF, cerebrospinal fluid; IIH, intracranial hypertension; NPH, normal pressure hydrocephalus.

**Table 1** Complications of thecoperitoneal shunts

Complication	Number of cases: 17.6% (n = 55)
Shunt block	7.3% (23) 52% (12) lumbar end, 48% (11) abdominal end
CSF leak	5.2% (16) 50% (8) abdomen, 50% (8) lumbar and flank site
Shunt wound infection	2.5% (8)
Subdural hygroma	2.2% (7)
Lumbar radiculopathy	0.3% (1)

Abbreviation: CSF, cerebrospinal fluid.

**Table 2** Shunt malfunction and characteristics

Shunt malfunction (n = 47)—15%	Intervention done
Shunt block (19)	Revision of entire shunt—7 (36%) VP shunt—3 (16%) Abdominal-end revision—1 (5%) Additional surgery—8 (42%)
CSF leak (18)	Shunt removal—5 (27%) Revision of TP shunt—5 (27%) Abdominal shunt revision—8 (46%)
Wound infection (10)	Shunt removal—6 (60%) Conservative—2 (20%) Conversion to VP shunt—1 (10%) Fresh TP shunt—1 (10%)

Abbreviations: TP, thecoperitoneal; VP, ventriculoperitoneal.

### Complications and Shunt Failure Rates

The complications were noted in 17% (55) patients (►Table 1).

The shunt block was noted in 12.6% of patients with CSF rhinorrhea, 8.8% with CSF leak, and 4% with pseudomeningocele. The CSF leak was equally seen in the lumbar and abdomen end in 12.7% of patients with IIH and 8.3%

pseudomeningocele. Subdural hygroma was seen in 2.2% (7) patients especially in NPH and IIH patients, among whom two patients underwent burr hole and evacuation, three patients underwent ligation of the shunt, and remaining patients were managed on conservative treatment. On regression analysis, there was no correlation between the complications and the preoperative demographic factors, or the clinical indication or the type of shunt used.

Low-pressure headaches were reported in 9% (30) patients. It was found that low-pressure headaches were found related to type of shunt performed with lower incidence in programmable shunts ( $p < 0.0001$ ), and though the incidence varied among the primary pathologies with up to 37% in IIH and 14% in CSF rhinorrhea, it was not significantly dependent on them ( $p > 0.05$ ).

### Shunt Malfunction

Forty-seven patients (14.69%) had shunt malfunction who had presented within a mean period of 0.28 year. Sixty percent of the shunts underwent revision in the first three months of the procedure and the remaining within 1 year and underwent various interventions (►Table 2). The 13 shunts that were reintroduced had no complications and malfunction till the last follow-up period.

### Discussion

Ferguson had introduced the concept of extracranial shunting for hydrocephalus in 1898 by using a catheter placed in the burr hole in lumbar vertebrae.<sup>1</sup> The complications such as arachnoiditis scoliosis were reported due to the polyethylene material, which led to the subsequent introduction of silastic material by Selman in 1975, thus popularizing these shunts. These shunts since then have been used for treating various pathologies such as communicating hydrocephalus and in the recent times for IIH and NPH (►Table 3).

**IIH patients:** The mean age of patients of IIH was found to be  $29.55 \pm 9.36$  years with female predominance in concordance to previous studies.<sup>2</sup> It has been found that 80% of the patients had vision loss that is higher than the reported 30% in the literature,<sup>3</sup> probably due to the delay in diagnosis in our socioeconomic setup. We have found post-surgery visual acuity improved in 64% patients with resolution of papilledema in 97% similar to established

**Table 3** Thecoperitoneal shunt indications—case series

Series (Year)	Number of cases (n)	Comm HCP (%)	CSF leaks (%)	CSF rhinorrhea (%)	Pseudomeningocele (%)	IIH (%)	NPH (%)
Aoki (1990) <sup>1</sup>	270	93.7	6	—	—	0.5	—
Chumas et al (1993) <sup>24</sup>	143	81	12	—	—	7	—
Yadav et al (2004) <sup>13</sup>	409	76	6	2	2	1	—
Huang et al (2014) <sup>29</sup>	19					100	
Kazui et al (2015) <sup>11</sup>	93						100
Our series (2022)	312	4.4	25.3	13.7	31.4	7.3	17.6

Abbreviations: CSF, cerebrospinal fluid; HCP, Hydrocephalus; IIH, intracranial hypertension; NPH, normal pressure hydrocephalus.

data.<sup>4,5</sup> It was found that visual acuity improvement was significant in patients who had papilledema preoperatively ( $p < 0.001$ ) compared to those with an established optic atrophy. The other treatment options include optic nerve fenestration that provide similar results initially but deteriorate in up to 45% in 3 years.<sup>6</sup> Venous stenting has been found effective in treating visual symptoms in up to 90% patients with focal stenosis,<sup>7</sup> but the long-term efficacy data is lacking.<sup>8</sup> It was noticed that though preoperative headache resolved in all patients, postoperatively 36% (20/55) patients had developed low pressure headache in the follow-up. Ninety percent (18) of these headaches had resolved on symptomatic treatment, while 10% (2) had to undergo shunt ligation, after which the primary pathology was treated with acetazolamide. Hence, the IHH consensus recommended that headache without visual symptoms should be treated symptomatically as the symptoms persist in 42% patients post-shunt.<sup>9</sup> The shunt complication rate was 12.7% mainly due to CSF leak.

**NPH patients:** Eighteen percent of NPH patients underwent programmable shunts, while the remaining underwent valveless shunts. After the surgery, improvement was seen in gait in 86%, urinary incontinence in 89%, dementia in 77% patients with improvement in MMSE score. The rate of improvement was higher than the previously reported rates of 60 to 77%.<sup>2</sup>

The complication rate was 39% (8/23) including shunt infection (4/23), subdural hygroma (3/23) requiring burr hole and evacuation in two of them and shunt ligation in one. The revision rate was 26% (6) with majority of them undergoing VP shunt (66.6%).

The gold standard treatment for NPH is debatable with VP shunts preferred in majority of the countries, while thecoperitoneal shunt in countries like Japan.<sup>10</sup> The SINPHONI-2 Randomized trial found out similar efficacy between theco and VP shunts, but higher adverse events with thecoperitoneal shunts. (49 vs. 35%).<sup>11</sup> Over-drainage is a problem with regular thecoperitoneal shunt, hence programmable thecoperitoneal shunts are being recommended. A meta-analysis by Giordan et al found that though the efficacy rates were similar among the fixed valve and programmable shunt groups, the rates of shunt revision were higher in the fixed valve group (12 vs. 9%).<sup>12</sup> Our data had a smaller sample size to reproduce a significant difference between them.

## Communicating Hydrocephalus

Around 4.4% patients with communicating hydrocephalus underwent shunt, 75% among which were posttraumatic. There was symptomatic improvement in all the patients. In posttraumatic hydrocephalus, thecoperitoneal shunts have been found to cause improvement in Glasgow Outcome scale (GOS) score in 52% patients.<sup>3</sup> Yadav et al<sup>13</sup> found that among the postinfectious meningitis hydrocephalus patients, Glasgow Coma Scale had improved in 60% of them. The utility of thecoperitoneal shunts for communicating hydrocephalus has decreased over time, with majority of

them being performed in the first decade. This is due to feasibility, lesser incidence of revision, and over-drainage problem with VP shunts in them (22.7 vs. 11%).<sup>14</sup>

## Pseudomeningocele and Postoperative CSF Leaks

Pseudomeningocele and CSF leaks accounted for more 50% of the shunt cases. The CSF leaks in supratentorial pathologies were mainly seen in trauma and skull base surgeries where water-tight dural closure was difficult. Among the infratentorial pathologies with CSF leak, cerebellopontine angle surgeries had higher incidence. Around 12 (3.8%) patients after spinal surgery with CSF leak and pseudomeningocele underwent shunt. The conservative measures such as pressure dressings, head-end elevation drainage lumbar puncture, and secondary suturing are helpful in fewer cases. Remaining had required CSF diversion techniques. In majority of the cases, the ventricles are not dilated enough for the VP shunt; thus, thecoperitoneal shunts are used. In our series, it was noted that the shunt was effective in pseudomeningocele in 96%, and in 91% of patients with wound CSF leak. The remaining patients were treated with repair of the defect. The complication rate was 9% with shunt failure in 6% and CSF leak from the wound in 3% patients. The serious events such as chronic subdural hematoma, acute posterior fossa syndrome, and subarachnoid bleed, which were touted as reason for subgaleal-peritoneal shunt, were not seen in our study.<sup>15</sup>

**CSF rhinorrhea:** About 13.7% (43) patients with CSF rhinorrhea underwent shunt, in which majority of them included postendoscopic surgery for suprasellar pathologies where there was arachnoid breach. In our series, majority of them were packed with autologous fat and fascial graft and a lumbar drain was placed to decrease the CSF tension. The patients who were dependent on the lumbar drain were converted into the shunt in a mean time of 12 days after which the leak had subsided in 86% (20). The remaining 14% (3) patients who had failure of the shunt had to undergo secondary reinforcement surgery. About 18.6% patients who had CSF rhinorrhea post-surgery for supratentorial pathologies due to communication with frontal sinus and clinoid during were minor and subsided on the shunts. Among the 9.3% (4) patients with spontaneous CSF rhinorrhea, three patients underwent repair of the defect followed by the shunt, while one patient underwent shunt primarily followed by definitive surgery. It was noted that raised intracranial pressure was a contributing factor in spontaneous CSF rhinorrhea, despite primary repair of the defect and addressing it could help in resolution.<sup>16</sup>

## Complications

The complications associated with the thecoperitoneal shunts are comparable to the other published case series (► Table 4).

Shunt malfunction was noted in 14.69% (47) patients within a mean period of 0.28 year. Among them shunt block was noted in 6% (19) patients. This rate is comparable to previous reported series.<sup>13,17</sup> This has been



**Table 4** Complications of thecoperitoneal shunt

Series	Type of shunt	Number of cases (n)	Shunt block	Infection	Hygroma	Radiculopathy
Aoki (1990) <sup>1</sup>	TP shunt	207	14%	1%	2%	5%
Yadav et al (2004) <sup>13</sup>	TP shunt	409	4%	3.4%	–	0.25%
Reddy et al (2011) <sup>28</sup>	VP shunt	284	13.8%	6.3%	–	
Menger et al (2014) <sup>30</sup>	TP shunt	1,754	Up to 6%	0.57%	0.2%	–
Merkler et al (2017) <sup>14</sup>	VP shunt	17,015	21.3%	6.1%	14%	–
Our series (2022)	TP shunt	312	7.3%	2.5%	2.2%	0.3%

Abbreviations: TP, thecoperitoneal shunt; VP, ventriculoperitoneal shunt.

due to the mechanical blockage of the shunt. Diagnosis of this is generally difficult with majority of the patients presenting with recurrence of symptoms or headache and visual complaints.<sup>18</sup>

Since headache is a poorly reliable symptoms, the other clinical symptoms must be considered prior to suspicion. Cranial imaging has a little role in imaging in diagnosis of shunt block in conditions such as IIH and NPH and the assessment of patency can be done by intrathecal administration of 111-DTPA,<sup>19</sup> or by shuntography with contrast injection. Thus, when in doubt of the nonimprovement or worsening of symptoms, the shunt must be re-explored. The most common site is the proximal shunt site. The distal block in certain conditions such as IIH could be explained by the principle of elevated intra-abdominal pressure in overweight individuals; thus, weight loss is an essential part of their management.<sup>6</sup> The CSF leaks were noted in 5.7% (19) patients that were equally distributed between the proximal and distal end. They were treated by shunt revision in 71% (13) of them and remaining with shunt removal (6). Majority of them who underwent shunt removal were patients who had CSF rhinorrhea postcranial surgery, indicating that the leak was minor in them; thus, they have become shunt independent. Shunt infection was seen in 3.2% patients. These rates are comparable to other studies that have showed the rates between 1 and 12%.<sup>13</sup> The diagnosis of them could only be made by clinical symptomatology as access to CSF is limited by the valve. Thus, patients with persistent fever or CSF leak from the wound were treated with antibiotics, while on nonimprovement after period of 3 days, they were treated with shunt removal and revision.

### Over-Drainage and Low-Pressure Headache

Shunts may paradoxically cause complications due to over-drainage. The low-pressure symptoms are more common in thecoperitoneal shunts due to the hydrostatic pressure on the fluid in the spinal column. The peritubal CSF leaks into paraspinal muscles have also a role to play in the low-pressure headaches.<sup>20</sup> In our series, low pressure headaches were noted in 9% (20) of the population. The low-pressure headache was seen in 37% of the patients with IIH and in remaining diagnosis it was distributed equally. Low-pressure headache was significantly lower in patients

for whom programmable shunt was done compared to regular shunt ( $p < 0.001$ ). Subdural hygroma was seen in 2.2% (7) patients who were treated with burr hole and evacuation in two patients and ligation of shunt in three patients. The use of valve such as flow related was found to be better than pressure gradient valve in preventing these complications; however, their efficacy in conditions such as NPH was doubtful.<sup>21</sup> The programmable valves and antisiphon devices can also be useful to treat these symptoms.<sup>22,23</sup>

Chiari malformation is a rare complication reported with the shunt. The incidence was reported to high in children in upto 70% by Payner et al and Chumas et al.<sup>24,25</sup> However, the recent series reported incidence upto 1% with usage of valve system, reducing the incidence.<sup>13</sup> However, we have not found any patient with Chiari after the shunt procedure. The other complications due to local injury such as cauda equina syndrome and lumbar radiculopathy due to the irritation by the catheter, though rare, were seen in one patient that resolved on conservative management.

Thus, we have found that in our study that the thecoperitoneal shunts were more effective in conditions with lower CSF pressure conditions such as pseudo-meningocele, CSF leak compared to IIH and NPH though not significant.

The thecoperitoneal shunt in comparison to VP shunt provides an advantage of lesser injury to neural structures, seizures, and intracerebral hematoma in conditions without ventriculomegaly.<sup>26</sup> In diseases such as IIH, Azad et al found no difference in outcomes and complications between VP shunt and lumbar peritoneal shunt (31.7 vs. 34.7%, respectively).<sup>27</sup> Most of the series reporting the superiority of VP shunts have used adjuncts such as navigation with lesser free hand shunts that could lead to complications in upto 16%.<sup>5</sup>

In NPH, a review by Giordan et al<sup>12</sup> found that there was no difference between the outcomes and complications between thecoperitoneal shunt and VP shunt (7% vs. 0–16%, respectively) with similar infection rates (3–12%). In cases of pseudomeningocele and CSF rhinorrhea, the incidence of shunt block (14.2 vs. 13.2%) and infection (6.1 vs. 6.3%) is comparable to VP shunts.<sup>14,28</sup>

Our study presents the most recent and a comprehensive review of the indications and outcomes of the shunt

especially in our subcontinent. This study suggests that the thecoperitoneal shunts have good clinical outcomes with revision and complication rates comparable to the other alternative treatment modalities.

## Limitations

The study has certain limitations: it was a retrospective analysis, with limited imaging follow-up for diseases such as IIH and NPH. The study lacked a control group such as VP shunt for comparison of the outcomes.

## Conclusion

Thecoperitoneal shunt is a useful treatment option for various pathologies including IIH, NPH, and wound CSF leaks. They have good clinical outcomes and acceptable revision rates in conditions especially associated with slit ventricle. However, the normal shunt is associated with complications such as low-pressure headache and adjuncts such as a programmable valve or antisiphon device can be used especially in pathologies such as IIH.

### Note

The work is original and has not been presented or published elsewhere in part or entirety.

### Conflict of Interest

None declared.

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