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Management of Abdominal Complications of Ventriculoperitoneal and Thecoperitoneal Shunts

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ABSTRACT

Background: The overall incidence of hydrocephalus in the general population is not known since the condition occurs in association with a large number of childhood and adult intracranial diseases. It is obvious that the reported incidence of infantile hydrocephalus, namely 3 to 4 per 1000 live birth is grossly understated.

Objective: The aim of this study was to study various complications of the ventriculoperitoneal shunt and their management. **Patients and methods:** This a prospective study, a total of assessed 20 patients of complicated shunt operations for hydrocephalus in single group, the age of the patients varied from two months to seventeen years?; there were ten males and ten female patients, at Al-Azhar University Hospitals between March 2017 and June 2018.

Results: Treatment of shunt obstruction was done by shunt revision using a new catheter which was easy with excellent results in absence of infections. 65% of the cases with shunt infection occurred during the first six months after initial shunt insertion. Treatment of patients with shunt infection was done by shunt removal, CSF drainage and combined intravenous and intraventricular antibiotics according to culture and sensitivity. Shunt insertion was done after negative three successive CSF cultures and lower CSF protein level. The cure rate was 62.5% in cases of shunt infections using the above-mentioned regimen. **Conclusion:** The complication due to non-infective causes is easy to manage and usually requires a short stay of the patient in the hospital.

Keywords: Abdominal Complications of Ventriculoperitoneal, Thecoperitoneal Shunts.

INTRODUCTION

Placement of ventriculoperitoneal (VP) shunt is the most common operation performed in the treatment of hydrocephalus (HC) **(1).** The use of the peritoneal cavity for CSF absorption in ventriculoperitoneal shunting was first introduced in 1908 by Kausch **(2).** Other shunting has since been used include a ventriculoatrial shunt (VA), a lumboperitoneal shunt, and a third ventriculostomy **(3).**

The peritoneal cavity is preferable to the pleural cavity for insertion and reinsertion of the shunt **(4).** Intraabdominal complications after ventriculoperitoneal shunt placement are most commonly located near the peritoneal end of the shunt catheter, more than 50% of patients require shunt revision **(5).** The most common complications have been reported to be; the infection of the shunt, malfunction due to blockage, disconnection, migration, and equipment failure, which are related to extraperitoneal retraction of the cathete[r] **(6).** Shunt infection remains a frequent and potentially fatal complication of CSF diversion **(7).**

Development of an incisional hernia, subcutaneous collection of CSF, and peritoneal pseudocyst formation due to low-grade infection followed by wrapping by the omentum, other complications include intestinal perforation, CSF ascites, inguinal hernia and intestinal volvulus **(6).** These complications may manifest as either local abdominal signs or increased intracranial pressure **(8).** Therefore, a key issue in the treatment of these complications is early and correct diagnosis of intraabdominal complications by CT, MRI, sonography or abdominal radiography **(6).**

The aim of this study was to study various complications of the ventriculoperitoneal shunt and their management.

PATIENTS AND METHODS

This Prospective study included a total of 20 patients of complicated shunt operations for hydrocephalus in single group, attending at Al-Azhar University Hospitals. This study was conducted between March 2017 and June 2018.

Ethical approval:

The study was approved by the Ethics Board of Al-Azhar University. All the procedures were in accordance with the ethical standards of the responsible committee on human experimentation. All parents were adequately informed and signed a consent form before surgery after they had received an explanation about the nature of the study and its potential complications.

The age of the patients varied from two months to seventeen years; there were ten males and ten female patients.

Inclusion criteria: Patient fit for surgery, managed by VP shunt and Thecoperitoneal shunt.

Exclusion criteria: Patients unfit for surgery, managed by other types of CSF diversion.

Demographic characteristics including: Age, gender, past history, family history, antenatal history.

All cases were subjected to the following procedures:

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1) Full clinical examination.
2) Examination of shunt device to assess its function (emptying the reservoir and refilling or collection around the tract).
3) Plain X-ray of the skull, chest and abdomen was done if there was any doubt or possibility of fracture or disconnection of the shunt tubing due to the natural growth in height.
4) CT scans of the brain and sonar of the head in those cases where the anterior fontanelle was not closed.
5) Culture and sensitivity for the proper identification of the infecting organism, whenever there was infection or collection around the tubing.
6) Definitive operative procedure either:

- Revision of the proximal or distal shunt catheters in cases of malfunction or obstruction.
- Removal of the shunt and obtaining sample of the CSF and/or any collection in cases of infection. After the infection subsided a new shunt was implanted.
- External ventricular drainage in cases of severely infected CSF and closed head until the infection subsided were a new shunt was implanted.
- Reconnection of any disconnected part or insertion of a longer distal catheter in cases of short distal tubing or fracture shunt tubing.
- Replacement of the whole shunt in cases of multiple fractures of shunt tubing or short device as in cases of unitized shunt.
- Evacuation of any subdural collection.
- Laparotomy or laparoscopy for any exteriorized distal shunt tubing outside the abdomen.

7) Follow up by CT scan of the brain after three and six months to assess the shunt function following the definitive management.

The following protocol is used in management:

- General examination, examination of shunt system and past history of shunting.
- **Investigations,** including laboratory investigations, plain X-ray, CT scan brain, cranial ultrasonography, pelviabdominal ultrasonography, CSF examination, diagnosis and management.

Postoperative follow up:

In the postoperative period, patients were followed as follow:

Early post-operative follows up for:

- fever.
- Bleeding.
- Intracranial device malfunction.
- Signs of peritonitis.

Late post-operative follows up for:

- Pseudo cyst assisted by US and CT scan.
- Intestinal perforation.
- Intraperitoneal device disconnection.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:
- Probability (P-value)
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant.

RESULTS

Baseline characteristics of studied subjects:

The results of our study are as follows. The study consisted of 20 patients. From **Table 1** the age incidence of the patients varied from two months to 48 years old. The first group of patients (3 cases: 33% males and 67% females) was less than 2 years old.

The second group of patients was in the age range of 2-6 years old (5 cases: 3 males 2 females). The third group was in the age range of 6-18 years old (3 cases: 1 male and 2 females) About 40% of cases were less than 6 years old. The next age group was 18-30 years old (one male) and the last group more than 30 years represented 40% of cases (3 males and 5 females). Out of the 20 cases, 9 cases were males and 11 were females.

Table 1: Age and Sex distribution of patients.

Age (In Years)	Sex	Case No.	Percentage (%)
Less Than two Year	Male	1	15 %
	Female	2	
2-6 Years Old	Male	3	25 %
	Female	2	
6-18 Years Old	Male	1	15 %
	Female	2	
18-30 Years Old	Male	1	5 %
	Female	0	
More than 30 Years Old	Male	3	40 %
	Female	5	

Regarding age with gender distribution; 40% of cases were less than 6 years old. 20% between 6 and 30 years and the remaining 40% older than 30 years.

Investigations

All cases had a CT head scan done for determination of the condition of the ventricular system and detection of the site of the ventricular catheter, in 7 cases sonography of the head was done through the open anterior fontanelle. Out of the 20 cases with CT

head scan, 5 cases needed plain X ray to assess the condition of the shunt catheter and the possibility of its fracture or disconnection.

5 cases needed abdominal sonography to investigate abdominal condition.

1 case had an MRI brain (for follow up of a brain tumor previously resected).

Table 2: Investigations performed in the cases studied

Investigations	Number Of Cases
C Scan of The Brain	**20**
Ultrasonography of The Head	**7**
Additional Investigations:	
Plain X Ray Skull	**5**
Abdominal Ultrasonography	**5**
MRI Of The Brain	**1**

Out of 20 cases with CT head, 4 cases showed a well-drained ventricular system (20%); 2 of them showed drained ventricles and 2 cases showed drained ventricles and subdural hematoma. 3 cases showed dilated ventricular system and the ventricular catheter was outside the ventricle. 1 case showed a slit ventricle.14 cases showed dilation of the ventricular system with the ventricular catheter in place (70%).

Table 3: CT findings in the cases studied

Findings	Number of Cases	Percentage
Dilated Ventricles And Catheter In Place	14	**70%**
Dilated Ventricles And Catheter Outside	1	**5%**
Slit Ventricle	1	**5%**
Drained Ventricles	2	**10%**
Drained Ventricles And Subdural Collection	2	**10%**
Total	**20**	**100%**

Table 4: Sonographic Findings in the cases studied

Finding	Number of Cases	Percentage
Dilated Ventricles	4	**57.1%**
Dilated Ventricles With Signs Of Ventriculitis	2	**28.7%**
Normal Sized Ventricles	1	**14.2%**
Total	**7**	**100%**

2 cases showed signs of ventriculitis (28.7%).

Table 5: CSF Cultures

Organisms	(N)	(%)
Staphylococcus Epidermidis	2	67%
Staphylococcus Aureus	1	33%

Management:

Table 6: Operative management in the cases studied

Operation	Number Of Cases	Percentage
Revision Of Distal End Of The Tube	8	**40%**
Revision Of Proximal End Of The Tube	3	**15%**
Revision Of Proximal And Distal Ends	1	**5%**
Replacement Of The Shunt	4	**20%**
Removal Of Shunt And External Drainage	2	**10%**
Evacuation Of Subdural Collection	2	**10%**
Total	**20**	**100%**

Distal revision:

Revision of the distal tubing was done in 8 cases revision of the distal tube, in 4 cases replacement of the whole shunt was done as the reservoir was malfunctioning and replaced.

In cases of distal revision, the tube was blocked by kinking, malposition (extraperitoneal and kinked), upward migration, peritoneal pseudocyst, subclinical peritoneal infection and debris (1 case).

In one case the distal tube was disconnected, and in 1 case the distal tube was short and replaced by new.

Table 7: Distal revision findings in the cases studied

Findings	Number of Cases	Percentage
Blocked Peritoneal End	6	**75 %**
Fractured Distal Tube	1	**12.5 %**
Short Peritoneal End (Replaced By New)	1	**12.5 %**
Total	**8**	**100%**

Proximal revision:

The proximal revision was required in 4 cases, of which one case had the ventricular catheter outside the ventricles. It had to be replaced by a new one. In 3 cases, the ventricular catheter was inside the ventricles but was obstructed by brain debris. The catheter was taken out and replaced by a new one.

Table 8: Proximal revision in the cases studied

Findings	Number Of Cases	Percentage
Tube Outside the Ventricle	1	**25 %**
Tube Inside the Ventricle and Blocked	3	**75 %**
Total	**4**	**100%**

- ***Distal and proximal revision:*** This was done in one case where the replacement of both the ventricular

catheter and the peritoneal catheter was needed and both were replaced by new catheters, the reservoir found to be functioning well, cleaned and reinserted.

- ***Replacement of the shunt device:*** This was done in 4 cases the majority of them were due to shortening of the device which is a unitized one.
- ***Removal of the shunt and external drainage:*** A total of 3 cases had severe infection around the shunt or in the ventricular system, so the shunt was removed totally in all of them. They needed external drainage of the infected ventricular system following the removal of the shunt and received antibiotic therapy. 1 case did not need external drainage, received antibiotic therapy and reshunted after the infection subsided.
- ***Evacuation of subdural collection:*** 2 cases had a subdural collection which needed to be evacuated using burr holes; one of them developed infection and subdural empyema. A big flap was done to drain the empyema.
- **Period of time between shunt operation and presentation:** 34% of cases were less than 6 months and 60% were within the first year.
- **Mortality rate:** One case (5%) died after the surgical procedure; that case developed sepsis at the wound site.

DISCUSSION

In this present study of 20 patients with Shunt complications, we found that 60% of cases occurred within the first year after shunt insertion.

In this study 16 out of total 20 cases of shunt complications, (80%) were operated for shunt obstruction.

Distal shunt obstruction due to occlusion of the peritoneal catheter is by far the most common cause of shunt obstruction in the pediatric age group[7, 9].

In this study by combined CT scan brain and operative findings we found that proximal obstruction was due to too long tube penetrating the ventricle and embedded in the brain matter either in the same side or in the interhemispheric fissure or crossing to the contralateral side with debris obstructing the tube (malposition) or it may be in the body of the lateral ventricle obstructed by the choroid plexus and debris, or it may be too short not reaching the ventricular system and it may be too long and kinked inside the ventricular system.

In this study in order to avoid malposition of the ventricular catheter or crossing the other side, full precautions during ventricular catheter insertion should be taken as regarding the length of the tube to be just anterior to the foramen of monro in the frontal horn. In adults without macrocrania, the inserted length is usually less than 12 cm when the burr hole is in line with the axis of the lateral ventricle.

In this study in hydrocephalic infants, usually 7-8 cm is required, use the stylet for the initial 6 cm of insertion, then remove it and insert the remaining length, this keeps the catheter straight during penetration of occipital parenchyma and prevents the tip from dropping into the temporal horn where there is choroid plexus, also the temporal horn may collapse and occlude the catheter when the hydrocephalus is resolved.

In this study during insertion, the catheter should be parallel to the skull base and initially aim for the middle of the forehead (glabella), if this fails, aim for ipsilateral medial canthus.

Insertion length in case of frontal burr hole (Kocher's point) should be < 5-7 cm depth; this may be 3-4 cm with markedly dialated ventricles. If CSF is not obtained until very long insertion (≥ 8 cm) the tip is probably in a cistern (prepontine cistern) which is undesirable.

Treatment of proximal shunt obstruction depends on the cause, varied from shortening the tube and correct intraventricular insertion, or change it by a new one, in our cases, we have a proximal catheter in the interhemispheric fissure with difficult removal, and so we leave it and insert a new shunt in the other side.

In this series, pseudocyst formation was the responsible cause of distal shunt obstruction in some cases without clear evidence of infection. While extraperitoneal insertion, too long kinked tube and upward migration of short peritoneal tube were encountered in other cases.

Abdominal pseudocysts are a rare complication and the reported incidence per patients varies between 0.8% and 10% which were comparable with our results [7].

In this series, we found that of 20 patients with shunt failure 4 cases (20%) were due to shunt infection and comes after shunt obstruction as the commonest two causes of shunt failure.

The percentage in our series (20%) in comparison with others is considered low, this may be due to good general condition of the patients.

In this series, most of the cases of shunt infection occur in the first 6 months and the rate of infection decline in the following years.

It is clear that any child with VP shunt who experienced fever should be considered as having shunt infection until proved otherwise. Refused feeding and irritability are the early symptoms encountered among all cases directing the attention to shunt failure [10].

This series supports the opinion of **Rotim *et al.* [10] and Kestle *et al.* [11],** who advocate the removal of the shunt system as the initial procedure in management of infected ventriculoperitoneal shunts, with targeted use of antibiotics and implantation of an external ventricular drainage device until the infection is completely healed, followed by a new shunt implantation contralaterally. Among the 20 cases of shunt complications included in our study, there was one death (5%). The cause of death was the infection. Thus mortality in this study is comparable in the average with those of others.

It is important to outline the ways in which shunt failure can be avoided. For this study, we think that for the reduction of the incidence of shunt failure we have to decide if the patient is suitable for a shunt

implant or revision or not. This may be a difficult decision and we have to avoid surgery in hydrocephalic patients in the presence of one of the contraindications of shunt insertion or revision which are in the following [12,13]: ventriculitis, other inadequately treated infections, acute intraventricular hemorrhage, extreme brain pathology (i.e., hydranencephaly) and asympatomatic nonprogressive hydrocephalus.

In our study we revealed:

1. There is controversy about shunting decision in cases of hydrocephalus due to obstructive lesions whether to attack the lesion from the start without shunting to be judged later on or to shunt at first then dealing with the obstructing lesion.
2. Infection of shunt systems is a very common and important that affects not only the various components of the shunt system but also the various systems of the body, like cardiovascular, respiratory, renal system etc., it lowers the body resistance and prolongs the patients' stay in the hospital.
3. Once there are colonizations and infection of the shunt system, the whole system has to be removed and CSF drainage is carried out through external ventricular drainage or related ventricular taping.
4. The patient cannot be operated upon for re-implantation of a shunt system unless the infection is treated by appropriate antibiotics to sterilize the CSF and lower the protein level.
5. On the other hand, correction of the general condition of the patient as regard anemia, and malnutrition with the eradication of chest infection may reduce the incidence of failure.
6. Shunt infection is still a major complication in pediatric cerebrospinal fluid shunt operations.
7. In particular, infants and newborns are high risk patients because of the immunologic immaturity in this age group and because of the particular features of neonatal hydrocephalus, often associated with conditions that make it very difficult to obtain real asepsis (spinal dysraphism for example), and that often require shunt insertion on an emergency basis.
8. The complications due to non-infective causes are easy to treat and usually require a short stay of the patient in the hospital.
9. Postoperative brain scanning at regular intervals is a noninvasive means of monitoring the size of ventricles, checking the position of the catheter and observing any asymptomatic development of complications.
10. In attempting to improve cerebrospinal fluid shunting procedures and products, it is clear that multifactorial analysis will be necessary to better understand the variables which potentially enhance or diminish shunt longevity.
11. When changes in shunt design or placement techniques are made to reduce the incidence of shunt failure, a reliable evaluation can be accomplished within two years at least. On the other hand, postoperative studies of new shunt materials will require a much longer follow up period to render an accurate assessment of their efficacy.

CONCLUSION

In particular infants and newborns there is a high risk of infection because of the particular features of neonatal hydrocephalus, often associated with conditions that make it very difficult to obtain real asepsis (spinal dysraphism for example) and that often require shunt insertion in an emergency basis.

The complication due to non-infective causes is easy to manage and usually requires a short stay of the patient in the hospital. In attempting to improve cerebrospinal fluid shunting procedures and products, it is clear that multifactorial analysis will be necessary; to better understand the variables which potentially enhance or diminish shunt longevity.

When changes in shunt design or placement technique are made to reduce the incidence of shunt failure, a reliable evaluation can be accomplished within two years at least; on the other hand, postoperative studies of new shunt materials require a much longer follow up period to render an accurate assessment of their efficacy.

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