The Turkish Journal of Pediatrics 1997; 39: 363-371

# CEREBROSPINAL FLUID SHUNT COMPLICATIONS*

*Elif Güzelbağ MD**, Yusuf Erşahin MD***, Saffet Mutluer MD*****

**SUMMARY: Güzelbağ E, Erşahin Y, Mutluer S. (Division of Pediatric Neurosurgery, Department of Neurosurgery, Ege University Faculty of Medicine, İzmir, Turkey). Cerebrospinal fluid shunt complications. Turk J Pediatr 1997; 39: 363-371.**

**We report our experience with cerebrospinal fluid shunt procedures performed on 306 patients between 1983 and 1993. Patients were between the ages of one day and 15 years (average 14.9 months) on admission. Three hundred and thirty-six shunt placements and 274 revisions were done. The first complication occurred in the first postoperative month in 52 patients and within the first six months following surgery in 97 patients. Age was determined as a statistically significant factor in only infection and the slit ventricle syndrome (SVS). Shunt types and systems were not significant factors causing complications. The level of consciousness of the patients at the time of surgery influenced the rate of complications; patients with impaired consciousness at the time of surgery had higher complication rates than those operated on in a normal state of consciousness (41% and 8.5%, respectively).** *Key words: cerebrospinal fluid shunts, complication, hydrocephalus, child.*

Many attempts have been made over the years to treat hydrocephalus surgically[1,2]. Since shunting systems became a therapeutic procedure for hydrocephalus in the late 1950s, significant progress has been made. However, this success has been overshadowed by a high incidence of serious complications.

The aim of this study was to present a series of 612 shunt procedures in 306 children and discuss their complications.

## Materials and Methods

Three hundred and thirty-eight new procedures and 274 shunt revisions were performed on 306 patients at the Division of Pediatric Neurosurgery between 1983 and 1993 (Table I). Hydrocephalus was due to myelomeningocele in 109 patients, congenital hydrocephalus in 51, meningitis in 48, tumors in 26, aqueduct stenosis in 17, encephalocele in 16, Dandy-Walker in 12, intraventricular hemorrhage in 11, arachnoid cyst in eight, trauma in five and porencephaly in three patients. The age of the patients on admission ranged from one day to 15 years (average 14.9 months). There were 165 boys and 141 girls. In this study, 612 procedures were performed not including external ventricular drainage

* From the Division of Pediatric Neurosurgery, Department of Neurosurgery, Ege University Faculty of Medicine, İzmir.

** Research Assistant in Neurosurgery, Ege University Faculty of Medicine.

*** Associate Professor of Neurosurgery, Ege University Faculty of Medicine.

**** Professor of Neurosurgery, Ege University Faculty of Medicine.

Table I: Number of Procedures Performed on 306 Children

| CSF shunting procedures | No. |
|---|---|
| VP shunt | 297 |
| VA shunt | 24 |
| CP shunt | 17 |
| Shunt revision | 274 |
| Total | 612 |

VP: ventriculo-peritoneal, VA: ventriculo-atrial, CP: cyst-peritoneal.

and shunt removals. The patients' medical records were reviewed retrospectively. The follow-up period of the patients ranged from six months to 10 years (average 102.4 months).

All shunt placements or revisions were performed by four neurosurgeons and 28 research assistants. The shunt types used were as follows: a multicomponent shunt was placed in 281, one-piece design in 26, and a flow-regulating shunt in two patients.

Two hundred and ninety-seven ventriculo-peritoneal (VP), 24 ventriculo-atrial (VA) and 17 cyst-peritoneal (CP) shunt systems were used. The majority of the VP shunts were multicomponent system (95%), consisting of a ventricular and a peritoneal catheter and an interposed valve reservoir or flushing device. Five percent of the VP shunts were the one-piece design. Standard shunt placement techniques were performed and prophylactic antibiotics were given in all cases. Fourteen VA shunts were inserted as the first procedure while seven were a second procedure after a recurrent abdominal pseudocyst or distal infection was observed in VP shunts. The results regarding shunt infection are not presented in detail, since data pertaining to shunt infections has been previously elucidated and published[3]. Chi-squared test was used in the statistical analysis.

## Results

Complications developed in 45 percent of the shunting procedures during the course of review, and 55 percent of the procedures remained free of complications. Two hundred and seventy-seven complications occurred in 133 patients. Obstruction developed in 22.8 percent of all shunt procedures and was the most common complication (49%) among shunt malfunctions. Proximal obstructions and distal obstructions occurred in 33.4 and 15.6 percent of the patients, respectively. Age was determined to be a significant factor in infection and the slit ventricle syndrome (SVS). The infection rate was 16 percent under one year of age, whereas it was six percent over the age of one year ($x^2$=5.3284,

p<0.025). SVS was not seen under one year of age, and all seven children with SVS were greater than one year old ($x^2$=15.388, p<0.000). Of the 24 patients in which a VA shunt was inserted, 11 (46%) had one or more revisions. Twenty-eight revisions were done in this group, with an average of 2.5 revisions, and 13 patients (54%) were not revised at all. Of 297 patients in which a VP shunt was inserted, 154 patients (52%) underwent one or more revisions. In this group 112 revisions were done, with an average of 0.7 revisions. No revision was done in 143 patients (48%) with VP shunts. Of 17 patients with a CP shunt, eight had one or more revisions (47%), while nine had none (53%). Eighteen revisions were done, with an average of 2.2 revisions for each patient. It appears that VA and CP shunts have a higher rate of revisions than do VP shunts. This finding was not statistically significant ($x^2$=0.444, p=0.801). Table II illustrates the total revision rates in relation to shunt systems ($x^2$=0.357, p=0.986).

Mechanical complications represented the most common type of shunt failure (28.4%). Obstruction of the ventricular catheter occurred in 95 cases (15.5%), obstruction of the distal catheter in 45 (7.3%), migration of the shunt device in 13 (2.1%), disconnection in 12 cases (1.9%), bowel perforation in five (0.8%), misplacement of the distal catheter and extrusion of the distal catheter in two cases (0.3%), and bladder perforation in one patient (0.1%) (Table III). Misplacement of the distal catheter was not observed in VA shunts. Shortening and extrusion of the peritoneal catheter from the abdominal cavity were observed in four patients with VP shunts. In 19 patients (3.1% of the complicated cases), subdural collection due to overdrainage was seen. We compared the burr-hole localization in terms of VP shunt complications. On CT scan, the tip of the ventricular catheter was observed in the opposite frontal horn in most cases in which a parietal burr hole had been used to place the ventricular catheter. The ventricular catheter was inserted through a parietal burr hole in 172 patients. In 42 of 172 patients, 60 ventricular obstructions were observed. The catheter was placed through a burr hole in the posterior parietal region in 122 patients. Twenty-five of these children (20%) had 34 ventricular obstructions ($x^2$=0.422, p=0.516).

Two hundred and eighty-four patients were operated on in a state of normal consciousness. Variable degrees of consciousness from drowsiness to deep

Table II: Revision Rates in Relation to VP, VA and CP Shunts

| Revision No. | VP shunt (n=297) | VA shunt (n=24) | CP shunt (n=17) |
|---|---|---|---|
| 0 | 143 (48%) | 13 (54%) | 9 (53%) |
| ≥1 | 154 (52%) | 11 (46%) | 9 (47%) |

VP: ventriculo-peritoneal, VA: ventriculo-atrial, CP: cyst-peritoneal.

Table III: CSF Shunt Complications

| Type of complication | VP shunt | VA shunt | CP shunt | Total No. | % |
|---|---|---|---|---|---|
| Proximal catheter obstruction | 78 | 16 | 1 | 95 | 15.5 |
| Distal catheter obstruction | 37 | 5 | 3 | 45 | 7.3 |
| Infection | 37 | 3 | 6 | 46 | 7.5 |
| Subdural collection | 16 | 1 | 2 | 19 | 3.1 |
| Migration | 9 | – | 4 | 13 | 2.1 |
| Disconnection | 11 | 1 | – | 12 | 1.9 |
| Shortening of distal catheter | 9 | – | 2 | 11 | 1.7 |
| Abdominal pseudocyst | 10 | – | – | 10 | 1.6 |
| Slit ventricle syndrome | 4 | 1 | 2 | 7 | 1.1 |
| Bowel perforation | 5 | – | – | 5 | 0.8 |
| Postoperative hematoma | 3 | 1 | – | 4 | 0.6 |
| Wound dehiscence | 2 | – | – | 2 | 0.3 |
| Misplacement of distal catheter | 2 | – | – | 2 | 0.3 |
| Extrusion of distal catheter | 2 | – | – | 2 | 0.3 |
| Double compartment hydrocephalus | 1 | – | – | 1 | 0.1 |
| Abdominal CSF fistula | 1 | – | – | 1 | 0.1 |
| Isolated lateral ventricle | 1 | – | – | 1 | 0.1 |
| Bladder perforation | 1 | – | – | 1 | 0.1 |
| Total | 292 | 28 | 20 | 277 | 45.2 |

VP: ventriculo-peritoneal, VA: ventriculo-atrial, CP: cyst-peritoneal, CSF: cerebrospinal fluid.

coma were described in 22 patients. Out of 612 shunt procedures, 292 were elective (95.4%) and 14 (4.6%) were performed in emergency situations. The level consciousness of the patients at the time of operation influenced the complication rates; the patients with impaired consciousness at the time of surgery had higher complication rates than did those who were alert (41% and 8.5%, respectively, $x^2=19.112$, $p=0.000$). Abdominal insertion of the peritoneal catheter was performed by a trocar in 95 percent of cases (290) and by an open technique in the rest because of an abdominal problem.

Fifty-nine deaths were recorded during the ten-year period, 39 of which were due to a shunt complication. The overall mortality rate was 9.6 percent while the shunt-dependent mortality rate was 6.3 percent. However, progression of the original disease, such as tumor, meningitis, pneumonia, or head injury, was the cause of death in 20 patients. Shunt infection was responsible for 27 deaths, thus constituting the most severe complicatin ($x^2=0.696$, $p=0.706$). We compared the causes of death following VP, VA and CP shunts. Although the shunt-related mortality rate was 5.3 percent in VP, 0.5 percent in VA and 0.5 percent in CP shunted patients, the differences were not found statistically significant ($x^2=0.696$, $p=0.706$).

## Discussion

The development of effective cerebrospinal fluid (CSF) shunts represents a landmark achievement in neurosurgery. However, this success has been tempered by a high incidence of serious complications. With relation to the cause of revisions, shunt malfunctions were more frequent (175 patients) than other complications (102 patients) in our series, comparable to rates reported in the literature[4,5]. The most frequent cause of shunt malfunction was obstruction, constituting 49 percent of all shunt malfunctions, 22.8 percent of all shunt procedures and 50.5 percent of all complications, as reported by many authors[4-14].

We determined on histopathologic examination of the obstructing material that the most commonly found tissues were glial, granulomatous and choroid plexus. Choroid plexus, fibrin, brain debris, blood clot and germs were found as obstructing material[8,14-16]. The tip of the ventricular catheter should be pointed away from the choroid plexus. Whether this is best accomplished by placement in the frontal horn remains controversial[11,17,18]. Saint-Rose[19] reported a slightly lower risk of proximal obstruction for ventricular catheter tips located in the occipital horn of the lateral ventricles than for those located frontally. We compared the burr hole locations in terms of the route of insertion, but the results did not have statistical significance, as Bierbrauer et al.[11] stated in a prospective study. The revision rate for VA shunts in large series varied between 46 and 78 percent[10,20,21] as compared to 17 and 58 percent for VP shunts[6,21,22]. A very high percentage of VP procedures (88%) compared to VA (7%) and CP (5%) procedures did not allow reliable comparative evaluation of different types of surgical procedures, and we found the incidence of revisions was slightly lower in VA shunts (46%) and CP shunts (47%) than in VP shunts (52%). The differences among them was not significant.

Mazza et al.[5] pointed out in his series of 165 children with nontumoral hydrocephalus that VA and VP shunts required 1.8 and 2.3 revisions per patient, respectively. In our study, we determined that there were 2.5, 2.2 and 0.7 revisions per patient in VA-, CP- and VP-shunted patients, respectively. It seems that VP shunts are associated with a lower rate of complications and revisions as compared to VA and CP shunts.

Griebel et al.[12] reported that host variables are one of the most elusive factors; neither the patient's age, sex nor the underlying condition appeared to influence the shunt complication rate or survival. Raimondi et al.[4] reported that both overall complication and infection rates were higher prior to three months of age. In our study, we found that age was a statistically significant factor in infection and SVS, but not in other types of complications. Steinbok[23] found an increased incidence of all complications in patients with spina bifida.

SVS is a well-known complication in the treatment of hydrocephalus by shunting. The symptoms may be due to "overdrainage" of CSF over either the short or generally long term, the effects of low pressure or intermittent shunt obstruction as a noncompliant ventricular system, and a growing brain that fills the intracranial space, leading to the development of increased intracranial pressure[24,25]. SVS is not seen in all patients who have anatomic slit ventricles, although the radiologic appearance of slit ventricles reaches high percentages[26-29], and up to 80 percent of shunted patients overall are at risk for the development of slit ventricles. Walker et al.[30] stated that only 11.5 percent of patients with slit ventricles on computed tomographic scan had been symptomatic and classified as having SVS, and 55 percent of those patients (6.5% of the total population) needed surgical intervention. In our study, seven patients required surgical treatment for SVS. All seven children with symptomatic SVS were greater than one year old ($x^2$=15.388, p=0.000). The initial treatment we use is upgrading of the shunt valve pressure (to high) in order to achieve a chronic increase in ventricular size and/or adding an antisiphon device at the same time. This therapy effectively reduced the negative intracranial pressures and treated all patients, as stated by many authors previously[30-34].

Griebel et al.[12] pointed out a marked difference between the complication rates of various surgeons in their series, testifying to the importance of this operative variable. He also demonstrated that the length of the surgical procedure did not have a statistically significant influence. We could not calculate the complication rates of different surgeons, because the revisions were performed by 32 different staff physicians or resident. Also, the duration of the surgical procedures was not noted on the charts; thus we were not able to conclude whether or not it influenced the results. We found 10 cases of abdominal pseudocyst, eight of which occurred in patients with multiple shunt revisions and previous shunt infections[35]. Symptoms generally consisted of focal abdominal fullness and discomfort as well as nausea and vomiting. Physical signs included generalized or focal abdominal tenderness, distension, decreased bowel sounds and a palpable mass. Pseudocysts were detected by abdominal ultrasound in all cases. In the absence of CSF infection, shunt removal and conversion of the shunt system to VA was the treatment of choice. Disconnection was found in 12 patients, five of which (60%) were due to normal growth. Disconnection was manifested by the appearance of a soft fluctuant mass along the shunt tract in most cases, as previously reported[16]. The reported incidence of subdural hematoma and hygroma varies between 4.5 and 21 percent[36-38]. We observed subdural collection in 19 cases.

Every structure that the shunt catheter bypasses can be penetrated or eroded. Perforations are uncommon complications, and most of the reports are case

studies[39-42]. The clinical manifestation of a hollow viscus perforation varies. We observed peritoneal irritation signs that prompted evaluation of the patient and surgical exploration, as stated by others[43,44]. However, in some cases, perforations occur without signs of peritoneal inflammation as stated by Rubin et al[44]. We noted one bladder and five bowel perforations in our study. The catheter tip was observed extending from the anus in two cases, both of whom died from intractable gram-negative infections. The risk factors determined in our study were comparable to those previously reported, such as a higher risk of complications in the youngest age group, in congenital hydrocephalus, after emergency operations and after operations performed in patients with an impaired level of consciousness. In this study, 277 shunted children (43%) experienced shunt complications, and in 39 of them the complication ended in death (14% of the patients with complications). In the VP-shunted patients, there were 33 deaths following shunt-related complications (21% of VP-shunted patients presenting with complications), while there were three deaths each in VA- and CP-shunted patients (27% of VA-shunted and 37% of CP-shunted patients presenting with complications). The absolute mortality for shunt-related complications in each group was 11 percent in VP, 13 percent in VA and 18 percent in CP-shunted patients. Of 39 shunt-related deaths, 27 were due to infection (not statistically significant). Keucher and Mealey[8] reported that 31 percent of surviving patients in their series still had their original VP shunt, compared to only two percent still having a virgin VA shunt. In our series, 48 percent of VP-shunted and 54 percent of VA-shunted patients still had their original shunts.

In conclusion, although the prognosis for hydrocephalic children has improved remarkably during the last 30 years, since the introduction of shunt surgery, it is still not possible to stop all the harmful complications. However, the treatment of hydrocephalus and its complications is a highly complex and difficult matter and needs close attention, knowledge and experience. We believe that complications can be avoided to a great extent in experienced hands.

## REFERENCES

1. Davidoff LM. Treatment of hydrocephalus. Historical review and description of a new method. Arch Surg 1929; 18: 1737-1762.
2. Scarff J. Treatment of hydrocephalus: a historical and critical review of methods and results. J Neurol Neurosurg Psychiatry 1963; 26: 1-26.
3. Erşahin Y, Mutluer S, Güzelbağ E. Cerebrospinal fluid shunt infections. J Neurosurg Sci 1994; 38: 161-165.
4. Raimondi AJ, Robinson, JS, Kuwamura K. Complications of ventriculoperitoneal shunting and critical comparison of the three-piece and one-piece systems. Child's Brain 1977; 3: 321-342.
5. Mazza C, Pasqualin A, Da Pian R. Results of treatment with ventriculoatrial and ventriculo-peritoneal shunt in infantile nontumoral hydrocephalus. Child's Brain 1980; 7: 1-14.
6. Ignelzi RJ, Kirsch WM. Follow-up analysis of ventriculoperitoneal and ventriculoatrial shunts for hydrocephalus. J Neurosurg 1975; 42: 679-682.

7. Illingworth RD, Logue V, Symon L, Uemura K. The ventriculocaval shunt in the treatment of adult hydrocephalus. Results and complications in 101 patients. J Neurosurg 1971; 35: 681-685.
8. Keucher TR, Mealey J. Long-term results after ventriculoatrial and ventriculoperitoneal shunting for infantile hydrocephalus. J Neurosurg 1979; 50: 179-186.
9. Little JR, Rhoton AL, Mellinger JF. Comparison of ventriculoperitoneal and ventriculoatrial shunts for hydrocephalus in children. Clin Proc 1972; 47: 396-401.
10. Overton MC, Snodgrass SR. Ventriculovenous shunts for infantile hydrocephalus. A review of five year experience with this method. J Neurosurg 1965; 23: 517-521.
11. Bierbrauer KS, Storrs BB, McLone DG, et al. A prospective, randomized study of shunt function and infections as a function of shunt placement. Pediatr Neurosurg 1990; 16: 287-291.
12. Griebel R, Khan M, Tan L. CSF shunt complications: an analysis of contributory factors. Childs Nerv Syst 1985; 1: 77-80.
13. Sainte-Rose C, Piatt JH, Renier D, et al. Mechanical complications in shunts. Pediatr Neurosurg 1991-92; 17: 2-9.
14. Sekhar LN, Moossy J, Guthkelch AN. Malfunctioning ventriculoperitoneal shunts. Clinical and pathological features. J Neurosurg 1982; 56: 411-416.
15. Collins P, Hockley AD, Woollam DH. Surface ultrastructure of tissue occluding ventricular catheters. J Neurosurg 1978; 48: 609-613.
16. Gower DJ, Lewis JC, Kelly DL Jr. Sterile shunt malfunction. A scanning electron microscopic perspective. J Neurosurg 1984; 61: 1079-1084.
17. Sainte-Rose C, Hooven MD, Hirsch JF. A new approach in the treatment of hydrocephalus. J Neurosurg 1987; 66: 213-226.
18. Albright AL, Haines SJ, Taylor FH. Function of parietal and frontal shunts in childhood hydrocephalus. J Neurosurg 1988; 69: 883-886.
19. Sainte-Rose C. Shunt obstruction: a preventable complication? Pediatr Neurosurg 1993; 19: 156-164.
20. Becker DP, Nulsen FE. Control of hydrocephalus by valve-regulated venous shunt. Avoidance of complications in prolonged shunt maintenance. J Neurosurg 1968; 28: 215-226.
21. Lajat Y, Lebatard-Sartre R, Guihard D, et al. Etude comperative des complications observe'es dans les derivations ventriculoatriales et ventriculoperitoneales. Neuro-Chirurgie 1975; 21: 147-161.
22. Robertson JS, Maraqa MI, Jennett B. Ventriculoperitoneal shunting for hydrocephalus. Br Med J 1973; 1: 289-292.
23. Steinbok P, Thompson GB. Complications of ventriculovascular shunts: computer analysis of etiological factors. Surg Neurol 1976; 5: 31-35.
24. Epstein FJ. "Slit ventricle syndrome": etiology and treatment. Pediatr Neurosci 1988; 14: 5-10.
25. Epstein FJ. Increased intracranial pressure in hydrocephalic children with functioning shunts: a complication of shunt dependency. In: Shapiro K, Marmarou A, Portnoy H (eds). Hydrocephalus. New York: Raven Press; 1985: 315-321.
26. Foltz EL, Blanks JP. Symptomatic low intracranial pressure in shunted hydrocephalus. J Neurosurg 1988; 68: 401-408.
27. Kiekens R, Mortier W, Pothmann R, et al. The slit-ventricle syndrome after shunting in hydrocephalic children. Neuropediatrics 1982; 13: 190-194.
28. Pudenz RH, Foltz EL. Hydrocephalus: overdrainage by ventricular shunts. A review and recommendations. Surg Neurol 1991; 35: 200-212.
29. Serlo W, Heikkinnen E, Saukkonen AL, von Wendt L. Classification and management of the slit ventricle syndrome. Child's Nerv Sys 1985; 1: 194-199.

30. Walker ML, Fried A, Petronio J. Diagnosis and treatment of the slit ventricle syndrome. Neurosurg Clin Am 1993; 4: 707-714.

31. Fox JL, Portnoy HD, Schulte RR. Cerebrospinal fluid shunts: an experimental evaluation of flow rates and pressure values in the anti-siphon valve. Surg Neurol 1973; 1: 299-302.

32. Gruber R. The Relationship of ventricular shunt cmoplications to the chronic overdrainage syndrome: a follow-up study. Z Kinderchir 1981; 34: 346-352.

33. Gruber R, Jenny P, Herzog B. Experiences with the anti-siphon device (ASD) in shunt therapy of pediatric hydrocephalus. J Neurosurg 1984; 61: 156-162.

34. Portnoy HD, Schulte RR, Fox JL. Antisiphon and reversible occlusion valves for shunting in hydrocephalus and preventing post-shunt subdural hematomas. J Neurosurg 1973; 38: 729-738.

35. Parry SW, Schumacher JF, Llewellyn RC. Abdominal pseudocysts and ascites formation after ventriculoperitoneal shunt procedures: report of four cases. J Neurosurg 1975; 43: 476-480.

36. Pudenz RH, Foltz EL. Hydrocephalus: overdrainage by ventricular shunts. A review and recommendations. Surg Neurol 1991; 35: 200-212.

37. Faulhauer K, Schimitz P. Overdrainage phenomena in shunt treated hydrocephalus. Acta Neurochir (Wien) 1978; 45: 89-101.

38. Samuelson S, Long DM, Chou SN. Subdural hematoma as a complication of shunting procedures for normal pressure hydrocephalus. J Neurosurg 1972; 37: 548-551.

39. Oi SZ, Shose Y, Asano N et al. Intragastric migration of a ventriculoperitoneal shunt catheter. Neurosurgery 1987; 21: 255-257.

40. Portnoy HD, Croissant PD. Two unusual complications of a ventriculoperitoneal shunt: case report. J Neurosurg 1973; 39: 775-776.

41. Sakoda TH, Maxwell JA, Bracket CE: Intestinal volvulus secondary to a ventriculoperitoneal shunt: case report. J Neurosurg 1971; 35: 95-96.

42. Whittle IR, Johnston IH. Extrusion of peritoneal catheter through neck incision: a rare complication of ventriculoperitoneal shunting. Aust NZ J Neurosurg 1983; 53: 177-178.

43. Schulhof LA, Worth RM, Kalsbeck JE. Bowel perforation due to peritoneal shunt. Surg Neurol 1975; 3: 265-269.

44. Rubin RC, Ghatak NR, Visudhipan P. Asymptomatic perforated viscus and gram-negative ventriculitis as a complication of valve-regulated ventriculoperitoneal shunts. J Neurosurg 1972; 37: 616-618.