Original papers

Child's Nervous System CNS

Child's Nerv Syst (1993) 9:253–255

Long-term results after ventriculoatrial shunting in children

O. Vernet, R. Campiche, N. de Tribolet

Department of Neurosurgery, University Hospital, CH-1011 Lausanne, Switzerland

Received: 29 December 1992

Abstract. A consecutive series of 120 patients with infantile hydrocephalus who were subjected to ventriculoatrial shunting was studied. The average length of follow-up was 11 years. Operative mortality was zero. Seven patients died during the follow-up period; in all cases but one of these the cause of death was not a consequence of a shunt-related procedure. The incidences of infection and slit ventricle syndrome were 4.2% and 1.8% respectively. Two hundred and fifty-three shunt revisions were performed, yielding a revision rate of 2.2 per patient. Of these 253 revisions 167 (66%) were elective lengthening of the atrial catheter. The number of reoperations for adjusting the length of the atrial catheter or for revision of the distal end of the shunting system is a major disadvantage of ventriculoatrial shunting which actually speaks in favor of ventriculoperitoneal shunting as the primary procedure for the treatment of pediatric hydrocephalus.

Key words: Hydrocephalus – Ventriculoatrial shunt – Shunt infection

Introduction

Since the introduction of the Spitz-Holter valve in 1952 [12], hydrocephalic children have been treated with numerous shunting procedures. The recognition of a wide range of sometimes serious complications has tempered early enthusiasm for ventriculoatrial shunts [2, 3, 6, 10, 11, 16, 17]. The high rate of complications encountered with ventriculoatrial shunts and the availability of silicone rubber tubing have made ventriculoperitoneal shunts increasingly popular over the last two decades [7, 9].

The aim of this study was to review a consecutive series of children subjected to ventriculoatrial shunting and followed up over a long period of time. The particularity of this series is its homogeneity including in regard to the type and location of the shunts, shunt hardware, and the surgical team.

Correspondence to: O. Vernet

Patients and methods

The clinical records of patients undergoing ventriculoatrial shunt-related procedures in the Department of Neurosurgery of the University Hospital of Lausanne in Switzerland during the years 1970 to 1991 were reviewed. One hundred and forty-three children with hydrocephalus were identified, some of whom had their initial shunt insertion as early as 1964. Twenty-three patients were dropped from the study because their initial shunting had been inserted at another institution or because they were followed up in other hospitals or countries.

With rare exceptions all shunt insertions, shunt revision, and shunt lengthenings were performed by the same neurosurgeon. All ventriculoatrial shunts used a proximal valve with a proximal Rickham reservoir, the ventricular catheter being inserted in the right frontal horn. Of the valves, 49% (59/120) were high-pressure Hakim valves, 48% (57/120) medium-pressure valves (Holter: 41, Hakim: 16), and 3% (4/120) low-pressure valves (Holter: 3, Hakim: 1).

All patients received perioperative antibiotics for initial shunt placements and revision, usually penicillin and in recent years a combination of amoxycillin + clavulanic acid (Augmentin) and choramphenicol (Chloromycetin) for 6 days.

The different etiologies of hydrocephalus in the 120 patients are listed in Table 1. The neoplasms included 4 cerebellar medulloblastomas, 4 cerebellar astrocytomas, 3 brain stem tumors, 1 craniopharyngioma, and 1 pineal germinoma. The group "other" includes 1 case of Crouzon's disease, 1 obstructive subarachnoid cyst, 1 complex malformation of the posterior fossa, 1 cyst of the III ventricle, and 1 case of posthemorrhagic hydrocephalus after rupture of an aneurysm.

The average age at initial shunt insertion varied according to etiology. Eighty-seven out of 120 patients (73%) had their initial shunt insertion during the 1st year of life (Table 2).

The follow-up period extended through December 1991. The average length of follow-up from the initial shunting was 11.4 years (range: 1–25 years). Only 4 patients (3%) had less than 2 years' follow-up (Table 3).

The patients were subjected to elective distal shunt lengthening as soon as the tip of the atrial catheter was above the T4-5 interspace.

Results

There was no operative mortality. Seven patients (5.8.%) died during the follow-up period. Of these seven patients four suffered from hydrocephalus of neoplastic origin

Table 1. Etiology of hydrocephalus in 120 patients

	n	(%)
Neonatal hemorrhage	27	(25)
Myelomeningocele	26	(22)
Idiopathic communicating hydrocephalus	16	(13)
Postinfectious hydrocephalus	13	(11)
Neoplasm	13	(11)
Aqueductal stenosis	10	(8)
Post-traumatic hydrocephalus	5	(4)
Congenital toxoplasmosis	3	(2)
Dandy-Walker syndrome	2	(2)
Other	5	(4)
Total	120	(100)

Table 2. Age at shunt insertion

Etiologic type of hydrocephalus	Mean (months)	Range
Neonatal hemorrhage	4.1	1 week to 14 months
Myelomeningocele	3.4	1 week to 5 years
Idiopathic communicating hydrocephalus	33.3	1 week to 14 years
Postinfectious hydrocephalus	18.5	2 months to 6 years
Neoplastic hydrocephalus	83.8	4 months to 13 years
Aqueductal stenosis	11.5	2 weeks to 6 years
Post-traumatic hydrocephalus	86.6	3 years to 12 years
Congenital toxoplasmosis	4.0	1 month to 8 months
Dandy-Walker syndrome	3.0	1 month to 5 months
Other	58.3	1 month to 12 years

Table 3. Length of follow-up (years)

Etiologic type of hydrocephalus	Mean	Range
Neonatal hemorrhage	9.4	1–19
Myelomeningocele	12.2	1–21
Communicating hydrocephalus	14.2	3–25
Postinfectious hydrocephalus	12.4	5–24
Neoplastic hydrocephalus	10.8	2–21
Aqueductal stenosis	10.7	3–19
Post-traumatic hydrocephalus	10.0	3–22
Congenital toxoplasmosis	17.3	9–22
Dandy-Walker syndrome	10.5	10–11
Other	12.5	7–18

Table 4. Indications for shunt revision

	n
Proximal obstruction	29
Proximal disconnection	6
Valve overdrainage	4
Valve underdrainage	2
Valve dysfunction	6
Elective distal lengthening	167
Distal obstruction	22
Distal disconnection	12
Shunt infection	4
Other	1
Total	253

Table 5. Surgical procedures performed during revisions

	n
Proximal revision	40
Valve change	24
Distal revision	36
Distal lengthening	158
Conversion to ventriculoperitoneal shunt	11
Shunt removal	2
Insertion of a new shunt	2
Total	273

and died because of progression of the tumor. They presented with a cerebellar medulloblastoma, a craniopharyngioma, a mesencephalic tumor, and a cerebellar astrocytoma invading the brain stem and the cervical medulla. They were followed-up for 6, 14, 2, and 3 years respectively. Two patients with lumbar meningomyelocele died after 1 year of follow-up, one after compartmentalized ventriculitis, the other following respiratory distress in tracheomalacia. The last patient died from terminal renal insufficiency following shunt glomerulonephritis after 12 years of follow-up.

Shunt revisions were performed in 253 instances, yielding an average revision rate of 2.2 revisions per patient (range: 0–11). Prophylactic lengthening of the atrial catheter alone averaged 1.4 per patient (range 0–5). The clinical indications for revisions and the operations performed are listed in Tables 4 and 5. The totals are not superimposable since some patients had a combination of different procedures during the same operation. Distal obstructions or disconnection and prophylactic distal lengthening represented 80% of the indications for shunt revision. In nine cases, inability to place the atrial catheter in the correct position necessitated conversion of the ventriculoatrial shunt to a ventriculoperitoneal shunt.

Infection of the shunt system was encountered in five patients during the entire study period, yielding an infection rate of 4.2% per patient. The operative infection rate was 1.8%. The average interval of time between the most recent shunt-related operation and the first clinical manifestation of infection was 4.6 months (range: 2–11 months). In two cases, treatment consisted in removal of the shunt hardware, transient external ventricular drainage with antibiotic therapy, and insertion of a new ventriculoatrial shunt once the cerebrospinal fluid was sterile. In one case the ventricular catheter was removed and the shunting system was not reinserted. In two cases antibiotic treatment alone was employed. The organisms responsible were *Staphylococcus epidermidis, Neisseria flavescens, Escherichia coli,* and a group C *Streptococcus.* One patient with clinical evidence of shunt infection had no growth on cultures.

Five patients (4.2%) were admitted to our department with recurrent clinical manifestations of slit ventricle syndrome, confirmed on CT scan. In one case the symptoms resolved spontaneously. In two cases, moderate relief of symptoms was obtained after change of the medium-pressure valves for high-pressure valves. In the two last

cases subtemporal craniectomy had to be performed, which was followed by slight improvement.

One case of subacute subdural hematoma was encountered during the whole study period. The hematoma was removed by burr holes and did not recur.

One patient who developed progressive visual loss was subjected to a sagittal craniectomy for secondary craniostenosis 3 years after the initial shunt insertion.

One patient presented with an isolated IV ventricle 4 years after initial shunt insertion, manifesting symptoms of intracranial hypertension. Shunting of the isolated IV ventricle was performed with a good clinical outcome.

Discussion

Despite the demonstrable effectiveness of ventriculoatrial shunts, it was soon learned that they carry numerous complications including death. The overall mortality of 5.8% in this study compares favorably with the incidence reported in a recent publication of 10.9% [5], or even more in older series [3, 7]. It is to be noted that, with the exception of one patient who developed lethal shunt glomerulonephritis, the causes of death in this study were not directly related to shunt procedures.

Infection is commonly thought to be the main complication of shunt procedures. In a recent chapter reviewing the subject, Klein [8] reported incidences of infections from 2%–5% in the most recent series to 29% in the older studies, infection rates being substantially similar for ventriculoatrial and ventriculoperitoneal shunts. The infection rate of 4.2% in our series can thus be considered as low. The fact that the overwhelming majority of these surgical procedures were performed by the same experienced neurosurgeon using a standardized procedure may account for this low incidence of infection. As a matter of fact, in analyzing 840 shunting procedures over 25 years, George et al. [4] found that the surgeon's experience was the largest single factor in the prevalence of infection. However, this statement was not confirmed by other authors who found no correlation of infection rate with the surgical team's composition or with operating time, type of procedure, or shunt equipment used [13–15].

Although it is difficult to draw any conclusion with only five cases of infection, it is nevertheless surprising that in this study *Staphylococcus epidermidis* was the responsible organism in only one case. It is well known in the literature that this organism is responsible for most shunt infections [5, 8]. In this study, two shunt infections were due to gram-negative organisms in children aged over 1 year; this is also atypical, since these organisms are usually responsible for shunt infection during the first 6 months of life [5,8].

Symptomatic slit ventricle syndrome was encountered in five patients in this series (4.2%), which is comparable with the incidence of 0.9% to 3.3% reported by Wisoff in a recent review of the subject [18]. Neither monitoring of the intracranial pressure nor a radionuclide shunt patency study were performed in these patients. However, all improved spontaneously or after change of the valve or bilateral subtemporal craniectomy.

The frequent use of high- and medium-pressure valves in this series probably explains the low incidence of overdrainage with subsequent postshunt pericerebral collections or craniostenoses [1, 5].

Despite the comparative overall low rate of complications in this series, the number of revisions per patient is elevated. Considering the fact that 66% of the revisions (167/253) were for elective lengthening of the atrial catheter, some patients having as many as five revisions for this reason, it seems advisable to prefer ventriculoperitoneal shunting as the primary procedure for the treatment of pediatric hydrocephalus.

References

1. Andersson H (1966) Craniosynostosis as a complication after operation for hydrocephalus. Acta Paediatr Scand 55:192–196
2. Fokes EC (1970) Occult infections of ventriculoatrial shunts. J Neurosurg 33:517–523
3. Forrest DM, Cooper DGW (1968) Complications of ventriculo-atrial shunts. A review of 455 cases. J Neurosurg 29:506–512
4. George R, Leibrock L, Epstein M (1979) Long-term analysis of cerebrospinal fluid shunt infections. A 25-year experience. J Neurosurg 51:804–811
5. Hirsch JF, Hoppe-Hirsch E (1988) Shunts and shunt problems in childhood. In: Symon L, Brihaye J, Cohadon F, Guidetti B, Loew F, Miller JD, Nornes H, Pastor E, Pertuiset B, Yasargil MG (eds) Advances and technical standards in neurosurgery, vol 16. Springer, Wien New York, pp 177–211
6. Huber ZA (1981) Complications of shunt operations performed in 206 children because of communicating hydrocephalus. Zentralbl Neurochir 42:165–170
7. Keucher TR, Mealey J (1979) Long-term results after ventriculoatrial and ventriculoperitoneal shunting for infantile hydrocephalus. J Neurosurg 50:179–186
8. Klein DM (1990) Shunt infections. In: Scott MR (ed) Hydrocephalus. (Concept in neurosurgery, vol 3) Williams & Wilkins, Baltimore Hong Kong London, pp 87–97
9. Little JR, Rhoton AL, Mellinger JF (1972) Comparison of ventriculoperitoneal and ventriculoatrial shunts for hydrocephalus in children. Mayo Clin Proc 47:396–401
10. Luthardt T (1970) Bacterial infections in ventriculo-auricular shunt systems. Dev Med Child Neurol Suppl 22:105–109
11. Nugent GR, Lucas R, Judy M, Bloor BM, Warden H (1966) Thromboembolic complications of ventriculo-atrial shunts. Angiocardiographic and pathologic correlations. J Neurosurg 24:34–42
12. Nulsen FE, Spitz EB (1952) Treatment of hydrocephalus by direct shunt from ventricle to jugular vein. Surg Forum 2: 399–403
13. Renier D, Lacombe J, Pierre-Kahn A, Sainte-Rose C, Hirsch JF (1984) Factors causing shunt infection. Computed analysis of 1174 operations. J Neurosurg 61:1072–1078
14. Shapiro S, Boaz J, Kleiman M, Kalsbeck J, Mealey J (1988) Origin of organisms infecting ventricular shunts. Neurosurgery 22:868–872
15. Shurtleff DB, Christie D, Foltz EL (1971) Ventriculoauriculostomy-associated infection. A 12-year study. J Neurosurg 35:686–694
16. Stauffer UG (1970) "Shunt nephritis": diffuse glomerulonephritis complicating ventriculo-atrial shunts. Dev Med Child Neurol Suppl 22:161–164
17. Steinbok P, Thompson GB (1976) Complications of ventriculovascular shunts: computer analysis of etiological factors. Surg Neurol 5:31–35
18. Wisoff JH, Epstein FJ (1990) Diagnosis and treatment of the slit ventricle syndrome. In: Scott MR (ed) Hydrocephalus. (Concept in neurosurgery, vol 3) Williams & Wilkins, Baltimore Hong Kong London, pp 79–85