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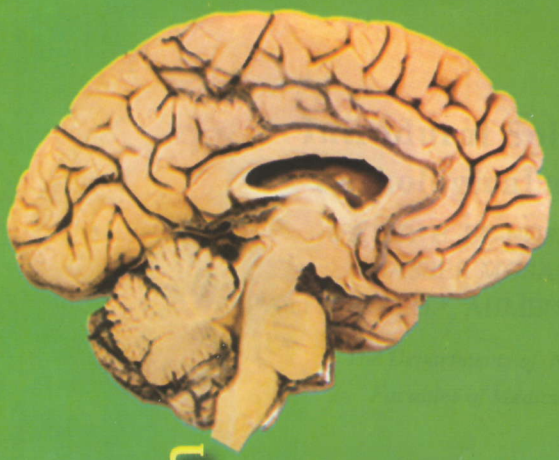

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Risk Factors for Revision of Ventriculoperitoneal Shunt in Pediatric Patients with Hydrocephalus

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Abstract

Objective: Repeated cerebrospinal fluid (CSF) shunt failures in pediatric patients who have undergone neurosurgical procedures are common. These devices are usually required for the duration of the patient's life and in most cases there is more than one episode of shunt failure. To date, the risk factors for repeated failure have not been established. This study conducted a prospective observational study to identify risk factors predisposing to repeated CSF shunt malfunction and to determine whether subsequent shunt failures are related to patient characteristics, and /or surgical details.

Patients and methods: There were 525 shunt failures in 300 patients with hydrocephalus requiring CSF diversionary procedures were included in a prospective observational study during 7 years in two neurosurgical centers. Patient characteristics were defined as age, gender, weight, head circumference, cause of hydrocephalus; and the shape of ventricular systems. Surgical details and procedures were studied to define any relation to the incidence of shunt failure.

Results: The patient's age at the time of initial shunt placement is important predictors of repeated shunt failures. There were significant association between the cause of hydrocephalus, and the shape of ventricular systems; and shunt failure. Some surgical details and procedures were associated with an increased risk of failure included whether the procedure was performed on an emergency or nonemergency basis, use of antibiotics, manipulation of the shunt hardware; and the duration of surgical procedure.

Conclusion: The patient's age at the time of initial shunt placement as well as the cause of hydrocephalus and the shape of ventricular systems are important predictors of shunt failures. Some surgical procedures were associated with an increased risk of shunt-related failure. Prevention and early identification and management of CSF shunt failures remain the main possibilities to assure the quality of the patient's long term outcome.

Key Words: hydrocephalus - risk factors - cerebrospinal fluid shunt failure - revision of ventriculoperitoneal

Introduction

The majority of children with hydrocephalus are treated with CSF shunt insertion. Cerebrospinal fluid (CSF) shunt failures in pediatric patients are common, causing morbidity and occasionally mortality observed in the patients with CSF shunt. Ventriculoperitoneal shunts are associated with several complications as shown in table [1]. Following initial shunt insertion, the failure rate by 1 year postimplantation is 25 to 40% [11] and a 2-year failure rate of greater than 40% [1]. The 10-year actuarial survival of a first CSF shunt is reported to be 30 to 37% [17, 23]. These devices are usually required for the duration of the patient's life and in most cases there is more than one episode of shunt failure. Analysis of preoperative, intraoperative, and early postoperative risk factors for CSF shunt failures are important to identifying potentially modifiable perioperative practices. To date, the risk factors for repeated failure have not been established; various risk factors for CSF shunt failure

have been indicated in the literatures and modified in our study. Table [2] With these assumptions, the agreement of Drake's suggestion that shunt failure rates of about or little less than 5% per year and infection rates of less than 1% per year should be considered the reasonable goals for the next decade in this new millennium [10].

Patients and methods

From February 1995 to January 2002, prospective observational studies of CSF shunt revisions were conducted to evaluate the risk factors predisposing to shunt failure, at Benha University Hospital, Egypt; and King Fahd Hospital, Al-Madinah, Saudi Arabia. Patients were considered eligible for this study if they were undergone revision of CSF shunt at our departments through a ventriculoperitoneal type. Patients who have undergone a CSF shunt procedure outside our departments were excluded. Patients with hydrocephalus were grouped into categories based on cause: aqueductal Stenosis, interventricular hemorrhage (IVH), postmeningitic, myelominingocele, post-traumatic, and other table [3]. Risk factors included those related to the patient's characteristics, intraoperative details, and postoperative variables were obtained from the prospective medical records and anesthetic sheet. Table [4] All patients underwent follow up in outpatients clinic at variable period of time and at least one year postoperatively, the majority of CSF shunt failures are diagnosed at this time. The outcome of shunt failure was based on the patient's clinical features, as well as laboratory diagnostic tests, radiological findings, and intra-operative findings. The outcome was categorized as shown in table [5]. For each patient repeated shunt failure were identified and the risk factors determined. Each shunt failure was indexed as a failure level (that is, 1, 2, and 3)

Table (1) Manifestations of SCF shunt failure

1) Mechanical malfunction (about 50% of cases)

* Obstruction of →
  - Ventricular end
  - Valve
  - Distal end
* Disconnection of the tube →
  - Proximal to valve
  - Distal to valve

2) Infection (about 5-18% of cases)

3) CSF overdrainage

* Acute →
  - Epidural hematoma
  - Subdural hematoma
* Chronic →
  - Subdural hematoma
  - Subdural hygroma

4) Post-shunt craniosynostosis

5) Pneumocephalus

6) Epilepsy

7) Isolated ventricle

8) Complications unique to peritoneal shunt

* Inguinal hernia and /or hydrocele
* Pseudocyst
* Peritonitis
* Ascitis
* Visceral perforation
* Migration or extrusion

Table (2) Risk factors related to shunt failure

1) ***Preoperative variables***
   * Patients characters
     - age
     - sex (M/F)
     - weight (kg)
     - head circumference (HC)
     - general condition
   * Cause of hydrocephalus
     - IV hemorrhage
     - myelominingocele
     - aqueduct Stenosis
     - tumors
     - meningitis
     - trauma
     - others
   * Ventricular system
     - congenital anomalies
     - loculated ventricles
   * Type of operation
     - emergency
     - elective
2) ***Intraoperative variables***
   * Prophylactic antibiotics
   * Operative time (minute)
   * Time of opening shunt system
     - Immediately pre-insertion
     - With other surgical instruments
   * handling of shunt system
     - One person
     - More than one person
   * Abdominal incision
     - Midline
     - Paramedian
   * Skull burr hole
     - Occipital
     - Others
3) ***Postoperative variables***
   * CSF leak from wounds
   * Premature stitches removal
   * post-operative hospital stays

Table (3) Preoperative variables related to shunt failure

Characters	1st failure 140 patients	2nd failure 95 patients	3rd failure 65 patients
Clinical characters			
Age / month (mean)	3-60 (40)	2-45 (21)	0-12 (4)
Sex (% male)	52	49	56
Weight /kg (mean)	5-40(25)	3.5-35(18)	0.9-20(12)
Head circumference (cm)	35-53(43)	37-55(46)	36-60(51)
Cause of hydrocephalus			
aqueduct stenosis	40(28.5%)	20(21%)	12(18.5%)
myelominingocele	45(32%)	40(42%)	32(49%)
IV hematoma	15(10.5%)	17(18%)	13(20%)
Meningitis	24(17%)	9(9%)	5(7.5%)
Trauma	9(6.5%)	5(5%)	3(4.5%)
Others	7(5%)	4(4%)	--

according to whether it was the first, second, or third episode of failure.

Results

Total 300 patients underwent 525 shunt revisions due to failure of their shunt system formed the basis of our analysis. Complete follow up data were obtained for all patients. The pre-operative variables related to shunt failure are mentioned at table [2]. The most common patient's characteristics factors related to shunt failure were the age followed by weight and head circumference of the patients. The incidence of the most common causes of hydrocephalus related to 2nd shunt failure were myelominingocele (42%), aqueduct Stenosis (21%), interventricular hematoma (18%), and post-meningitic (9%) table [3]. The surgical and post-operative variables related to shunt failure are mentioned at table [4]. With respect to the surgical procedure 20 to 40% of the cases were treated on an emergency basis. Prophylactic antibiotics drugs were used in about 85% of cases. The median duration of procedures was 60 minutes. The occipital burr hole was common site for the insertion of ventricular catheter. The proportion of failure in cases at which we used a midline abdominal incision and an occipital burr hole were slightly less than those in which a paramedian and lateral burr hole used. There were two post-operative very important variables related to the shunt failure, first one was CSF leak from the wound and the second was the time of hospital stay which had strong relation to shunt failure. The post-operative demonstrated causes related to shunt failure in the first time were as the following order, obstruction occurred in 65%, infection in 20%, overdrainage in 8% As the number of shunt failure increased, the proportion of cases in which obstruction occurred increased, and those of infection and overdrainage decreased table [5].

Table (4) Surgical and post-surgical characters

Variables	1st failure 140 patients	2nd failure 95 patients	3rd failure 65 patients
Surgical			
Type of operation			
Emergency	28 (**20%**)	26 (**25%**)	26 (**40%**)
Prophylactic antibiotics	112 (**80%**)	80 (**85%**)	58 (**90%**)
Operative time by minute (mean)	15-120 (77)	30-180 (123)	35-180 (130)
Time of opening shunt package			
Pre-insertion	120 (**85%**)	70 (**73%**)	50 (**77%**)
With surgical inst	20 (**15%**)	25 (**27%**)	15 (**23%**)
Handling of the shunt system			
> one person	85 (**60%**)	40 (**42%**)	22 (**34%**)
Abdominal incision			
midline	100 (**71%**)	60 (**63%**)	30 (**46%**)
Burr hole			
occipital	112 (**80%**)	65 (**68%**)	35 (**54%**)
post-operative			
CSF leak	20 (**15%**)	28 (**30%**)	32 (**49%**)
Hospital stay >3 days	95 (**68%**)	82 (**86%**)	60 (**92%**)

Table (5) Causes of shunt failure

Cause of failure	1st failure 140 patients	2nd failure 95 patients	3rd failure 65 patients
Obstruction	91 (**65%**)	70 (**74%**)	52 (**80%**)
Infection	28 (**20%**)	15 (**16%**)	7 (**12%**)
Over drainage	11 (**8%**)	6 (**6%**)	2 (**4%**)
Ventricular system anomalies	8 (**6%**)	4 (**4%**)	2 (**3%**)
others	2 (**2.8%**)	-------	2 (**1.3%**)

Discussion

All neurosurgeons struggle with CSF shunt failure, and most have had professional experiences that lead them to suspect that particular subgroups of patients, types of shunt equipment, or surgical techniques may be the culprits. Identification of risk factors, however, has been difficult because of the requirement of a large population of patients, who are required to undergo follow-up review for a considerable length of time. In this study we attempted to identify perioperative risk factors for CSF shunt failure by using careful prospective observation of shunt operation in children. In a number

of previous studies the authors have evaluated risk factors contributing to shunt malfunction. These studies have essentially been descriptive or observational in nature, and interventional studies have been rare. There are many literatures on CSF diversionary procedures in children [2,3,4,5,9,16,21,22,24]. Reference to multiple shunt failures, particularly in relation to patient characteristics, has rarely been made. The role of age at the time of first shunt insertion has been evaluated previously in several observational studies [4, 7, 9, 15, 16, 18, 19]. In a retrospective study of 170 hydrocephalic patients with myelominingocele, no statistically significant difference in risk of failure was demonstrated in those patients undergoing a first placement procedure at less than and greater than one week of age [4]. In our study the results indicate that age at the time of first shunt insertion proved to be an important contributor not only to the first failure but also to the subsequent failure levels. Prematurity at first shunt insertion would presidispose to subsequent shunt revisions is again a fascinating finding, which may lend further support that some fundamental tissue reaction occurs in response to shunt insertion, and factors such as a poorly developed immune system, generally poorer skin condition, and high skin bacterial density may be attributable factors for this increased risk [14]. Because of the substantially higher infection risk, alternative to shunt insertion should be seriously studied for this age group [6,20]. Weight and head circumference (HC) are clearly age-related factors in this patient population. It has been reported that, patients who weighted less than 3000 gm had no statistically significant difference in the rate of infection, and there was a barely significant worse overall shunt survival rate among patients weighting less than 3000 gm [16]. In 67 patients with neural tube defects, who underwent a total of 122 shunt procedures, HC at the time of shunt insertion did not correlate with shunt survival [15]. Our study indicate that age of the patient was a better indication of patient maturity, because age was so highly correlated with weight and HC, and particularly HC may be influenced by the extent of hydrocephalus. Much controversy surrounds the effect of cause of hydrocephalus on multiple shunt failures. In a number of studies the authors have addressed this issue, [5,7,9,12,13,16,18,19,24]. although its role in repeated failures has not been evaluated. Three reports have suggested that interventricular hemorrhage (IVH), [7]. tumor [24] and neural tube defects [16]. appeared as significant contributors to shunt failure, where as in three others - aqueduct stenosis, postmeningitic, and post-traumatic - causation did not appear to play a role [12,18,19]. In reports in which only initial insertions were evaluated, IVH appeared as a causative factor [9,13]. Our findings revealed that IVH, postmeningitic, and tumor were a little significant causative factors in shunt failure. In our study the presence of postoperative CSF leak was the strong risk factor for shunt failure, all the patients who suffered from CSF leak were underwent revision of their shunt, it represented about 49% as the causative factors in 3rd shunt failure table [4]. Abhaya [1] described the CSF leak as the strongest risk factor for shunt infection. Welch [25] reported CSF leak as the causative factor in 15% of shunt infection and Davis [8] described accumulation of CSF at the operative site as a potential risk factor. In most cases CSF accumulation indicate an underlying shunt infection, it may also act as a conduit for contamination of the underlying shunt system by external skin organisms, or it may act as a marker for poor wound healing, reflecting an increase risk for infection and failure of the shunt system. To avoid this complication meticulous opening of the dura, choice the site of insertion of the ventricular catheter and also the proper wound closure are highly important surgical procedures.

Conclusion

In conclusion, many risk factors had been identified for the development of CSF shunt

failure. Age at first shunt insertion and associated congenital anomalies are most important patient-related predictors of repeated shunt failures. Prematurity at first shunt insertion would predispose to subsequent shunt revisions. Great care should be taken intraoperatively to avoid a postoperative CSF leak. Surgeon and attendant personnel should minimize manual contact with the shunt system and consider the use of double gloves. Preoperative antibiotics and reduction of the hospital stay time should be considered.

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