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Shunt Infection in Adults: A Retrospective Study of 1324 Cases

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Abstract

Background: Shunt infection (SI) is a serious major complication in the management of hydrocephalus after cerebral fluid shunts. Here we study retrospectively hydrocephalus shunting to evaluate the incidence of SI, including the risk factors and types of infection.

Meterial and Methods: 1556 patients (age≥18years) who had undergone shunt surgery from January 2013 to December 2019 at our center were included(6-78 months follow-up period). 1324 cases of them were confirmed as effective cases. Infection rate and risk factors were investigated.

Results: We found 79 (6.0%) cases (58 men and 21 women) with SI, of which 72 were ventriculo-peritoneal (VP) shunt and 7 were lumbo-peritoneal (LP) shunt. Risk factors include male gender ($p=0.04$), patients with a history of intracranial infection ($p<0.001$) and patients suffered an infection when shunt surgery performed ($p=0.008$). Surgery type ($p=0.80$), Glasgow Coma Score (GCS) before shunt procedure ($p=0.57$) and history of hypertension ($p=0.16$), diabetes ($p=0.44$) or cerebral infarction ($p=0.29$) were not risk factors of SI. Brain or spine surgery performed within 2 years prior to shunt procedure increased rate of SI ($p=0.015$, SI rate: 7.4%), but not when performed after shunt procedure ($p=0.42$). Idiopathic hydrocephalus and hydrocephalus caused by trauma, hemorrhage, tumor and other factors showed no significant correlation with SI. Of all SI, 48 (60.8%) and 62 (78.5%) cases were present within 1 and 2 months after shunt surgery, respectively. Only 2.5% (2/79) of SI were found after 1 year since shunt placement. Pathogens were found in 46 cases, and Gram positive cocci were accounted for 50.0% (23/46).

Conclusions: Our study suggests that male, history of intracranial infection, patients' infection status when shunt surgery performed and history of brain or spine surgery performed within 2 years are risk factors of SI. Infections are more likely to present within the first 2 months after shunt placement, only 2.5% shunt infections were found after more than 1 year form shunt operation.

Introduction

Shunting is a common treatment procedure for hydrocephalus. Despite advances in shunt technology and surgical technique, shunt infection (SI) remains a serious complication with high morbidity. The incidence of SI ranges from 1.5–39%, with an average of 10% (7, 12, 13). Studies on SI concern mainly the pediatric population (4, 5). Although some studies in recent years describe shunt complications in adults (3, 10), only limited data focused on SI are available (1, 2, 16).

Meterial And Methods

In this retrospective study, a total of 1556 adult patients (age ≥ 18years), who underwent a shunt surgery in the Department of Neurosurgery at the Second Affiliated Hospital of Zhejiang University, School of Medicine between January, 2013 and December, 2018, were initially screened. 102 cases were excluded as not meet the condition (shunt surgery not for hydrocephalus, a shunt surgery performed before in other hospital or a second surgery for shunt device repair or replacement) or obvious confounding factors (e.g. severe head injury or intracranial hemorrhage, death which is not clear whether it is related to shunt surgery, infections after other surgery with is performed after the shunt surgery and so on), and 130 cases were excluded for lost to follow up. A follow-up study of the remining 1324 cases was conducted (6–78 months, average: 13.7 months), including 33 cases of death in 6 months after surgery and the follow-up was terminated (Fig. 1). During follow-up period, a thorough symptom inquiry followed by physical examination and laboratory tests were performed. SI was defined by either microbiological findings of presence of bacteria in a culture or Gram stain of cerebrospinal fluid (CSF), wound swab, and/or pseudocyst fluid or shunt erosion (visible hardware) or abdominal pseudocyst (even without positive culture) (13). We also included patients with apparent peritonitis and/or meningitis and obvious high white blood cell count (> 50/uL) and neutrophils proportion, decreased sugar level and increased protein level in CSF. All 1324 cases were categorized by gender, age, surgery type, Glasgow Coma Scale (GCS) score before shunting, underlying cause of hydrocephalus, and types and pathogens of SI, and SI rate was analyzed in each subgroup.

Results

A total of 79 (6.0%) SI cases were found among 1324 patients who underwent shunt surgery for hydrocephalus. 58 SI cases were male patients (n = 821, average age: 56.2 ± 15.2 years, SI rate: 7.1%), of which 53 were ventriculo-peritoneal (VP) shunt (n = 748, SI rate: 7.1%) and 5 were lumbo-peritoneal (LP) shunt (n = 73, SI rate 6.8%), 21 SI cases were female patients (n = 503, average age: 57.1 ± 13.9 years, SI rate 4.2%), of which 19 underwent VP shunt (n = 447, SI rate 4.3%), and 2 underwent LP shunt (n = 56, SI rate: 3.6%). There was significant difference between male and female (p = 0.04),there was no significant difference between LP and VP (P = 0.80)No significant difference was found in male vs female SI in VP shunt subgroup (p = 0.06) or in LP shunt subgroup (p = 0.44). Patient demographic in summarized in Table 1.

We then evaluated SI rate based on pre-shunting GCS score: patients with GCS score between 3 to 8 had a SI rate of 5.4% (16/294), patients with GCS score between 9 to 12 had a SI rate of 7.6% (17/224), and patients with GCS score between 13 to 15 had a SI rate of 5.7% (46/806) (Table 2). Group B seems have a higher SI rate than group A (p = 0.35) and group C (p = 0.33), but there are no significant different between each group. When comparison among the three groups, there is no significant difference (p = 0.57).

We then evaluated SI rate based on etiologies of hydrocephalus (Table 3). SI rate is 6.7% (33/496) in posttraumatic hydrocephalus, 5.5% (10/181) in hydrocephalus after spontaneous subarachnoid hemorrhage (SAH), 7.1% (11/155) in hydrocephalus after intracranial hemorrhage, 6.8% (11/161) in tumor-associated hydrocephalus, 4.0% (10/252) in idiopathic hydrocephalus, and 5.1% (4/79) in others. There are no significant different between each group.

We then inspected SI rate under different infection status when shunt surgery was performed. SI rate was 4.8% (46/954) in patients without any sign of infection when shunt procedure was performed, and 8.9% (33/370) in patients with an infection when shunt procedure was performed, which show a significantly high SI rate ($p = 0.008$). In cases with infections of multiple systems, SI rate increased to 25.0% (8/32). There were 54 patients with a history of intracranial infection, 10 of them had SI, the infection rate was 18.5%, while the infection rate of patients without a history of intracranial infection was 5.4% (69/1270). There was significant difference between the two groups ($p < 0.001$)

Medical history of hypertension ($p = 0.16$, SI rate 4.6% (21/453)), diabetes ($p = 0.44$, SI rate 4.4% (6/136)) and cerebral infarction ($p = 0.29$, SI rate 9.4% (15/194)) did not show a significant contribution to SI rate. Patients with and without a history of craniotomy or spine surgery within two years before shunt had a SI rate of 7.4% (58/789) and 3.9% (21/535), respectively ($p = 0.015$) (Table 4). Craniotomy or spine surgery performed meanwhile or after shunt surgery (SI rate: 7.5% (15/201)) did not have a significant impact on SI rate ($p = 0.42$).

Finally, 79 cases of shunt infection were further analyzed. 48 (60.8%) SI cases were present within 1 month after shunt surgery, 62 (78.5%) within 2 months, 70 (88.6%) cases within 6 months,77 (97.5%)cases within 1 year. Only 2 SI cases were diagnosed more than 1 year after shunt surgery. In 38 cases shunt devices were extubated, 2 cases were adjusted, 28 cases were treated conservatively, 11 cases were debridement; 61 cases were cured and 18 cases were deteriorated after treatment.

Pathogens were found in 46 cases. Gram positive cocci accounted for 50.0% (23/46) of cases, in which 12 (52.1%) cases were Staphylococcus epidermidis and 7 (30.4%) cases were Staphylococcus aureus. After treatment, 78.3% (18/23) of the patients got better and 21.7% (5/23) got worse. Epidermidis gram negative bacillus accounted for 45.7% (21/46) of cases, in which 5 (23.8%) cases were Acinetobacter baumannii, 5 (23.8%) cases were Klebsiella pneumonia, and 4 (19.0%) cases were Pseudomanas aeruqinosa. Bacillus Cereus ($n = 1$) and Cryptococcus ($n = 1$) were also found in SI. After treatment, 47.6% (10/21) of the patients got better and 52.4% (11/21) got worse.

Discussions

Shunt is the most common treatment for hydrocephalus, and infection is a very common complication following shunt surgery. Most studies on SI focus on pediatric population. Currently there is only a few studies focusing on SI in adults, and the study samples are limited. Adult hydrocephalus and children hydrocephalus have distinct characteristics. In this study we present one of the largest retrospective investigation on SI specifically in adults.

Both VP shunt and LP shunt are routine surgical options at our center. VP shunt is the most common care for hydrocephalus, LP shunt is another effective shunting procedure in communicating hydrocephalus. There is no consensus on which shunt surgery has lower SI rate, and whether LP shunt can be an alternative to VP shunt remains controversial (6, 15). Our data suggests no significant difference between VP shunt and LP shunt in terms of SI rate.

Hydrocephalus etiology is another factor. We divided these cases into 6 different groups: posttraumatic hydrocephalus, hydrocephalus after spontaneous SAH, hydrocephalus after intracranial hemorrhage (excluding spontaneous SAH), tumor-associated hydrocephalus, idiopathic hydrocephalus, and others. The SI rate for idiopathic hydrocephalus (4.0%,10/252) seems lower than other groups (6.4%,69/1072), but this didn't show a statistic difference ($p = 0.16$).

Surgical history of craniotomy or spine surgery is associated with higher rate of SI. 73.4% (58/79) of these SI cases have recent history of craniotomy or spine surgery (less than 2 years). We speculate that this is related to increased levels of protein, blood cells and debris in CSF which makes the CSF suitable for bacteria living. In the meanwhile, we found the craniotomy or spinal surgery underwent more than 2 years ago don't contribute to a higher risk of SI. Patients who had an craniotomy or spinal surgery performed within two years before shunt, suggest a SI rate of 7.4% (58/789), and this rate is 3.9% (21/535) in rest cases. These two groups show a significant difference ($p = 0.015$). But these operations performed meanwhile and after shunt surgery didn't contribute to SI ($p = 0.42$).

The infection status when shunt surgery is performed is a significant factor of SI rate. In patients with infection of pulmonary, and/or other systems, the SI rate is much higher than patients without infection when shunt surgery is performed. We observe these data and found the SI rate is 4.8% (46/954) in patients without infection when shunt were performed, and 8.9% (33/370) in patients with an infection in their lung or/and other organs. In cases which have infection in two or more system, the SI rate comes to 25%.

Infection is a very common complication following shunt surgery for hydrocephalus. Our study shows most cases of shunt infections are present within 2 months (up to 78.5%) of the shunt surgery, by 1 year 97.5% of shunt infection became clinical manifested. This situation is similar to other reports by different authors. Atiqur Rehman reported 10 cases of SI in 111 VP shunt, and in 70% of the cases clinical symptoms appeared in 2 months post-operation (11). Florian and Fried aim that infections symptomatic rapidly after shunt insertion, 70% of them being diagnosed within the first month (8). We suggest make a more closely follow up in the first 2 months after the shunt operation as an early stage, the infection cases at this stage are usually surgeryl-related, common symptoms include fever, headache, and obstruction, and shunt device removal and antibiotics are often necessary.

There is no persuasive guide to tell us the time point and whether or not to remove the shunt device when the infection is present (14). In our study, 76.3% (29/38) has a good outcome after totally removing catheters, and 78.0% (32/41) has a good outcome of the cases not completely removed shunt devices. However, it was not a random arrangement to remove the shunt device during the treatment of SI cases, often the shunt devices have to be removed when other treatments were not effective. In our study the shunt devices removal rate in these SI cases is as high as 48.1% (38/79).

Gram positive cocci accounted for 50.0% (23/46) of all SI cases in our study, in which 95.7% (22/23) is staphylococcus. These bacteria are parasitic on the skin, which is very easy to be brought into the CSF or adhesive in the shunt device. Based on our experience (9) gram positive cocci have a relatively high morbidity of infection, we usually started out with vancomycin (1.0g twice a day), or linezolid (0.6g twice a day) once SI was diagnosed. This study suggest that shunting infection caused by gram-positive cocci had a good prognosis (cure rate 78.3%), and the cure rate of gram-negative bacilli was only 47.6%. The use of vancomycin may be helpful in the control of gram-positive cocci infection. Compare with our previous data (9), this study shows the proportion of gram-negative bacilli related SI is also high. Further investigation found that 71.4% (15/21) of these cases had lung infection history, whereas only 34.8% (8/23) in gram-positive cocci induced SI cases, and 41.8% (33/79) in all SI cases, but this analysis didn't show statistical difference. Gram-negative bacilli are mostly conditional pathogenic bacteria, and history of lung infection may contribute to this finding. Because the basic situation of such patients is often poor, this may lead to poor prognosis with a lower cure rate.

Conclusion

Our study suggests that male, history of intracranial infection, patients' infection status when shunt surgery performed and history of brain or spine surgery performed within 2 years are risk factors of SI. Infections are more likely to present within the first 2 months after shunt placement, only 2.5% (2/79) shunt infections were found after 1 year form shunt operation.

Declarations

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Conflict of interests: The authors have no conflict of interests to declare.

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Authors' contributions: This work was designed by Bing Qin and Lin Wang, case material were collected by Chenghan Wu, this article was written by Bing Qin, Liansheng Gao and Chun Wang participated in discussion development. Lin Wang reviewed the article, and provided expert guidance. All authors read and approved the final manuscript.

Ethics approval: This study was approved by the clinical ethics committee of the Second Affiliated Hospital of Zhejiang University School of Medicine.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

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Tables

Table 1. Shunt infection in different shunt type and gender

Shunt type	Male	Female	Total
VP	748(53)	447(19)	1195(72)
LP	73(5)	56(2)	129(7)
VA	1(0)	0	1(0)
total	822(58)	503(21)	1324(79)

VP, ventriculo-peritoneal; LP, lumbo-peritoneal; VA, ventriculo-atrial.

The number of shunt infection cases are in parentheses.

Table 2. Ddifferent GCS score group and shunt infections

GCS score	Total cases	Shunt infection	Infection rate
3~8(group A)	294	16	5.40%
9~12(group B)	224	17	7.60%
13~15(group C)	806	46	5.70%
Total	1324	79	5.80%

GCS, Glasgow Coma Scale.

Table 3. Shunt infection and operation history in different etiology group

Etiologies	Total cases	Shunt infection	Operation within 2 years
Posttrumatic	496	33	397
SAH	181	10	159
Other hemorrhage	155	11	122
Tumor	161	11	83
Idiopathic	252	10	9
Others	79	4	19
Total	1324	79	789

SAH, subarachnoid hemorrhage.

Table 4. Shunt infection and operation history

Operation	Total cases	Shunt infection
Within 2 years	789	58
More than 2 years	35	0
No	500	21
Total	1324	79

Figures

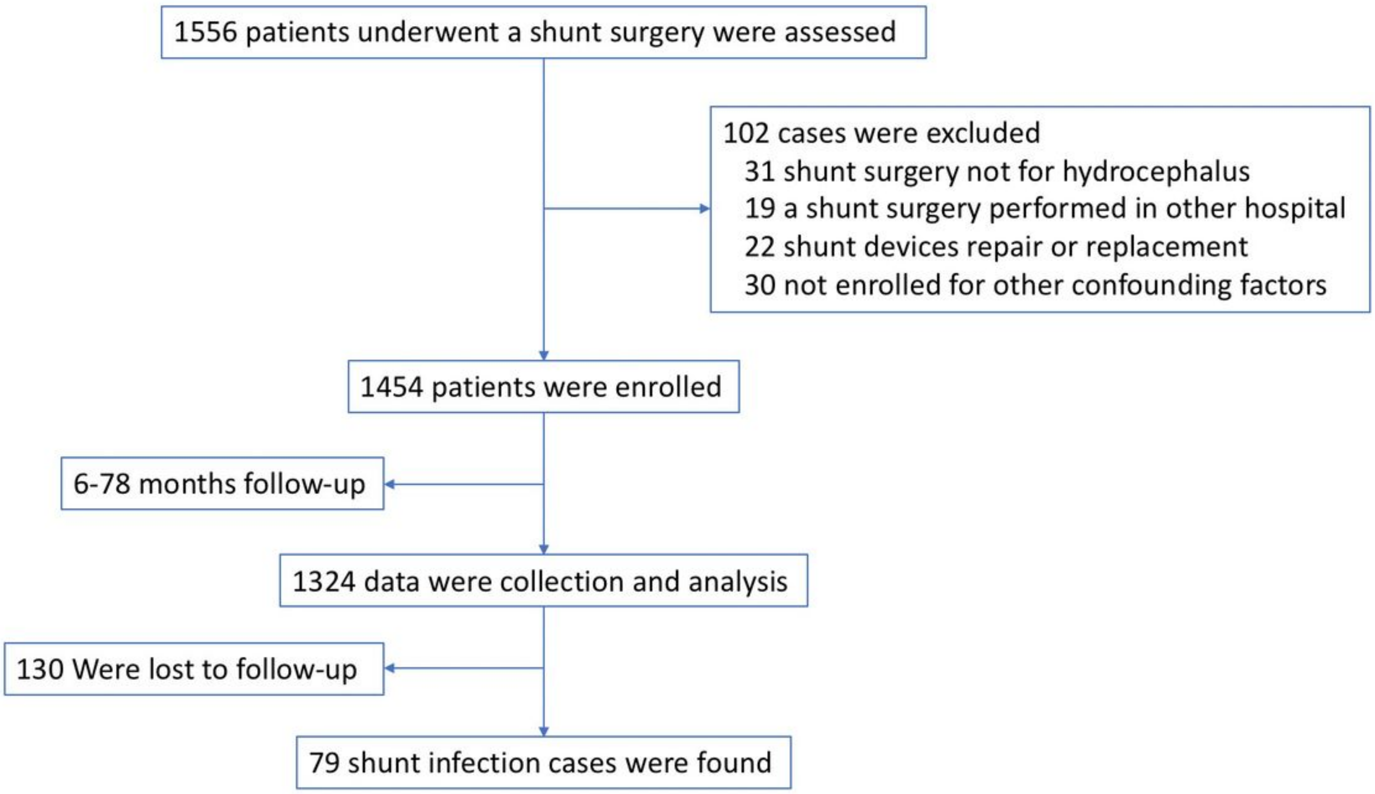

Figure 1

Screening and follow-up.