Risk factors associated with slit ventricle syndrome after ventriculoperitoneal shunt surgery

Joseph Hwang, MD, Jae Meen Lee, MD

Department of Neurosurgery, Pusan National University Hospital, Busan, Korea

Objective: Slit ventricle syndrome (SVS) is defined as a slit-like appearance of the lateral ventricles with associated symptoms such as headache, vomiting, or drowsiness. The study investigated the risk factors associated with the incidence of SVS following ventriculoperitoneal shunt surgery.

Methods: We retrospectively reviewed the medical records of patients who underwent ventriculoperitoneal shunt surgery from January 2011 to 2019 at a single institution. SVS was diagnosed by a slit-like appearance of the lateral ventricles and a low Evan's ratio (<0.25) on follow-up radiologic images.

Results: SVS was diagnosed in 53 (18.2%) of 292 patients who underwent ventriculoperitoneal shunt surgery. The mean age of patients with SVS (48.3 years; range, 4–85 years) was significantly lower than the mean age of those without SVS (58.4 years; range, 0.5–85 years) (p=0.024). Male patients showed a slightly higher incidence of SVS, but the result was not statistically significant. Patients who had hydrocephalus with vascular causes (e.g., subarachnoid hemorrhage and intracranial hematoma) showed a significantly lower incidence of SVS than those with non-vascular causes (p=0.002).

Conclusion: The incidence of SVS was higher in younger patients and in those with a non-vascular cause of hydrocephalus.

KEY WORDS: Hydrocephalus, Ventriculoperitoneal shunt, Slit ventricle syndrome, Incidence, Risk factors

INTRODUCTION

Hydrocephalus can be induced by many different factors, such as spontaneous intracranial hemorrhage, traumatic brain injury, and normal-pressure hydrocephalus (NPH). Ventriculoperitoneal shunt (VPS) implantation is one of the most effective treatments for hydrocephalus. However, complications such as infection and valve obstruction can occur postoperatively. The complication rates remain relatively high. VPS failure rates have been estimated at approximately 11–25% within the first year after initial shunt placement [1-4]. Slit ventricle syndrome (SVS) is one of those complications. SVS is caused by over-drainage of cerebrospinal fluid (CSF). Generally, SVS is characterized by small ventricles, documented by computed tomography (CT) scan with intermittent or chronic headaches [5]. Over-drainage of CSF can cause subdural hemorrhage or brain herniation, leading to altered mental state or critical complications such as death [6,7]. Recently, to prevent over-drainage of CSF, anti-siphon devices were developed; however, they cannot completely prevent SVS or over-drainage of CSF [8,9].
Over-draingage of CSF and SVS are currently recognized as one of the most devasting and difficult complications to manage after VPS implantation [9]. However, the factors that affect the occurrence of SVS have yet to be investigated comprehensively. The purpose of this study was to analyze the risk factors associated with the prevalence of SVS after VPS.

MATERIALS AND METHODS

Patients

This is a retrospective study based on a review of medical records of patients undergoing VPS surgery at our hospital from January 1, 2011 to December 31, 2019. Key clinical data included age at surgery, sex, follow-up duration, and the cause of hydrocephalus. Preoperative and postoperative cranial CT or magnetic resonance imaging (MRI) scans were reviewed. We diagnosed SVS by measuring ventricular size and Evan’s ratio based on these images and patient’s associated symptoms. Patients’ symptoms varied from mild to severe headache or nausea to drowsiness. We evaluated patients’ CT or MRI of brain to establish SVS or CSF over-drainage.

A total of 315 patients who underwent VPS surgery were included. We excluded patients who died or underwent removal surgery due to malfunction or infection of VPS catheter within 2 months after VPS surgery. Patients with follow-up loss or no follow-up imaging results within 2 months were also excluded. Thus, 23 patients did not satisfy the above criteria. The analysis included 292 patients who met the inclusion criteria.

This study was approved by the Institutional Review Board of Pusan National University Hospital (H-2208-033-118). And, this was a retrospective observational study that only required a review of previously collected patient data. Patient-identifying information was not revealed in this study, so informed consent from the patients was not required.

Radiologic evaluation

We diagnosed SVS based on patients’ follow-up radiologic images. If characteristic slit-like ventricle appeared on patients’ brain images and the patient had associated symptoms, an SVS diagnosis was made. We evaluated brain CT or MRI of all patients who were included (Fig. 1). We measured Evan’s ratio, which is defined as the ratio of the maximal width of the frontal horns to the maximum inner skull diameter [10], based on the images acquired preoperatively and postoperatively. If Evan’s ratio was less than...
Factors associated with slit ventricle syndrome

0.25 and the lateral ventricle showed a slit-like appearance post-operatively at least once with patient’s related symptoms like headache or drowsiness, SVS was diagnosed (Fig. 2). In our study, SVS were diagnosed in 53 patients.

Statistical analysis

All analyses were performed with IBM SPSS ver. 28.0 (IBM Corp.). The results were expressed as percentages and mean ± standard deviation. Student’s t-test, Fisher’s exact probability test, and chi-squared test were used for the statistical analysis. A statistical threshold of p < 0.05 (two-tailed) was considered significant.

RESULTS

SVS was diagnosed in 53 out of 292 patients who underwent VPS surgery. We separated all patients into two groups: 1) patients with SVS in follow-up radiologic images (SVS group); and 2) patients without SVS (non-SVS group). The overall incidence of SVS was 18.2%. The characteristics of all 292 patients and two groups are listed in Table 1.

The SVS group comprised a higher number of males. However, no statistically significant difference in prevalence was detected according to sex. The mean age of patients in the SVS group was 48.3 years, which was 10 years younger than that of non-SVS group. Younger patients tend to develop SVS after VPS surgery, and a statistically significant difference in prevalence was found, according to patients’ age at surgery (p = 0.024). The mean follow-up duration of total patients was 2.8 years, with no difference between the two groups. Forty-one patients (14.0%) underwent revision surgery and only two patients underwent revision surgery twice. There was no significant difference between the two groups.

We categorized patients according to diagnosis before developing hydrocephalus to establish the cause of hydrocephalus. We divided patients into six groups according to the cause of hydrocephalus; 1) trauma; 2) vascular (such as subarachnoid hemorrhage [SAH], intracranial hemorrhage, and intraventricular hemorrhage [IVH]); 3) NPH; 4) infection; 5) congenital; and 6) tumor. Relatively, patients who had traumatic brain injury or tumors frequently developed slit ventricles. The incidence of slit ventricle among shunted patients who had a vascular cause was significantly lower than in those with other non-vascular causes, and the difference showed statistical significance (p = 0.002) (Table 1).

DISCUSSION

SVS is one of the complications of VPS surgery with an incidence ranging from 1% to 50% [11]. In our study, its incidence was 18.2% consistently. Symptoms of SVS are multiple, including headache, vomiting, weakness, drowsiness, ataxia, and seizures [11-13]. SVS can be led to subdural hemorrhage or other severe complications, such as death [6,7]. Treatments for SVS vary from conservative care to surgical methods such as endoscopic third ventriculostomy, cranial expansion, change to lumbo-peritoneal shunt, and shunt removal [13,14]. However, SVS is difficult to manage and complications often occur during treatment [9,11]. Thus, it is important to control risk factors and predict SVS.

Several risk factors including patients’ age, the cause of hydrocephalus, baseline ventricle size, previous shunt revisions, and shunt valve type in children were reported previously [15]. In this study, patients’ age on the day of operation played an important role in the development of SVS. Similar to pediatric studies [15,16], other studies involving younger patients reported the occurrence of slit ventricles frequently, probably due to higher intracranial pressure (ICP). If the patients’ ICP was higher, the difference between ICP and shunt valve pressure was larger together with the volume of drained CSF, which might lead to the develop-
ment of slit ventricles. Hydrocephalus was another risk factor in our study. The cause of hydrocephalus might play an important role in SVS because the mechanism underlying hydrocephalus varies according to the etiology. Therefore, we categorized patients according to the cause of hydrocephalus and compared the two groups of patients with SVS after VPS surgery. The incidence of SVS in patients who had hydrocephalus with vascular cause was significantly lower than in those with non-vascular causes. Hydrocephalus caused by SAH or IVH is related to blood clots and fibrosis of arachnoid granulation, resulting in CSF absorption [17,18]. Hydrocephalus after hemorrhage usually develops more acutely than primary hydrocephalus or tumor-associated hydrocephalus due to the blockage of CSF absorption system. We thought that impairment of CSF absorption was more severe in hydrocephalus with vascular etiology than in those with non-vascular causes. Therefore, over-drainage of CSF occurs more easily in hydrocephalus with non-vascular cause because arachnoid granulation and CSF absorption system is relatively preserved.

This study has several limitations. First, patients’ ICP data were not included in this study. Since ICP plays an important role in SVS [19], it can be considered as one of the important risk factors. Second, the incidence of SVS in our study may be inaccurate because patients’ follow-up duration varied from 2 months to more than 5 years. SVS can occur later than the follow-up period. Therefore, the actual incidence of SVS can be higher than the estimated rate in our study. Finally, follow-up images were not obtained at the same time, and the image modalities were not uniformly utilized. Therefore, the Evan’s ratio may be erroneous, which can lead to a misdiagnosis of SVS.

CONCLUSION

In our study, we evaluated a few risk factors contributing to the occurrence of SVS after VPS. The incidence of SVS was higher when the patient’s age was younger and the cause of hydrocephalus was not vascular. Despite a few study limitations, the results can be used to predict the occurrence of SVS. Further studies are needed to reduce the overall incidence of SVS.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Khan F, Shamim MS, Rehman A, Bari ME. Analysis of factors
Factors associated with slit ventricle syndrome affecting ventriculoperitoneal shunt survival in pediatric patients. Childs Nerv Syst 2013;29:791-802


https://doi.org/10.52662/jksfn.2023.00024