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Subdural Hematoma after Shunt Operations

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Abstract Among a series of 388 shunt operatioins, subdural hematoma occurred in 8 cases (2.1%). It occurred in both children and adults, in 5 low- and 3 medium-pressure shunt systems, on the ipsilateral and contralateral sides to a ventriculo-peritoneal shunt in 3 and 4 cases, respectively, and 1 in a lumbo-peritoneal shunt. Preceding subdural effusion was noted in 7 cases. Symptoms, duration and character of the hematoma were similar to those of chronic subdural hematoma. Symptoms tended to be rather mild and were compensated by a shunt system. Furthermore, removal of the hematoma in three cases required additional procedures such as ligation of the shunt, replacement to a higher-pressure valve or a subdural-peritoneal shunt for reexpansion of the brain. One case of cranio-cerebral disproportion required the reduction cranioplasty for prevention of hematoma recurrence. Promoting factors were thought to be low intracranial pressure resulted from the shunt system or the pumping valve, head and individual anatomical susceptibility. Subdural effusion after a shunt operation should be regarded as a warning sign, and precautions should be taken against occurrence of chronic subdural hematoma. To prevent this complication, addition of an anti-siphon device is recommended.

Key Words : Subdural hematoma, Subdural effusion, Shunt opration, Hydrocephalus, Intracranial pressure

Shunt surgery is an important procedure in the neurosurgical field and is performed routinely. Generally, three main types of pressure shunt systems are available, except for a recently introduced pressure valve[4,18]. Appropriate selection of the pressure of the shunt system is difficult, and shunt revision is sometimes necessary. Among the causes of shunt revision, subdural hematoma (SDH) is seen occasionally. We have experienced 8 cases with this complication, which resembles chronic subdural hematoma; it occurred not only in ventriculo-peritoneal (VP) shunt, but also in lumbo-peritoneal (LP) shunt, not only on the shunt side, but also on the opposite side, and not only in adults, but also in children. These experiences are reported and discussed in this paper.

Material and Methods

After the introduction of CT at our hospital in 1976, we have performed 388 shunt operations for hydrocephalus. Among these, cases of shunt revision were included only when the pressure or the route of the shunt system had to be changed. The type of hydrocephalus was classified as high-pressure hydroceplalus (HPH) or normal-pressure hydrocephalus (NPH) according to the symptoms or intra-operative findings. The method of shunt surgery and the pressure of the shunt system were investigated in these cases. In the 8 cases with SDH, investigations were also made of the side and the thickness of the lesion, the time interval between the detection of the lesion and the shunt operation, the time interval between the onset of symptoms and the shunt operation, the symptoms and the treatment.

In one case of VP shunt using a Sophy programmable pressure valve[4] (model SU8, Sophysa, France) and an telemetric intracranial pressure (ICP) sensor[13] (Nagano Keiki Seisakusho, Japan), the ICP was monitored while changing the valve pressure and the paitent's posture to study the effect of the shunt system on ICP.

Results

The incidence of SDH was 2.1% (8/388) overall, 2.5% (3/161) for HPH, 1.8% (5/227) for NPH, 2.0% (7/350) for VP shunt and 2.9% (1/35) for LP shunt. Table 1 shows the incidence according to the pressure of the shunt system, which was 1.4%(3/209) for medium-pressure systems and 3.4%(5/148) for low-pressure systems. SDH did not occur in cases using high-pressure systems. Statistically, no significant differences the incidences was seen between according to the pressure settings of the shunt systems.

Table 1 Incidences of subdural hematoma (SDH) classified according to shunt system pressure.

Shunt Pressure	No	SDH	Incidence(%)
high	31	0	0
medium	209	3	1.4
low	148	5	3.4
total	388	8	2.1

No: number of cases

The background of the SDH patients, shunt operations, and the side on which the lesions occurred are summarized in Table 2. Main causes of hydrocephalus were congenital for children and subarachnoid hemorrhage (SAH) for adults. In case 4 of HPH with a medium-pressure shunt system, the valve was pumped 50 times twice a day because of no evident improvement on CT after the shunt operation. Most of the affected patients (7/8) had been noted to have subdural effusion (SDE) preceding SDH. In case 2, CT scan was not taken until convulsion occurred 5 weeks after the shunt operation, and the presence of preceding SDE was unkown. Case 5, 6 and 8 were diagnosed incidentally by CT scan. Three cases were ipsilateral and 4 were contralateral to the shunted side, and moreover, the LP shunt case also had SDH. There was no relation between the side of the shunt operation and that of SDH.

Table 3 shows the timing of each incident in relation to shunt operation and the type of symptoms occurring. SDE was detected a few weeks after surgery. Symptoms then occurred and SDH was detected a few months later. Children suffered vomiting, fever and convulsion, whereas adults showed

Table 2 Background, shunt operation, subdural effusion (SDE) and subdural hematoma (SDH) in each case.

	Background of Patients				Shunt opreration			SDE	SDH
Case	Age	Sex	Cause	Type	Side	Mode	Pres	Side	Side
1	9 mo	F	meningocele	HPH	R	VP	medium	R	R
2	2 yr	M	congenital	HPH	R	VP	low	-	R
3	4 yr	M	congenital	HPH	L	VP	medium	R	R
4	39 yr	F	unknown	NPH	R	VP	medium*	L>R	L
5	59 yr	M	SAH (aneurysm)	NPH	-	LP	low	L>R	L
6	67 yr	M	SAH (trauma)	NPH	R	VP	low	R	R
7	71 yr	M	SAH (unknown)	NPH	R	VP	low	R>L	L
8	73 yr	M	unknown	NPH	L	VP	low	R	R

F: female, M: male, SAH: subarachnoid hemorrhage, Type: type of hydrocephalus, HPH: high-pressure hydrocephalus, NPH: normal-pressure hydrocephalus, R: right, L: left, Mode: method of shunt operation, VP:Ventriculo peritoneal shunt, LP:Lumbo peritoneal shunt Pres: pressure of the shunt system,*: The flushing valve was pumped,

Table 3 Time course and thickness of subdural effusion (SDE) and subdural hematoma (SDH) after shunt operations.

Case	SDE Date	SDE Thickness	Symptom Onset	Symptom Contents	SDH Date	SDH Thickness
1	2 wk	5 mm	9 wk	vomiting, fever	10 wk	30 mm
2	-	-	5 wk	convulsion, fever	5 wk	60 mm
3	1 d	24 mm	3 wk	headache, vomiting	4 wk	54 mm
4	2 wk	15 mm	18 wk	disorientation	18 wk	40 mm
5	4 wk	10 mm	-	-**	12 wk	12 mm
6	4 wk	12 mm	8 wk	failing*	10 wk	25 mm
7	3 wk	3 mm	11 wk	disorientation	11 wk	27 mm
8	5 wk	10 mm	-	-**	12 wk	25 mm

Date: time interval from the shunt operation
Thickness: actual thickness of the lesion on CT
*CT taken because of mild head injury.
**Detected by periodical CT.

Table 4 Operative procedures for SDH cases.

Case	procedures
1	BH
2	CT, VS shunt
3*	Reduction cranioplasty
4*	TP, Membrane removal
5*	BH, Shunt ligation
6	BH, Shunt ligation
7	BH, Ommaya placement
8	CT, SP shunt, Sophy VP shunt

BH: burr-hole operation, CT: craniotomy, VS shunt: ventriculo-subdural shunt, TP: trepanation,*: Reoperation because of recurrence after first burr-hole operation.

disorientation. The symptoms tended to be rather mild in view of the volume of SDH, especially in children.

Table 4 shows the final treatment in each case. In all cases, the hematoma was liquefied as if usual for chronic subdural hematoma. A burr hole operation alone was performed initially in 4 cases, but SDH recurred in 3 cases. Cranio-cerebral disproportion was present in case 3 and multi-lobulated hematoma was seen in case 4. A disproportionately large skull was remodeled by reduction cranioplasty[21] in case 3, the intervening membrane was resected in case 4 and the shunt tube was ligated in case 5. SDH did not recur in 4 cases treated by combined procedures other than evacuation of the hematoma. Ventriculo-subdural shunt was performed in case 2, shunt ligation in case 6, Ommaya reservoir was placed for aspiration in case 7, and a combination of subdural-peritoneal (SP) shunt and VP shunt revision with a higher-pressure system was performed in case 8. Final outcomes of each cases were excellent.

Details of case 8 were presented in Fig. 1. This 73-year-old man had NPH symptoms for 5 months and left VP shunt was performed. Three months later, right SDH was detected incidentally on CT, and evacuation of the hematoma with a right SP shunt (low pressure) and VP shunt revision with a Sophy programmable shunt system and a telemetric ICP sensor were performed. Initially, the valve was set at high pressure and SDH was resolved. ICP was measured after SDE had disappeared (Fig. 2). ICP showed a positive value within the official pressure range of the valve in a supine position and negaitve value on sitting. The symptoms became aggravated and valve pressure was gradually reduced to low pressure one month later, resulting in improvement of the symptom.

Discussion

Subdural hematoma (SDH) has been reported by several authors to occur after shunt operations. Samuelson[19] reported the incidence to be 20.8% (5/24) for NPH, Becker and Nulsen[1] gave an incidence of 5% (7/140) for NPH, Illingworth[9] reported 4.5% (8/175)

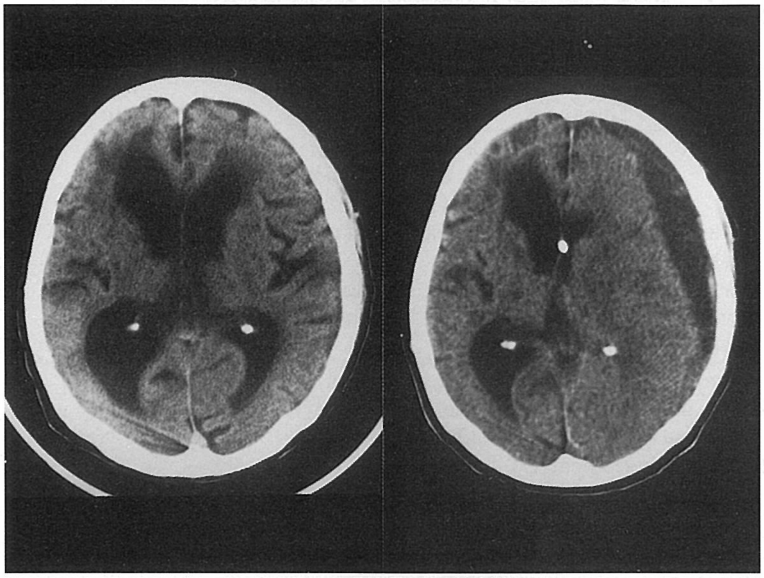

Fig. 1 CT scans in case 8. a: Before the shunt operation, hydrocephalus with PVL is present. b: Before the SDH operation, right SDH is present.

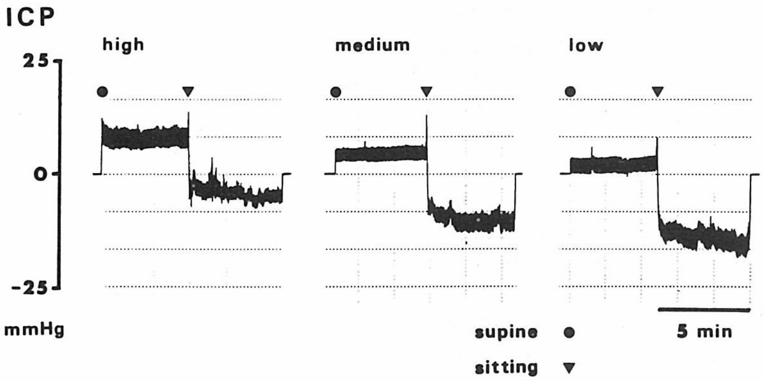

Fig. 2 ICP monitored in case 8 changing the pressure of the valve and the posture of the patient. ICP was positive in a supine position, but negative on sitting regardless of the valve pressure.

for HPH and Takahashi[20] 2.0% (4/177). We experienced 8 cases with this complication among 388 patients with shunt operations after the introduction of CT scan at our department. The incidence of SDH after shunt operations at our institute was 2.1%, which was not higher than that of previous reports. It occurred in both medium- and low-pressure shunt systems, but never occurred in high-pressure systems. SDH seemed to show a tendency to occur in low-pressure systems, but no statistically significant difference was found between low-pressure system and medium-pressure system.

Symptoms, the time interval between shunt operation and hematoma formation, and the characteristics of the hematoma resembled those seen in usual chronic subdural hematoma[11]. Because of compensation for the increased ICP by the shunt system, hematoma tended to become large, especially in children, and no symptoms of increased ICP were seen in adults.

Promoting factors for SDH after shunt surgery were thought to be as follows.

First, the lower pressure in the ventricle caused by the shunt system seemed to promote the brain retraction and the occurrence of SDH[11]. SDE, not present before shunt surgery, usually preceded by SDH, suggesting negative pressure and retraction of the brain. Most of such cases required procedures for decreasing the shunt negative pressure to promote reexpansion of the brain. Retraction of the brain might stretch bridging veins, and thus the chance of these veins being damaged might increase. The lack of any relation between the side of the shunt operation and SDH formation proved that the operation itself was not direct cause of SDH. The time when SDE changed into SDH was usually unknown. Patients are usually kept in bed after these operations, and after wound healing and recovery from gait disturbance, they spend most of their time sitting up, thus producing hydrostatic negative pressure loads. This might be one of the causes of aggravated SDE and SDH. ICP monitoring using various shunt pressures and postures in one adult patient showed negative ICP on sitting for all pressure types owing to hydrostatic pressure, and the siphon effect, therefore every pressure type shunt system seems to carry a risk of brain retraction[2,3,6,7,12]. The negative ICP on sitting was more marked with lower pressure valve.

Second, pumping of a valve was a promoting factor of SDH formation. We measured experimentally the flow on pumping a valve using a low-pressure shunt system (American Heyer-Shulte) and the results revealed that 10 flushes forced 2.1～2.7 (mean 2.4) ml of shunt flow. Fifty fluhses may thus evacuate about 12 ml of CSF. The time required to flush 50 times is usually less than one minute. Much shunt flow in a short time might periodically an excessive negative ICP and promote the formation of SDH. Therefore, pumping of a valve with an inappropriately high pressure seems dangerous.

Third, mild head injury could change SDE into SDH.

Fourth, many patients were operated on with a low-pressure shunt system and some of them had temporary low-ICP symptoms[6] or slit-like ventricles, although they did not have SDH. Therefore, some individual anatomical susceptibility might be present. The fact that the side of SDH was not related to the side of the shunt supports this idea.

For treatment of this complication[5,10,16], evacuation of the hematoma alone was not usually sufficient, as seen in case 5. Low ICP produced by the siphon effect of the shunt system, regardless of the valve pressure, might be one of the factors promoting SDH, and therefore some procedures for reducing the negative ICP caused by the shunt system are necessary. Ligation of the abdominal catheter[10] in two cases achieved this, purpose although symptoms of hydrocephalus had a chance to recur. Use of an upgrade valve[10], or an anti-siphon device[3,7,8,14,15,16,17], has been proposed. In cases of insufficient reexpansion of the brain, SP shunt might be another method. To treat these two antagonistic conditions, that is hydrocephalus and subdural hematoma, a Sophy programmable pressure valve can respond flexibly, because its pressure is easily changeable from low to high using a magnet after the operation[4]. At first, the valve is set high pressure to resolve the SDH, then the pressure of the valve can be decreased according to the clinical symptoms and CT findings, as seen in case 8. Reduction cranioplasty[21] was necessary to prevent the recurrence of SDH. in one patient with an inappropriately large skull, .

From our experience, the use of a low-pressure system for adult patients with NPH and a low- or medium-pressure system for pediatric patients are associated with a risk of SDH. Addition of an anti-siphon device (ASD) to avoid excessively negative ICP is therefore recommended. No statistically significant difference was seen in the incidence of SDH between the low and the medium pressure of the shunt system although whether an ASD should also be added in other cases is not known[15]. As normal ICP is reported to be slightly negative on sitting or standing[2,3,7,12,13], if the negative ICP produced by the shunt system is within the normal physiological range, an ASD is thought to be unnecessary.

Cases of SDH after shunt surgery require careful treatment to avoid multiple operations.

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