

# Lumbar Drainage and Low Rate of Permanent Shunt Insertion after Treating Aneurysmal Subarachnoid Hemorrhage

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**Objective:** This study investigated the predictive factors contributing to shunt-dependent hydrocephalus and the rate of shunt requirement in a ruptured aneurysmal subarachnoid hemorrhage. The factors related to short-term clinical outcomes were also determined.

**Material and Method:** A retrospective review was conducted of 200 patients who underwent surgical clipping of ruptured aneurysmal subarachnoid hemorrhage based on protocols of CSF drainage at Prasat Neurological Institute (PNI) between January 2008 and February 2010. Patient demographic, Glasgow Coma Score (GCS), Hunt and Hess (H&H) grade, Fisher's grade and Glasgow Outcome Scale (GOS) were evaluated. The rate of shunt requirement was analyzed. PNI score was designed for predicting shunt requirement.

**Results:** Two hundred patients who underwent surgical clipping aneurysm consisted of 86 males and 114 females aged ranging from 34-78 years (Mean 56 years). The patients were divided into two groups by treatment protocols; 164 patients (82%) in the first group were operated using supraorbital craniotomy (SOC) with a pre-operative spinal drain. Thirty-six patients (18%) in the second group were operated using mini-open craniotomy and without pre-operative spinal drain. Three patients (1.5%) required a permanent shunts and all of them had full PNI Score (PNI score = 7) ( $p < 0.001$ ). In all, 189 patients (94.5%) with high preoperative GCS 9 ( $p < 0.001$ ) had satisfactory surgical outcomes (GOS 4&5).

**Conclusion:** This study demonstrated the decreased rate of permanent shunts in patients with ruptured aneurysmal SAH who were treated under the PNI protocol. A factor that effectively predicted shunt-dependency was the PNI score equivalent to 7.

**Keywords:** Rupture aneurysm, SAH, Permanent shunt, Clinical outcome

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Incidence of intracranial aneurysm rupture varies from 13% to 35%, resulting in high morbidity and mortality<sup>(1)</sup>. Principle treatment is surgical clipping or endovascular intervention (coiling) which producing different outcomes<sup>(1)</sup>. These procedures may cause hydrocephalus which is a common and important complication before and after operation<sup>(2-7)</sup>. The incidence of hydrocephalus, also known as sequelae of aneurysmal subarachnoid hemorrhage (SAH), has been reported, ranging from 6% to 67%<sup>(1,8)</sup>. Three stages of hydrocephalus in SAH patients have been recognized<sup>(7)</sup>, i.e., acute (0-3 days after SAH), subacute

(4-13 days after SAH), and chronic (14 days after SAH). The condition of hydrocephalus usually requires further management. Some patients were treated using a pre-operative external ventricular disease. Nevertheless, cerebrospinal fluid (CSF) drainage in patients with an unsecured, recently ruptured cerebral aneurysm may increase transmural pressure across the aneurysm wall, thereby increasing the likelihood of recurrent hemorrhage<sup>(9)</sup>. Most of the patients, who required a permanent shunt due to hydrocephalus, are associated with multi-factors such as increasing age, hypertension, intraventricular hemorrhage, diffuse subarachnoid blood, posterior circulation aneurysm sites, focal ischemic deficits, large ventricles at the time of admission, poor Hunt and Fisher grades, symptomatic vasospasm, aneurysmal rebleeding and female gender<sup>(1,8,10-12)</sup>.

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## Material and Method

Patients diagnosed with ruptured aneurysm and SAH whom were admitted to Prasat Neurological Institute (PNI) were estimated about 50 cases per year and the principle treatment is surgical clipping. The purpose of this present study was to investigate the predictive factors (PNI scores) contributing to shunt-dependent hydrocephalus and the rate of shunt requirement in a ruptured aneurysmal subarachnoid hemorrhage. Simultaneously, the guidelines for treatment of a ruptured aneurysm with SAH were also utilized, aiming to obtain the satisfactory clinical outcomes, including decreasing rates of permanent shunt requirement. Additionally, the factors related to short-term clinical outcomes were determined.

This present study's protocol was reviewed and approved by the Research Ethics Committee of Prasat Neurological Institute (PNI), Bangkok, Thailand. Retrospective review was performed with 200 patients diagnosed aneurysmal SAH, who underwent clipping procedure by our senior author (AL) at Prasat Neurological Institute between January 2008 and February 2010. The patients who underwent endovascular treatment using surgical clipping by other doctors or obtained pre-operative external ventricular drainage were excluded from the study. The management for patients with ruptured aneurysm was early surgical obliteration of aneurysm. Most patients were referred from other hospitals and underwent operations as soon as possible within 48 hours after their arrival. All of these patients were diagnosed by magnetic resonance angiography (MRA), computed tomographic angiography (CTA) or angiography. The management guidelines for lumbar drainage was divided into two groups.

### *Supraorbital craniotomy with spinal drain*

Aneurysms that fit these procedures include anterior communicating artery aneurysm (ACoA), anterior cerebral artery (ACA), posterior communicating artery aneurysm (PCoA).

In order to reduce an intracranial pressure, which helps reduce brain injury, lumbar drain was performed in the operating room. The CSF was released just before the opening of dura mater. The advantages of releasing CSF are: (1) softening the brain, (2) gaining more subdural space, (3) less traction injury to the brain, (4) easy access to the aneurysm, (5) continued release of CSF in the post operative period.

First day after operation, the intracranial pressure of over 20 mmHg was considered unsafe.

Measurement of CSF release until the pressure was less than 20 mmHg was carried out (Fig. 1). The spinal drain was kept in place for no more than seven days to prevent a central nervous system (CNS) infection. If the ICP was less than 20 mmHg during the seven days of observational period, the spinal drain was removed. However, in case of worsening symptom of longer period of CSF diversion than seven days, CT scan was done to rule out hydrocephalus.

### *Mini-open craniotomy without spinal drain (Fig. 2)*

Aneurysms that fit these procedures include carotid cave, Internal Carotid Artery (ICA), Middle Cerebral Artery (MCA), Posterior Cerebral Artery (PCA), Basilar Artery (BA), Vertebral Artery (VA), and Posterior Inferior Cerebral Artery (PICA).

In the second post operative day, intracranial pressure would be measured by spinal puncture. If the intracranial pressure was over 20 mmHg, CSF release was necessary through lumbar drainage and daily imperative serial lumbar puncture was obliged until the pressure was less than 20 mmHg. Lumbar puncture was terminated only when the pressure was below 20 mmHg for two consecutive times.

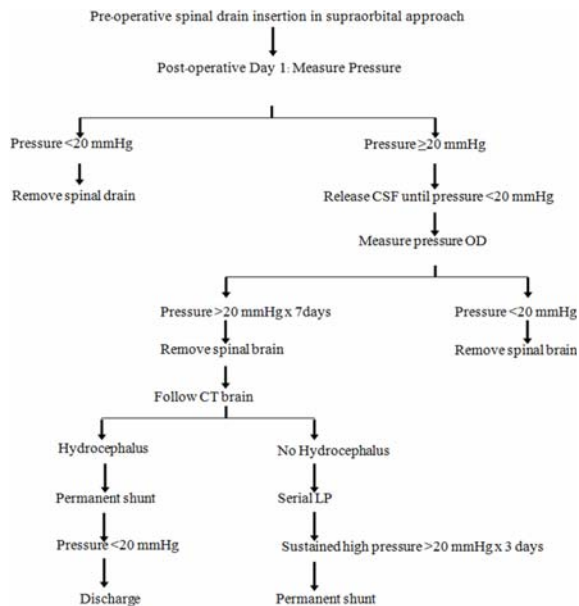
In case of persistent high pressure of clinical deterioration, CT scan was performed to rule out the post operative hydrocephalus. Post operative neurological status was evaluated using Glasgow Outcome Scale (GOS).

### *Statistical analysis*

Descriptive statistics were analyzed. The Chi-square or Fisher exact tests were used for univariate analysis of categorical variables. The student t-test was applied for univariate analysis of continuous variable. Significance was considered at a probability value lower than 0.001.

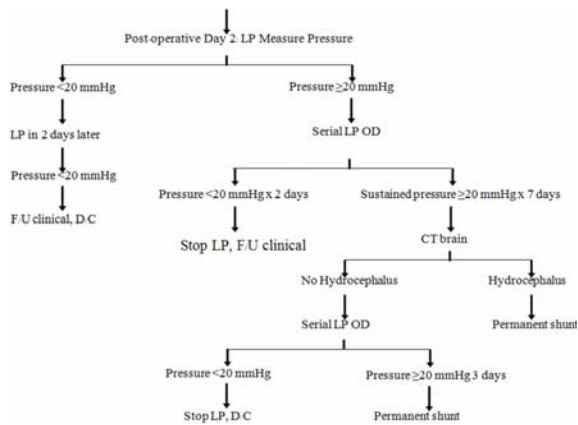
## Results

Of the 200 patients, 164 patients (82%) were operated by SOC approach with pre-operative spinal drain. The other 36 patients (18%) were operated by mini-open craniotomy without pre-operative spinal drain. The patients presented with mild Glasgow Coma Score (GCS) 14-15 (n = 116, 58%) moderated GCS 9-13 (n = 68, 34%) and severe GCS 4-8 (n = 22, 6%). Only four patients (2%) presented in moribund state. In all, 65% of the patients had Fisher's grade 3 and 4 and 34% revealed poor Hent and Hess (H&H) 4, 5. Aneurysm locations were AcoA in 119 patients (59%), P-com in 45 patients (22%), MCA in 11 patients (5.5%),



CSF = cerebrospinal fluid; LP = lumbar puncture; OD = once a day; SOC = supraorbital craniotomy

**Fig. 1** Supraorbital craniotomy (SOC) with spinal drainage.



**Fig. 2** Mini-craniotomy without spinal drainage.

ICA (carotid cave, cavernous, supraclinoid and ICA bifurcation) in 10 patients (5%), Basilar artery in 8 patients (4%), PICA in 3 patients (1.5%), PCA in 2 patients (1%) and vertebral artery 2 patients (1%) (Table 1).

One hundred and fifty-eight cases (79%) were referral cases from other province hospitals and 42 cases (21%) were diagnosed and investigated at PNI. Duration from the onset time to the operation time varied in each group; 34-78 hours (mean 56 hours) in the referral group

**Table 1.** Patient demographic data

Gender	
Males	56 (43.0%)
Females	114 (57.0%)
Age	
34-78 years	Mean = 56
Underlying disease	
Hypertension	166 (83.0%)
Diabetes mellitus	26 (13.0%)
Ischemic heart disease	8 (4.0%)
Glasgow coma score	
<3	4 (2.0%)
4-8	12 (6.0%)
9-13	68 (34.0%)
14-15	116 (58.0%)
Fisher's grade	
1	23 (11.5%)
2	47 (18.5%)
3	88 (44.0%)
4	42 (21.0%)
Hunt & Hess grade	
1	18 (9.0%)
2	38 (19.0%)
3	78 (39.0%)
4	55 (27.5%)
5	13 (6.5%)
Aneurysm location	
AcoA	119 (59.5%)
P-com	45 (27.5%)
MCA	11 (5.5%)
ICA	10 (5.0%)
PICA	3 (1.5%)
Vertebral artery	2 (1.0%)
Basilar artery	8 (4.0%)
PCA	2 (1.0%)
Duration from SAH to operation	
First visit 42 cases (21.0%)	32 hours
Referral 158 cases (79.0%)	56 hours
Mean	44 hours
Approach	
SOC with clipping aneurysm	164
Mini-open craniotomy with clipping aneurysm	36
Operation time	
Average	3 hours 20 minutes

Anterior communicating artery aneurysm (ACoA), Basilar Artery (BA), Internal Carotid Artery (ICA), Middle Cerebral Artery (MCA), Posterior Cerebral Artery (PCA), Posterior communicating artery aneurysm (PCoA), Posterior Inferior Cerebral Artery (PICA) and Subarachnoid Hemorrhage (SAH).

and 12-52 hours (mean 32 hours) in the PNI group. The overall average time was 44 hours. Operation time varied

from two hours and ten minutes to four hours and 30 minutes, with an average of three hours and 20 minutes. Results of operation were 198 complete clipping (99%) and two partial clipping (1%). Obliteration of aneurysm was evaluated intraoperatively by tapping aneurysm. In case of suspected partial degree of obliteration or aneurysmal tap considering unsafe, post operative angiography would be performed to evaluate the completeness of obliteration. Post operative management revealed that duration of spinal drain ranged between one and seven days (mean four days, protocol I) and frequency of LP ranged two to ten times (average four times, protocol II). Twenty-two postoperative CT scans (11%) were performed due to the clinical deterioration and/or the persistent high intracranial pressure (Table 2). Two patients were diagnosed with meningitis. Both were received the proper antibiotics and experienced uneventful post operative course. The post operative GOS were Grade 1 in two cases (1%), Grade 2 in three cases (1.5%),

Grade 3 in six cases (3%), Grade 4 in 32 cases (16%) and Grade 5 in 157 cases (78.5%). Grade 1 patients died from severe vasospasm. The good clinical outcomes (GOS Grade 4 and 5) in 189 cases (94.5%) were correlated with the high pre-operative GCS (GCS9-15) ( $p<0.001$ ). All shunt-dependent patients had PNI score = 7 ( $p<0.001$ ) (Table 3). Three patients (1.5%) sustained high intracranial pressure which required permanent CSF diversion (Table 4).

## Discussion

Ruptured aneurysm with SAH can cause high morbidity and mortality. Subsequent hydrocephalus in this group of patients occurs frequently and they may require CSF diversion either temporary (external ventricular drainage) or a permanent shunt<sup>(8,10)</sup> for treating hydrocephalus. Rajshekhar and Harbaugh<sup>(13)</sup> reported a reoccurring bleeding rate of 14% in patients who underwent ventriculostomy after SAH. The complications of CSF diversion are intracerebral hemorrhage, infection or shunt malfunction, in which these might be avoided by trying not to place the permanent CSF diversion. Our institute implies the early surgery within 48 hours of symptom onset and the guidelines for treatment of SAH-related hydrocephalus, so as to evade the external ventricular drainage and to reduce the rate of shunt dependency.

### Rate of permanent shunt

Shunt-dependent hydrocephalus occurred between 6% and 37% of patients with SAH<sup>(1,4,7,8,10,11,13)</sup>. From our present study, only three patients (1.5%) required a permanent shunt. This was significantly less than the number reported in other studies<sup>(1,2,3,10,11,13)</sup>. This low incidence of permanent shunt might be due to the consecutive drainage of CSF following the guideline protocol. The authors believed that the drainage might help reducing the spilled blood in subarachnoid space and lowering the chance of hydrocephalus following

**Table 2.** Post-operative management

Duration of spinal drain	1-7 days (mean 4 days)
Lumbar puncture (frequency)	2-6 times (average 4 times)
Post-operative CT	22 (11.0%)
Permanent shunt	3 cases (1.5%)
Complication	
Vasospasm	11 (5.5%)
Spinal drain infection	2 (1.0%)
Glasgow outcome scale	
Grade 1	2 (1.0%)
Grade 2	3 (1.5%)
Grade 3	6 (3.0%)
Grade 4	32 (16.0%)
Grade 5	157 (78.5%)

CT = computed tomography

**Table 3.** Predictive score for shunt dependent (PNI score)

Gender	Age (years)	GCS	H&H	Fisher's grade	Vasospasm	Duration of lumbar drainage (d)	Score
Female	68	8	4	3	Yes	8	7
Female	71	12	4	3	Yes	10	7
Female	59	11	4	4	Yes	9	7

d = day; GCS = Glasgow coma score; H&H = hunt and hess grade

**Table 4.** Characteristics of patients who required permanent shunt

Age	
<60	0
≥60	1
Gender	
Male	0
Female	1
Glasgow coma score	
9-15	0
≤8	1
Hunt & hess grade	
<3	0
≥3	1
Fisher's grade	
<3	0
≥3	1
Vasospasm	
No	0
Yes	1
Duration of lumbar drainage (day)	
≤7	0
>7	1
Total score	7

SAH. This could be demonstrated by the decreased amount of red blood cells in the released spinal CSF after several spinal punctures.

#### **Factors related with shunt-dependent patients**

It took about three weeks after evidence of SAH until permanent shunts were placed in our three patients. This could be classified as a chronic hydrocephalus according to the study of Vale and colleagues<sup>(8)</sup>. Factors that related to shunt-dependent patients include advancing age, high Fisher grade and poor H&H grade<sup>(7,8)</sup>. Kwon et al<sup>(12)</sup> described factors that relate to shunt-dependent chronic hydrocephalus after aneurysmal subarachnoid hemorrhage. These factors were: (1) advancing age; (2) poor Hunt and Hess grade at admission; (3) intraventricular hemorrhage; (4) Fisher's grade 3 and 4 at admission; (5) radiological hydrocephalus at admission; and (6) post-surgery meningitis.

Our present study proposed the PNI score as a predictive score for shunt requirement in aneurysmal SAH patients following the management guideline protocol. The PNI score of 7 would suggest the high chance of permanent shunt requirement. Nevertheless, there were only a few numbers of permanent shunt patients in our present study; further research should

be conducted to ensure the reliability of this predictive score.

#### **Spinal drain as a tool of ICP monitoring**

Measuring ICP helps in identifying patients requiring CT scan and its timing. This measurement could reduce the cost of management fee according to the less frequency of postoperative imaging, and minimize the exposure of patient to the radiation. This present study would recommend CT only when patients experienced clinical deterioration or revealed the sustained high lumbar pressure more than seven days. Placements of spinal drain possess the risk of CNS infection. However, only two cases (1%) were found and revealed an uneventful post operative outcome after the treatment with appropriate antibiotics. However, we would recommend no retaining the spinal drain longer than seven days.

The clinical outcomes of treatment were assessed by GOS which demonstrated that the expected outcome (4 or 5) associated with GCS >9 at the time of admission and low H&H grade (grade 1-3). This is consistent with the previous study<sup>(14)</sup>.

#### **Conclusion**

This present study demonstrated a significant low rate of permanent shunt requirement in ruptured aneurysmal SAH patients compared with the results of other studies. Both perioperative CSF drainage via continuous spinal drain and serial lumbar drainage may decrease incidence of chronic hydrocephalus. PNI score is a useful predictive tool for forecasting the shunt dependency after the aneurysmal SAH. However, this present study is retrospective study; further prospective research should be conducted to confirm the results of our study.

#### **What is already known on this topic?**

An important complication that often occurs before and after aneurysmal operation is hydrocephalus. The incidence of hydrocephalus, also known as sequelae of aneurysmal SAH, has been reported ranging from 6% to 67%. Most of the patients, who required a permanent shunt due to hydrocephalus were associated with multi-factors.

#### **What this study adds?**

The authors investigated the predictive factors (PNI scores) contributing to shunt-dependent hydrocephalus and introduced the guidelines for achieving the low rate of shunt requirement in a

ruptured aneurysmal subarachnoid hemorrhage.

#### Potential conflicts of interest

None.

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การระบายน้ำที่ไขสันหลังผ่านสายระบายที่หลังและการลดอัตราการผ่าตัดใส่สายระบายน้ำผ่านทางสมองในผู้ป่วยจากภาวะเลือดออกใต้ช่องเยื่อหุ้มสมอง

ธีรภัทร บุญญาวรรณกิจ, วุฒิพงษ์ จุริโมไธ, อนุศักดิ์ เลียงอุดม

**วัตถุประสงค์:** ศึกษาปัจจัยการผ่าตัดใส่สายระบายน้ำไขสันหลังที่หลังในผู้ป่วยที่มีภาวะน้ำคั่งในโพรงสมอง และประเมินอัตราความจำเป็นในการผ่าตัดใส่สายระบายน้ำผ่านทางโพรงสมองแบบถาวรในภาวะเลือดออกใต้ช่องเยื่อหุ้มสมองจากการแตกของ aneurysm รวมถึงประเมินผลการผ่าตัดในระยะเวลาอันสั้น

**วัสดุและวิธีการ:** ทบทวนรายงานผู้ป่วยจำนวน 200 ราย ที่เข้ารับการผ่าตัดโดยการหนีบคลิป (surgical clipping) ในภาวะเลือดออกใต้ช่องเยื่อหุ้มสมองจากการแตกของ aneurysm และการประยุกต์ใช้แนวทางการระบายน้ำไขสันหลังผ่านทางท่อเจาะออกทางหลัง ณ สถาบันประสาทวิทยา ในระหว่างเดือนมกราคม พ.ศ. 2551 ถึง เดือนกุมภาพันธ์ พ.ศ. 2553 ใช้แบบประเมินปัจจัยการผ่าตัดจากข้อมูลพื้นฐานของผู้ป่วย, Glasgow Coma Score (GCS), Hunt and Hess (H&H) grade, Fisher's grade and Glasgow Outcome Scale (GOS) และวิเคราะห์อัตราความจำเป็นในการผ่าตัดใส่สายระบายน้ำแบบถาวร โดยใช้ PNI score ช่วยในการพิจารณา

**ผลการศึกษา:** ผู้ป่วยจำนวน 200 รายเข้ารับการผ่าตัดหนีบหลอดเลือดที่โป่งพอง (surgical clipping aneurysm) เป็นชาย 86 ราย หญิง 114 ราย อายุ 34-78 ปี (เฉลี่ย 56 ปี) แบ่งเป็น 2 กลุ่มตามวิธีการรักษา ผู้ป่วยจำนวน 164 ราย (82%) ในกลุ่มแรกรับการผ่าตัดเปิดกะโหลก (supraorbital craniotomy) มีภาวะระบายน้ำที่หลังก่อนการผ่าตัด กลุ่มที่สองผู้ป่วยจำนวน 36 ราย (18%) รับการผ่าตัดเปิดกะโหลกแบบแผลเล็ก ไม่ต้องมีการระบายน้ำที่หลังก่อนการผ่าตัด โดยพบว่าผู้ป่วยจำนวน 3 ราย (1.5%) ต้องรับการใส่สายระบายน้ำถาวร (PNI score = 7) (มีค่าระดับ p น้อยกว่า 0.001) ในขณะที่ผู้ป่วยจำนวน 189 ราย (94%) ให้ผลประเมินความรู้สึกตัวก่อนการผ่าตัดในระดับสูงที่ GCS  $\geq$  9 (มีค่าระดับ p น้อยกว่า 0.001) โดยความพึงพอใจผลการผ่าตัดอยู่ในเกณฑ์ดี (GOS 4&5)

**สรุป:** จากการศึกษาพบว่าอัตราการผ่าตัดระบายน้ำแบบถาวรของผู้ป่วยที่มีภาวะเลือดออกใต้ช่องเยื่อหุ้มสมอง ณ สถาบันประสาทวิทยามีอัตราที่ต่ำ และพบว่า PNI score ที่มีค่าเท่ากับ 7 สามารถนำมาใช้ประเมินถึงแนวโน้มความจำเป็นของการใส่สายระบายน้ำไขสันหลังแบบถาวรได้

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