CLINICAL ARTICLE

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Effect of Continuous External Ventricular Drainage on Delayed Ischemic Neurologic Deficits after Aneurysmal Clipping in Spontaneous Subarachnoid Hemorrhage

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Objective : The purpose of this reports is to describe the influence of continuous external ventricular drainage (EVD) on delayed ischemic neurologic deficit (DIND) after early surgery in ruptured aneurysmal patients.

Methods : The authors reviewed 229 patients with aneurysmal subarachnoid hemorrhage (SAH) who had been treated with clipping at a single institution between 1998 and 2004. Of these, 121 patients underwent continuous EVD (Group A) postoperatively, whereas 108 patients did not (Group B). EVD was performed at ipsilateral Kocher's point and maintained 2 to 14 days postoperatively.

Results : DIND occurred in 15.7% (19 cases) of patients in Group A, 25% (27 cases) from Group B (P value=0.112). Compared with Group A, Group B was more likely to suffer acute symptom of DIND and showed poor response to 3- H therapy. Major symptoms of DIND in Group A were mild confusion (36.8%) and mild deterioration of mental state (26.3%), contrary to weakness of extremities (59.2%) in Group B. At discharge, Glasgow Outcome Scales (GOS) of Group A were: good recovery (63.2%), moderately disabled (21%), severely disabled (10.5%), dead (5.3%) and Group B : good recovery (48.1%), moderately disabled (37%), severely disabled (14.8%) and dead (0%). Of 121 patients from group A, 35 patients (28.9%) suffered ventriculitis.

Conclusion : Continuous EVD after aneurysmal clipping in patients with SAH reduced the risk of DIND and its sequelae, relieved its symptoms, and improved the outcome.

KEY WORDS : Aneurysm · Ventriculostomy · Vasospasm · Delayed ischemic neurologic deficits (DIND) · Subarachnoid hemorrhage · Ventriculitis.

Introduction

Recently the incidence of delayed ischemic neurologic deficit (DIND) has been decreased in ruptured aneurysmal patients because of early surgery and preventive treatment of vasospasm, but its pathophysiology is not clearly defined and it is still a major factor in morbidity and/or mortality[10].

Increased intracranial pressure (IICP) is one of the major factors for outcome in management of DIND.

In ruptured aneurysmal patients suffering acute hydrocephalus or high intracranial pressure (ICP), enlarged caliber of major cerebral vessels are sometimes observed after external ventricular drainage (EVD) (Fig. 1).

The aim of this study was to determine the influence of continuous EVD on DIND and its effects on the DIND.

Materials and Methods

Patient population

The authors reviewed 377 patients with aneurysmal subarachnoid hemorrhage (SAH) who had been treated with craniotomy between 1998 and 2004. Between 2001 and 2004, 121 of the 252 patients were treated with continuous EVD postoperatively (Group A). Between 1998 and 2000, 108 of the 125 patients were managed without continuous EVD postoperatively (Group B) (Table 1).

Of 377, 148 patients with poor clinical status at admission,

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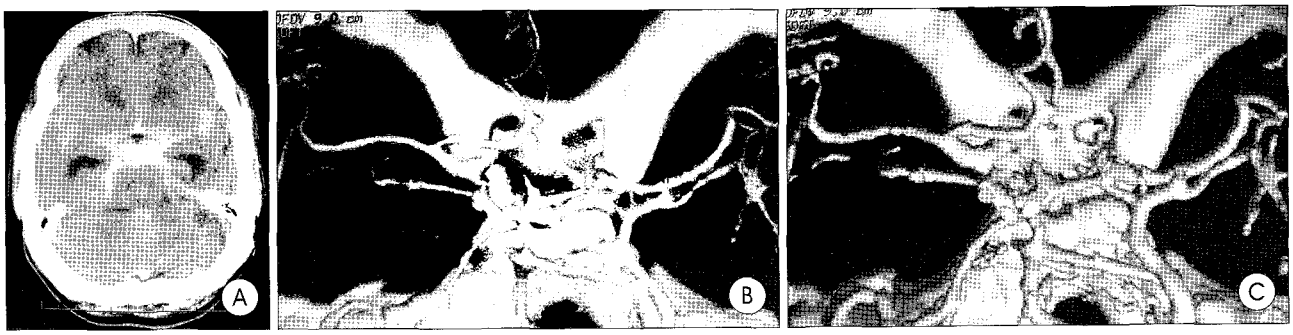

Fig. 1. A : Computerized tomography scan showing SAH. B, C : Computerized tomography angiogram before (B) and after (C) EVD. The caliber of cerebral vessels are enlarged generally after EVD.

Table 1. Baseline characteristics of patients (N=229, 1998.1-2004.12)

Clinical characteristics	Group A (N=121)	Group B (N=108)
Age	27-78 (mean 57)	22-77 (mean 61)
Sex (male : female)	39 : 82	37 : 71
H&H grade		
I	10 (8.3%)	12 (11.1%)
II	69 (57.0%)	55 (50.9%)
III	25 (20.7%)	23 (21.2%)
IV	12 (9.9%)	14 (13%)
V	5 (4.1%)	4 (3.7%)
Fisher grade		
I	5 (4.1%)	7 (6.5%)
II	44 (36.4%)	37 (34.3%)
III	25 (20.7%)	34 (31.5%)
IV	47 (38.8%)	31 (27.8%)

H&H grade : Hunt & Hess grade, N : number of patients

scanty SAH and incidental aneurysm, and those treated with EVD due to acute hydrocephalus were excluded in study. However, Group B included patients in whom incidental EVD was performed due to hydrocephalus developed during postoperative care.

Patient management

Aneurysmal neck clipping was done at an early stage by a single neurosurgeon in all cases. During operation, Lilliquest's membrane was opened and cisternal blood clots were removed as much as possible. For the prevention and treatment of DIND authors have applied standard regimens such as nimodipine administration and triple-H therapy (hypertension, hypervolemia, hemodilution).

Management of EVD

In Group A, EVD was performed during craniotomy at ipsilateral Kocher's point and maintained for 2 to 14 days postoperatively with catheter pressure at 15cmH_2O. If this volume was less than 100cc per day, we replaced the EVD catheter to contralateral Kocher's point. If CSF drained a small amount (<100cc/day), we clamped the catheter and opened occasionally for the purpose of measuring ICP. Removal of EVD catheter was decided when ICP level was maintained in nomal ranges and when there was no clinical deterioration after clamping of EVD.

Table 2. Clinical summary of patients in group A who have developed DIND

No	Age/Sex	H/F	Location of Aneurysm	Major Symptoms of DIND	GOS (at discharge)
1	53/F	II/II	Pcom	H	GR
2	63/F	III/IV	MCA	M	GR
3	38/M	III/IV	Acom	C	GR
4	59F/	II/IV	Pcom	M	GR
5	36/M	II/II	Acom	C	GR
6	59/M	IV/III	Acom	C	GR
7	54/F	II/II	Acom	C	GR
8	54/F	IV/III	Pcom	H & A	GR
9	62/F	III/IV	MCA	C	GR
10	50/M	III/IV	Pcom	C	GR
11	72/F	II/IV	Acom	M	GR
12	58/F	III/III	MCA	H	GR
13	37/M	I/II	Pcom	H	MD
14	67/F	III/III	Acom	H	MD
15	56/M	II/II	Acom	Mo	MD
16	43/F	II/I	Pcom	M	MD
17	63/F	II/IV	A2	C	SD
18	66/F	IV/IV	Pcom	H&M	SD
19	53/F	III/II	Acom	M	D

A : aphasia, DIND : delayed ischemic neurologic deficit, H/F : Hunt & Hess grade/Fisher grade, C : consciousness change, M : aggravation of mental state, Mo : monoparesis, H : hemparesis, Acom : anterior communicating artery, MCA : middle cerebral artery , Pcom : posterior communicating artery, A2 : distal anterior cerebral artery, GOS : Glasgow Outcome scale, GR : good recovery, MR : moderate disabled, SR : severe disabled, D : death

Statistical analysis

We analyzed the incidence of DIND and clinical outcome in Group A and B, and the incidence of ventriculitis in group A. Clinical status was graded according to Glasgow Outcome Scales (GOS) at discharge. All statistical analyses were performed using SPSS® program by comparing the data using pearson's chi square test, and significance was determined at P values less then 0.05.

Table 3. Clinical summary of patients in group B who have developed DIND

No	Age/Sex	H/F	Location of Aneurysm	Major Symptoms of DIND	GOS (at discharge)
1	59/M	II/III	Acom	H	GR
2	64/F	II/III	MCA	H	GR
3	62/F	II/II	Acom	C	GR
4	53/F	I/II	MCA	H	GR
5	41/F	II/II	Acom	H	GR
6	69/F	III/III	Acom	C	GR
7	54/M	II/IV	Acom	C	GR
8	73/F	II/II	MCA	C	GR
9	65/M	II/II	Pcom	Mo	GR
10	52/F	II/II	Acom	H	GR
11	56/F	II/II	MCA	H & A	GR
12	51/M	III/III	Acom	C	GR
13	58/F	III/III	Acom	C	GR
14	74/M	II/II	MCA	M	MD
15	50/M	III/III	Acom	H	MD
16	66/M	III/III	MCA	H	MD
17	74/F	III/IV	Pcom	H	MD
18	68/F	III/IV	MCA	C	MD
19	38/M	I/II	Acom	H	MD
20	52/F	II/III	Acom	H	MD
21	40/F	III/IV	Acom	H	MD
22	58/F	I/I	Pcom	H	MD
23	59/F	III/III	A2	H	MD
24	77/F	III/III	Pcom	H&M	SD
25	35/F	II/II	MCA	H	SD
26	69/F	IV/IV	MCA	H&M	SD
27	61/F	II/IV	ICA	C	SD

A : aphasia, DIND : delayed ischemic neurologic deficit, H/F : Hunt & Hess grade/ Fisher grade, C : consciousness change, M : aggravation of mental state, H : hemparesis, Acom : anterior communicating artery, MCA : middle cerebral artery, Mo : monoparesis, Pcom : posterior communicating artery, A2 : distal anterior cerebral artery, GOS : Glasgow Outcome scale, GR : good disabled, MR : moderate disabled, SR : severe disabled, D : death.

Results

The presentation of DIND

The criteria of DIND were as follows : neurologic deficits which newly developed between 4 and 14 days after the onset of SAH and were not concerned with rebleeding, metabolism disorder, electrolyte imbalance, hydrocephalus, and which were not associated with operative procedure such as injuries to perforating artery or occlusion of maternal artery[17].

DIND was present 19 cases (15.7%) in group A, and 27 cases (25%) in group B (Table 4).

Major symptoms of DIND in Group A were mild confusion (7 cases, 36.8%) and mild deterioration of mental state (5 cases, 26.3%), contrary to weakness of extremities (16 cases, 59.2%) in Group B. (Table 2, 3).

The onset and progression of DIND were more rapid in group B than Group A, and response to 3-H therapy was better in group A.

Table 4. Summary of results

Characteristics	Group A (N=121)	Group B (N=108)	P-value
DIND	19 (15.7%)	27 (25%)	0.112
GOS			
GR	12 (63.2%)	13(48.1%)	0.763
MR	4 (21.0%)	10(37%)	0.109
SR	2 (10.5%)	4(14.8%)	0.579
D	1 (5.3%)	0(0.00%)	1.000
Ventriculitis	35(28.9%)	5(4.6%)	0.000

DIND : delayed ischemic neurologic deficit, N : number of patients, GOS : Glasgow Outcome scale, GR : good recovery, MR : moderate disabled, SR : severe disabled, D : death

Clinical Outcome

Clinical status according to GOS at discharge were good recovery (12 cases, 63.2%), moderately disabled (4 cases, 21%), severely disabled (2 cases, 10.5%) and dead (1 case, 5.3%) in Group A. In Group B there were good recovery (13 cases, 48.1%), moderately disabled (10 cases, 37%), severely disabled (4 cases, 14.8%), and dead (0%) (Table 4). There were no statistical signigicant differences of clinical outcome in two groups although there were more cases with good recovery in Group A.

Continuous EVD related complications(ventriculitis)

The major complications of EVD were ventriculitis. In group A, incidence of ventriculitis is high (35/121 cases, 28.9%) (Table 4). The duration of catheterization was 2 to 14 days (mean 6.5 days). In CSF analysis, WBC count was $<100/mm^3$ in 9 cases, $100\text{-}500/mm^3$ in 19 cases, $500\text{-}1000/mm^3$ in 2 cases, and $>1000/mm^3$ in 5 cases. Although there was relatively high incidence of ventriculitis, there were controlled well by antibiotic therapy in all cases.

Three(8.57%) of these cases developed chronic hydrocephalus and they were treated with ventriculoperitoneal shunt.

Discussion

Recently the treatment of ruptured aneurysm favors early surgery and active preventive therapy for vasospasm, and consequently DIND has been decreased. The postoperative management may also for the major factors affecting the development of DIND and overall prognosis. It was reported in subarachnoid hemorrhage patients that the incidence of angiographic vasospasm was 40-70%, DIND 20-45%[6,11,12,21,24], and severe morbidity and mortality in 10-15%[9,14].

Despite extensive experimental and clinical investigations, the etiology and pathophysiology of cerebral vasospasm are not clearly defined but concerned mostly with hemoglobin and increased endothelial-1 in subarachnoid space contracting the vessels[7]. However it is postulated that DIND may develop by defect of autoregulation reflex due to decrease of

local cerebral blood flow and microcirculation changes[16,20]. The treatment of DIND has generally been administration of calcium channel blocker, 3-H therapy, intra-arterial papaverine infusion and transluminal angioplasty. Paul, et al.[18], reported that the incidence of vasospasm lessened by removal of spasmogens in subarachnoid space using continuous spinal drainage. However, there were no description on direct mechanical pressure effects to the cerebral vessels in the cases of cerebral vasospasm.

Also, there have been many reports regarding the pathogenesis and treatment of vasospasm, but none of there have emphasized the significance of mechanical pressure effect to vessels. It is generally known that the subarachnoid blood after aneurysm rupture disturb the flow and absorption of CSF[3,5,8]. A large volume of subarachnoid blood can develop retention of CSF and mass effect, leading to an ICP increase. In addition, the ICP will increase further if accompanied by intraventricular or intracerebral hemorrhage, and occasionally acute hydrocephalus may occur. The vasospasm can be aggravated when increased ICP exerts pressure effect on vessels in the critical period of DIND. Although the external mechanical pressure to a vessel is not a single cause of vasospasm, as a aggravating factor of vasospasm. This effect may be specifically seen as an enlarged caliber of cerebral vessels after ventricular puncture in subarachnoid hemorrhage patients (Fig. 1). From this theoretical point of view we have studied to determine whether the removal of external pressure to a vessel can decrease the incidence of DIND by continuous EVD in the critical period. In this study, 15.7% of group A experienced DIND and this incidence is lower than group B and those from previously reported series[6,11,12,21,24]. Also, major symptoms of DIND in Group A were mild confusion and mild deterioration of mental state, contrary to weakness of extremities in Group B (Table 2, 3). Moreover, the representation of DIND was more rapidly onset and aggravated in group B than Group A and was insidious and responded well to 3-H therapy in group A. Hence postoperative management of group A was considered more effective and than Group B as the number of patients who needed 3-H therapy was decreased so the complications due to 3-H therapy were also reduced. Furthermore, clinical outcome was better in group A (Table 4).

The possibility of infection will increase with a longer duration of EVD catheterization[1,4,15]. We also experienced high incidence of ventriculitis with long-term catheterization. The majority showed WBC count in range of 10-500/mm^3 from CSF analysis but fortunately ventriculitis was controlled well by antibiotic therapy in all cases. In 3 case, the chronic hydrocephalus was developed and treated with ventriculoperitoneal shunt. However, whether ventriculitis as the cases of hydrocephalus was not certain.

The incidence of infection by lumbar drainage is generally lower than by trephination[2,22], but the possibility of brain herniation should be emphasized in high ICP[13,19]. Yang, et al.[23], reported that change of EVD to lumbar drainage was good option after simple screening for the possibility of herniation in long-lasting acute hydrocephalus. For the reduction of infection, it should be kept in mind the importance of EVD device and minimizing the duration of EVD. In inevitable situation, continuous lumbar subarachnoid drainage, or EVD initially, then change to continuos lumbar drainage or repeated spinal tapping may be useful options.

But, with long period of catheterization, even if spinal drainage, the potentiality of infection will be greatly increased regardless of thorough attention.

Conclusion

This study results indicate that continuous EVD after aneurysmal clipping in patients with SAH is effective for prevention and treating the DIND. The incidence of DIND was decreased and the postoperative management was more feasible because the symptoms of DIND were mild and progressed slowly and better clinical outcome was improved.

However, the incidence of ventriculitis was markedly increased with long-term maintenance of EVD catheterization. Therefore continuous drainage of CSF should be done in selective patients with high ICP, symptoms of DIND or high possibility of DIND (i.e. poor mental state, high Fisher grade in CT findings, visible vasospasm in preoperative CT angiogram, diffuse and severe vasospasm in postoperative angiogram, intraventricular hemorrhage which can cause hydrocephalus and this medical problems that may not tolerable to use of 3-H therapy.

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Commentary

The authors report the positive effects of continuous EVD management on DIND of surgically clipped aneurysmal SAH patients. They studied 121 EVD patients group and 108 non-EVD patients group during different period. They found mild clinical symptoms and signs, good response to 3-H therapy and good surgical outcomes in the patients with DIND who underwent continuous EVD. They have EVD procedure related high infection rate (28.9%) which resolved with antibiotics therapy.

In dealing with DIND in aneurysmal SAH, cerebral vasospasm should be considered and it's accurate diagnosis is mandatory. In order to evaluate the exact effectiveness of a proposed preventive or treatment modality for DIND, accurate diagnosis of vasospasm together with comparative study of the patients group in same clinical and radiological grade among the study population is needed. There is only comparison data of whole grade patients who underwent EVD or not in this paper. According to this report's table 2&3, there were 9 out of 19 patients and 16 out of 29 patients have DIND in good grade (H&H grade I&II) SAH patients in group A and B respectively. It seems too high DIND proportion occupied by good grade patients. The authors proposed mechanical forces of high pressure CSF as one of the etiology of cerebral vasospasm. But in my view point vascular luminal enlargement after EVD seems to be caused by reduced ICP not caused by improvement of vasospasm itself. In other words EVD has no specific therapeutic effect on cerebral vasospasm other than reducing increased ICP which can help enhancing CBF and cerebral perfusion. There is a question about that EVD has a same positive effect on the normal ICP patient with vasospasm. Is it risk-acceptable procedure for all SAH patients to prevent or treat vasospasm?

EVD is well known procedure for the management of high ICP especially due to disturbed CSF circulation in SAH and sometimes it is rescue procedure for acute hydrocephalus due to SAH with or without intraventricular hemorrhage but the risks of rebleeding, infection and overdrainage should be considered. CSF diversion procedure for the high ICP patients with vasopasm is also expected to control ICP and enhance CBF and cerebral perfusion. In my experience, twist drill hole on the forehead and long subcutaneous tunneling, about 10 cm, for EVD catheter with closed drainage system can help lowering infection rate. CSF diversion is very useful and risk-acceptable procedure for managing SAH patients by controlling ICP and rinsing out blood clots if appropriate patient selection and adequate time to do and remove it were achieved.

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