Extent of subarachnoid hemorrhage and development of hydrocephalus

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Background and objective Factors associated with the development of acute hydrocephalus following subarachnoid hemorrhage are not fully elucidated. The goal of this study was to present the relative predictive values of Hunt-Hess grade and Fischer score in determining the propensity for developing post-hemorrhage hydrocephalus and to document the frequency of acute and chronic hydrocephalus following subarachnoid hemorrhage. **Patients and methods** Our study encompassed 102 patients with anurismal subarachnoid hemorrhage. The Hunt-Hess scale was used for the initial neurological status assessment and the extent of subarachnoid hemorrhage was graded based on the Fisher scale. Assessment of hydrocephalus was made on the basis of the size of both temporal horns, the ratio of FH/ID and Evan's ratio. **Results** Thirty-two percent of patients exhibited hydrocephalus requiring CSF diversion procedure. External ventricular drainage was performed in 29 % of patients for early hydrocephalus. Seventy percent of patients with acute hydrocephalus requiring external ventricular drainage were graded as 3, 4 or 5 according to the Hunt and Hess scale on admission, in contrast to 58 percent of patients without hydrocephalus. Ninety-three percent of patients with hydrocephalus were graded as 3 and 4 according to Fisher grade on initial CT scan, in contrast to 83% of patients without hydrocephalus. **Conclusion** Even though an increased frequency of hydrocephalus was noted among patients that presented with higher Fisher and Hunt-Hess grades, none of these grades were shown to bear a statistically significant predictive value in determining the propensity for the development of hydrocephalus.

Key words: Hydrocephalus, Subarachnoid hemorrhage, Fisher scale.

Introduction

A complete therapeutic approach to the treatment of subarachnoid hemorrhage (SAH) encompasses preventing re-rupture of the aneurysm, preventing and treating vasospasm, correcting metabolic abnormalities, preventing and treating seizures and hydrocephalus (1).

One of the well-recognized complications of subarachnoid hemorrhage is a hydrocephalus, that can be explained by alterations affecting the pia mater and arachnoid membranes. Therefore increased ICP, commonly seen after SAH, is usually the result of the increased resistance to cerebrospinal fluid outflow (2), which results from an acute obstruction of arachnoid granulations, the principal site of CSF absorption by red blood cells and fibrin cloths. Late hydrocephalus is probably a consequence of CSF flow obstruction at multiple points along the CSF pathways (3). Because it is plausible that acute hydrocephalus has a negative impact on the cerebral perfusion, hydrocephalus on the admission CT scan may be a risk factor for delayed ischemia as well, even though there are recent studies that dispute this conclusion (4). An acute hydrocephalus, commonly diagnosed by computerized tomography (CT) scan, is usually treated by placing an external ventricular drainage, whilst persisting form is commonly treated by ventriculoperitoneostomy (5, 6). Factors associated with the development of acute hydrocephalus upon SAH are not fully elucidated.

The goal of this review was to present the relative predictive values of Hunt-Hess grade and Fischer score in determining the propensity for developing post-hemorrhage hydrocephalus and to document the frequency of acute and chronic (shunt-dependent) hydrocephalus following subarachnoid hemorrhage.

Patients and methods

Data were retrieved from a prospectively collected database that sequentially encompassed all patients with aneurysmal SAH admitted to the Department of Neurosurgery at the University Clinical Center Tuzla. Patients were included in the study if they had been admitted between May 2003 and April 2007 and if the initial CT scan had been performed within 4 days upon the onset of SAH. Patients with evidence of subarachnoid hemorrhage caused by a different pathology than a ruptured aneurysm and patients with a negative angiography were excluded from the study.

The Hunt-Hess scale was used for the initial neurological status assessment (7). Aneurysmal SAH was diagnosed by the presence of blood in the basal cisterns on CT or by xanthochromia of the cerebrospinal fluid in combination with an aneurysm confirmed by conventional or CT angiography. The extent of subarachnoid hemorrhage was graded based on the Fisher scale (8) (Table 1). Patients with aneurysms revealed by angiography underwent either surgical occlusion on the aneurysm neck following cisternal irrigation or endovascular aneurysm occlusion.

Table 1 The Fisher scale of the extent of subarachnoid hemorrhage on CT

Group	Hemorrhage on CT
1	No hemorrhage evident
2	Diffuse or vertical layer of subarachoid hemorrhage < 1 mm thick
3	Localized clot and/or vertical layer of subarachnoid hemorrhage ≥ 1 mm thick
4	Intracerebral or intreaventricular clot, with or without a diffuse subarachnoid hemorrhage

Assessment of hydrocephalus was made on the basis of computed tomographic studies obtained from the day of admission to

48 months after SAH, 25 months (SD ±13 months) on average. Criteria indicating the occurrence of hydrocephalus were the size of both temporal horns (TH) ≥ 2 mm in width, the ratio FH/ID > 0.5 (where FH is the largest width of the frontal horns) and Evan's ratio > 30% (ratio of FH to maximal biparietal diameter). Patients with documented hydrocephalus were treated either by external ventricular drainage or by ventriculoperitoneostomy. The Glasgow Outcome Scale was used in documenting the degree of functional impairment upon completing the treatment.

Results

Associations among various factors and the occurrence of hydrocephalus after aneurysmal subarachnoid hemorrhage were evaluated retrospectively in 102 patients admitted to the Department of Neurosurgery of the University Clinical Center Tuzla for aneurismal subarachnoid hemorrhage, in the period between May 2003 and April 2007.

The mean age at presentation was 54.7 years, ranging from 30 to 87 years. Female to male ratio was 2.2:1 (Figure 1).

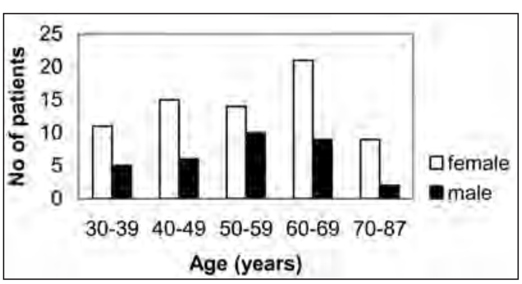

Figure 1 The distribution of patients according to age and gender

Table 2 depicts the interval between the onset of hemorrhage and admission. Ninety-one percent of patients were admitted within 72 hours of hemorrhage. Sixty seven percent of patients were graded as having Hunt-Hess grade 1, 2 or 3 at admission. In accordance, two-thirds of patients were in satisfactory neurological condition, including those admitted 72 hours upon the onset of hemorrhage or later.

In the group of patients admitted on the very day that the hemorrhage commenced, 64 % exhibited a favorable neurological status, whilst 70% of patients admitted between the first and third post-hemorrhage day exhibited a good neurological status. Among patients admitted 72 hours post-hemorrhage 67 % exhibited a favorable neurological status. A head CT scan at admission revealed a subarachnoid hemorrhage in 98% of patients (Table 2). The subarachnoid hemorrhage was diffuse in 66.6% of patients, of which 7.8 % had a thin (under 1mm) and 58.8 % had a thick (more than 1 mm) layer of hemorrhage. Intracerebral or intraventricular hematomas were present in 31.4 % of patients. There were twice as much female subjects as male patients and the influence of this selection bias on the results cannot be denied. Out of 102 patients with verified aneurysm, 100 patients were operated on by aneurysm neck occlusion following cisternal irrigation and 2 patients underwent aneurysm embolization.

Thirty-two percent of patients exhibited hydrocephalus requiring CSF diversion procedure (Table 3). External ventricular drainage was performed in 29 % of patients for early hydrocephalus. A permanent CSF diversion was required 14 % of patients. An average intracranial pressure value was 20.9 cm H_2O, as measured during the external ventricular drainage, ranging from 15-32 cm H_20. Three patients without prior external ventricular drainage developed hydrocephalus requiring a VP shunt.

Seventy percent of patients with acute hydrocephalus requiring external ventricular drainage were graded as 3, 4 or 5 according to the Hunt and Hess scale on admission, in contrast to 58 percent of patients without hydrocephalus. Ninety-three percent of pa-

Table 2 Hunt-Hess and Fisher grades on admission according to days after hemorrhage

*Hunt-Hess Scale (grades)	Day 0 No (%)	Day 1-3 No (%)	Day > 3 No (%)	Total No (%)
I	13 (22)	6 (17.6)	3 (33.3)	22 (21.5)
II	10 (16.9)	7 (20.5)	1 (11.1)	18 (17.6)
III	15 (25.4)	11 (32.3)	2 (22.2)	28 (27.4)
IV	18 (30.5)	8 (23.5)	3 (33.3)	29 (28.4)
V	3 (5.1)	2 (5.8)	–	5 (4.9)
°Fisher Scale (grades)				
I	2 (3.4)	–	–	2 (1.9)
II	6 (10.2)	1 (2.9)	1 (11.1)	8 (7.8)
III	29 (49.2)	25 (73.5)	6 (66.6)	60 (58.8)
IV	22 (33.9)	8 (23.5)	2 (22.2.)	32 (31.4)
Total	59 (57.8)	34 (33.3)	9 (8.8)	102 (100.0)

*T=3.175, P=0.0131; °T=1.907, P=0.1051

Table 3 Treatment modalities for early and late hydrocephalus

Treatment modality	Cases (N; %*)
External ventricular drainage	30 (29)
Ventriculoperitoneostomy	14 (14)

*Percent of 102 patients.

tients with hydrocephalus were graded as 3 and 4 according to Fisher grade on initial CT scan, in contrast to 83% of patients without hydrocephalus (Table 4).

The analysis of the extent of the subarachnoid hemorrhage, based on a head CT, revealed a good correlation between the outcome (as graded by GOS) and the amount of subarachnoid blood on CT. Patients that presented with diffuse hemorrhage on the initial CT scan exhibited a favorable outcome twice as often as compared to those that presented with intraventricular and intracerebral hemorrhage (Table 5). Distribution of blood on the initial CT scan was

Table 4 Predictive value of Hunt-Hess and Fisher grade for hydrocephalus

¹Hunt-Hess Scale (grades)	Patients without hydrocephalus No (%)	Patients with hydrocephalus No (%)	Total No (%)
I and II	31 (43)	9 (30)	40 (39)
III, IV and V	41 (67)	21 (70)	62 (61)
²Fisher Scale (grades)			
I and II	8 (11)	2 (7)	10 (10)
III and IV	64 (89)	28 (93)	92 (90)
Total	72 (100.0)	30 (100.0)	100 (100.0)

¹T=2.689, P = 0.115; ²T = 0.680, P = 0.5665

Table 5 Outcome as graded by GOS in relation to extent of hemorrhage

Fisher Scale (grades)	Good recovery No (%)	Moderate disability No (%)	Severe disability No (%)	Vegetative state No (%)	Lethal outcome No (%)	Total No (%)
I	2 (100.0)	–	–	–	–	2 (100.0)
II	8 (100.0)	–	–	–	–	8 (100.0)
III	33 (56.9)	8 (13.8)	9 (15.5)	–	8 (13.8)	58 (100.0)
IV	10 (29.4)	6 (17.6)	6 (17.6)	3 (8.8)	9 (29.4)	34 (100.0)
Total	53 (51.9)	14 (13.7)	15 (14.7)	3 (2.9)	17 (16.6)	102 (100.0)

Chi-square = 4.479; $p < 0.005$

one of the factors influencing the outcome in patients with SAH.

Conclusion and discussion

In spite of substantial progress in the treatment of intracranial aneurysms and subarachnoid hemorrhage over the past few decades, the severe disability rate continues to peak at 50 % level in SAH survivors, while 66 % of patients with successfully occluded aneurysms never achieve their original life quality (9, 10). Patients who survive an aneurysm rupture run the risk of a secondary rupture and repeated, even more prominent bleeding, or of developing angiospasm, hydrocephalus, seizures or metabolic disturbances (4).

CSF flow disturbance early after SAH is the principle cause of early hydrocephalus and is most likely caused by villi arachnoidales or ventricular obstruction by a blood clot. Late hydrocephalus is in fact a communicating form and usually develops days or weeks after SAH (3). The clinical significance of post SAH hydrocephalus remains poorly defined, with the recognized fact that hydrocephalus can cause cerebral perfusion pressure disorder, thus determining clinical status. Increased intracranial pressure upon SAH and intraventricular hemorrhage is usually caused by increased liquor flow resistance.

According to De Oliveira et al. (11) the Hunt and Hess grade, Fisher grade, acute hydrocephalus, intraventricular hemorrhage and angiographic vasospasm all pose significant risk factors for shunt dependency. Clipping of a ruptured aneurysm may be associated with a lower risk for developing shunt dependency, possibly by clot removal. This might influence the long-term outcome and surgical decision making (11).

Katano et al. (12) showed the difference in two different programmable valve shunt systems and mentioned their complications and revision rates, but they did not demonstrate limitations in the clinical efficacy of shunting for hydrocephalus. Temporary or permanent cerebrospinal fluid diversion is recommended in symptomatic patients and may improve clinical status in this group of patients (13). Ventriculostomy has been generally recommended for patients with acute hydrocephalus and diminished level of consciousness after SAH (14, 15, 16), although it was believed to increase the risk of rebleeding, until recent studies disputed this finding (17).

The predisposing factors leading to hydrocephalus after subarachnoid hemorrhage are not fully elucidated. This study assessed the predictive value of various factors for the development of this condition. Almost one third of patients in our study developed hydrocephalus severe enough to require CSF diversion procedure**.** Even though an increased frequency of hydrocephalus was noted among patients that presented with higher Fisher and Hunt-Hess grades, none of these grades were shown to bear a statistically significant predictive value in determining the propensity for the development of hydrocephalus. The analysis of the extent of subarachnoid hemorrhage, based on a head CT, revealed a good correlation between the outcome (as graded by GOS) and the amount of subarachnoid blood on CT.

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