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External ventricular drainage for acute obstructive hydrocephalus developing following spontaneous intracerebral haemorrhages

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Abstract There is no consensus in the literature on the effects of the development of hydrocephalus on survival and disability after intracerebral haemorrhage (ICH) and the benefits of external ventricular drainage (EVD). In this open, prospective study, we investigated the clinical courses, radiological findings and outcome scores of 47 consecutive patients who were admitted to our clinic with spontaneous ICH. Hydrocephalus developed in 6 (12.8%) of the 47 patients, and EVD was applied in these 6 cases. In one of the 6 patients, the lesion was additionally excised due to the large cerebellar haematoma. Intraventricular haemorrhage was more common in patients developing hydrocephalus (83.3% vs. 29.3% in patients without hydrocephalus; $p<0.05$) and the lesions of all the patients were in the proximity of the ventricular system. Hospital mortality and functional outcome were not significantly different between patients with and without hydrocephalus. Our results shows that acute obstructive hydrocephalus should be anticipated if haematoma is near the ventricle or if it is opening to the ventricle. EVD is a life-saving and effective procedure that should be performed in patients who develop hydrocephalus following spontaneous intracerebral haemorrhage.

Key words External ventricular drainage • Hydrocephalus • Intracerebral haemorrhage

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Introduction

Spontaneous intracerebral haemorrhage (ICH) is one of the most common causes of cerebrovascular disease (CVD). It is more common at young ages, is responsible for 10%–20% of all the CVD types and its mortality is higher compared to other types [1].

The most common etiological factor for ICH is hypertension [2]. Other causes are aneursyms, vascular malformations, amyloid angiopathy, anticoagulant treatment and clotting disturbances. Medical and surgical treatment options are evaluated by taking into account the size and localisation of the haematoma.

Hydrocephalus resulting from ICH is generally treated with external ventricular drainage (EVD) [3]. However, although appropriate treatment is offered, mortality rates are higher in this group [4, 5]. On the other hand, the clinical response to EVD and its effects on hydrocephalus are not known in detail. The efficacy of ventricular drainage can be evaluated by knowing the patients who will benefit from the treatment by clinical improvement and reversal of the hydrocephalus. The aim of this study was to investigate the efficacy and the results of EVD in hydrocephalus developing after ICH.

Material and methods

We studied 47 consecutive patients (32 men) who were hospitalised in Bayindir Medical Center, Ankara with a diagnosis of ICH between 1996 and 2000. The patients were aged 40–82 years (mean ± SD; 60.7±10.6). Patients with haemorrhages due to aneursym, arteriovenous malformations (AVM), tumours and haemorrhagic infarctions were excluded. At the time of admission, all the patients had computed tomography (CT) and routine blood tests including the determination of clotting factor levels. According to the clinical course, the patients went through repeat CT or cranial magnetic resonance imaging (MRI). Digital subtraction angiography, performed in 7 patients in order to exclude aneursym or AVM, revealed no sur-

gical abnormality. One neurologist (MS) measured haematoma volume, calculated using the formula 0.5 x a x b x c, with a and b being the largest perpendicular diameters measured on the initial CT scan and c being the slice thickness [6].

In order to provide airway patency and refrain from pulmonary complications, the necessary measures were undertaken in all patients. Endotracheal intubation and mechanical ventilation were used for the patients who had hypoventilation. In patients with blood pressure values above 135–150 mmHg, antihypertensive treatment was administered. The patients who were suspected to have an increase in intracranial pressure with clinical and radiological findings were administered mannitol and/or dexamethasone, yet hyperventilation was not applied. In patients demonstrating fever and metabolic problems, treatment was administered following the necessary investigations. All the patients were followed using the Glasgow coma scale (GCS). In patients whose neurological status was deteriorating, appropriate treatment was initiated following a diagnostic work-up.

If the clinical deterioration turned out to be due to hydrocephalus after obtaining clinical and radiological evidence, a ventriculostomy catheter (Phoenix external drainage set) was placed to the frontal horn of the right lateral ventricle. Daily microbiological analyses were performed on cerebrospinal fluid (CSF) samples. During the EVD, flow rate adjustments were made by changing the height of the drainage set. The patency of the system was checked with frequent intervals; in case of blockage, it was opened by pressure application. All patients who had ventricular catheters placed received prophylactic cephazoline. For the termination of ventricular drainage, the following criteria were evaluated: improvement of the clinical and radiological findings, reduction in the drainage flow rate, and clearance of the CSF colour. The GCS score was recorded in all patients before and after the procedure. The patients were evaluated on the Rankin scale at the time of discharge and six months after for daily life activities.

Student's *t* test was used for continuous variable and Fisher's exact test was used for noncontinuous data (SPSS for Windows).

Results

Hydrocephalus developed in 6 (12.8%) of the 47 patients with spontaneous ICH. The mean age of the patients who developed hydrocephalus was less than that of patients who did not, but the difference was not statistically significant (Table 1). The Glasgow coma scale scores at onset were also not significantly different between the two groups of patients. The mean haematoma volume of the patients who developed hydrocephalus was 16.9 cm^3, while it was 14.1 cm^3 for those without hydrocephalus (not significant).

The rates of independence in daily activities (Rankin scale score <2) were 63% (23 of 36 patients) at the time of discharge and 75% (27 of 36 patients), at the 6-month follow-up for patients who did not develop hydrocephalus (Table 1). For those patients who did develop hydrocephalus they were 20% (1 of 5) and 60% (3 of 5), respectively. The differences in Rankin scale scores between groups, at discarge or at 6 months, were not significant.

The most commonly encountered risk factor for ICH was hypertension, observed in 36 patients (77%). Other causes for ICH were anticoagulant usage (5 patients) and thrombolytic treatment due to acute myocardial infarction (2 patients). In 4 patients without an identifiable cause for ICH, the localisation of the haematoma was cortical and the possible diagnosis was amyloid angiopathy.

EVD was applied in the 6 patients who developed hydrocephalus (Table 2). In one of these patients, additional surgical interventions were carried out due to the presence of large cerebellar haematoma.

In all but one patient who underwent EVD for hydrocephalus after ICH, the haemorrhage was already opened to the ventricle (Table 2). Two of these patients had a cerebellar localization, while the others had a thalamic localization. In patients in whom hydrocephalus did not develop, haemorrhages were located in the thalamus (11 patients), lobar (11), putamen (n=10), pons (n=4), caudate (n=3) and cerebellum (n=2). Within these 41 patients, 12 had extension of the haemorrhage into the ventricle. Significantly more patients with hydrocephalus had ventricular haemorrhage (p=0.02).

The deterioration in neurological status was observed as blurring and loss of conscience in all hydrocephalus

Table 1 Clinical characteristics of the 47 patients with spontaneous intracerebral haemorrhage, according to the subsequent development, or not, of hydrocephalus. Values are mean (SD; range) unless otherwise noted. No differences between groups are significant

	Hydrocephalus (n=6)	No hydrocephalus (n=41)
Age, years	53.5 (11.2; 36–65)	61.7 (10.2; 40–82)
GCS score at onset	10.7 (2.0; 8–14)	11.6 (3.4; 3–15)
Haematoma volume, cm^3	16.9 (15.3; 1.7–35.0)	14.1 (14.5; 0.8–52.0)
Independence in daily activities, % of patients[a]		
Discharge	20[b]	63[c]
6-month follow-up	60[b]	75[c]

[a] Rankin scale score <2
[b] For 5 patients
[c] For 36 patients
GCS, Glasgow coma scale

patients. All these patients had ventricular enlargement, disappearance of sulci and brain oedema on CT. None of the patients experienced infection or obstruction of the catheter that necessitated a revision. The development of hydrocephalus and the initiation of EVD occurred within first 96 hours following the haematoma. In order to evaluate the response to drainage, post-procedure CT scans were obtained within 24 hours and compared with those obtained initially (Fig. 1).

Of 6 patients who had a drainage, 1 (16.7%) died during the hospitalization. In this patient, posterior fossa decompression was performed in addition to the drainage; however he died on the fortieth day of hospitalization. Due to the high doses of anticoagulants that he was utilising, the haemorrhages could not be stopped. Of the 41 ICH patients who did not undergo drainage, 5 (12.2%) died during hospitalization. The difference in mortality rates was not statistically significant between the two groups (p=0.6).

Table 2 Characteristics to the 6 patients who developed hydrocephalus

Age, years	Sex	Localisation	GCS score			EVD initiation, h[a]	Rankin scale score		Ventricular haemorrhage
			Admission	Before EVD	After EVD		Discharge	6 months	
58	M	Thalamic	11	7	10	48	3	0	+
64	M	Cerebellar	14	8	14	8	2	0	–
52	F	Thalamic	8	5	7	72	5	5	+
36	M	Thalamic	10	7	8	96	4	3	+
46	M	Cerebellar	10	4	6	24	Exitus	–	+
65	M	Thalamic	11	7	10	48	4	2	+

GCS, Glasgow coma scale; *EVD*, external ventricular drainage

[a] Time interval between ICH and EVD

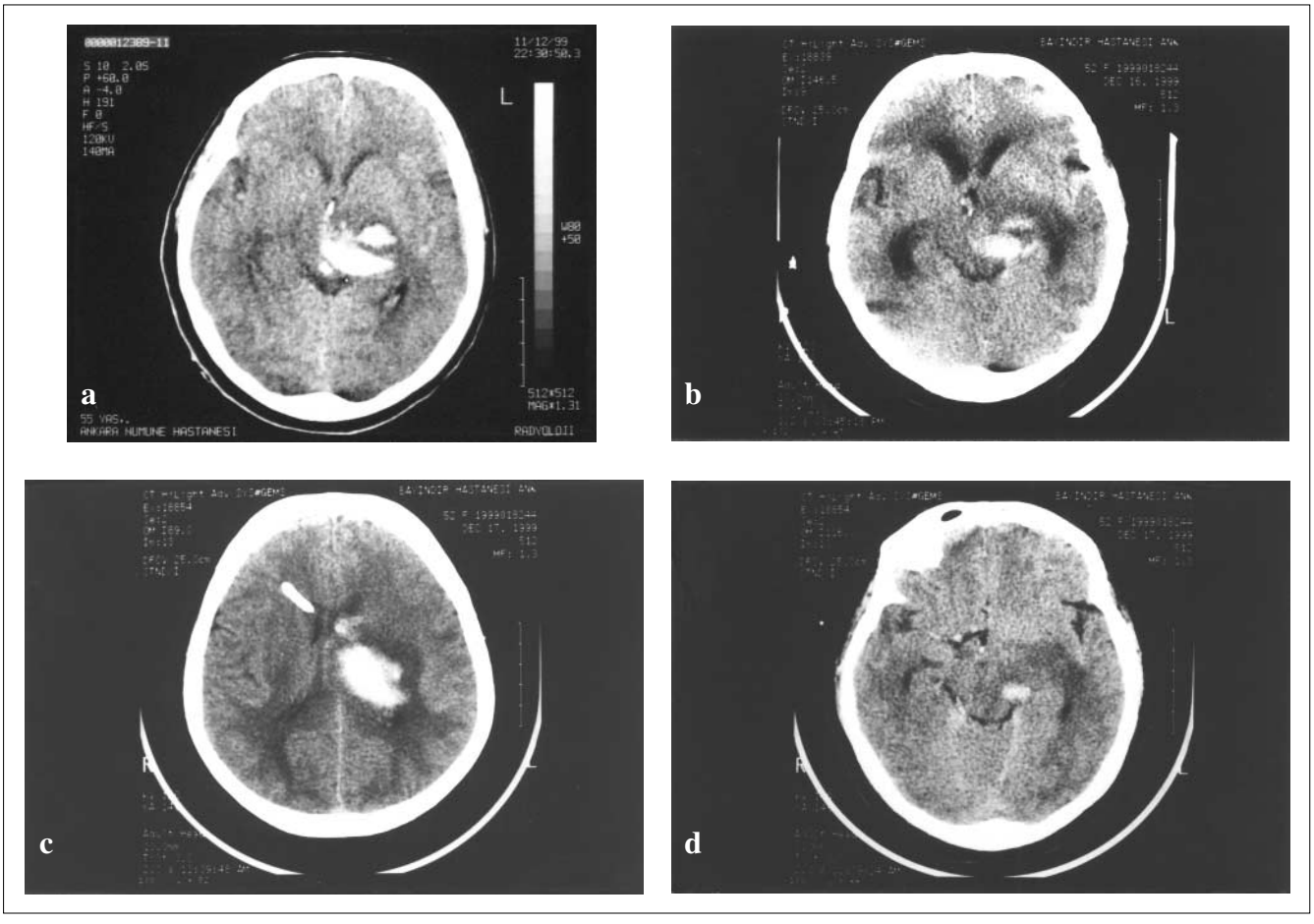

Fig. 1a-d *CT imaging of hydrocephalus treated by external venticular drainage (EVD).* **a** Thalamic haematoma obstructing the aqueduct. **b** The evolution of hydrocephalus. **c** Inserting a catheter into right lateral ventricle. **d** After EVD, at the same level

Discussion

Intracerebral haemorrhage is a devastating disorder with high mortality and morbidity rates. The factors affecting the prognosis are: the age of the patient, the size and the localisation of the haemorrhage, the state of consciousness of the patient, the presence of midline shift and the opening of the haemorrhage to the ventricle [7–12]. Hydrocephalus is an independent risk factor with a negative impact on the prognosis [4–13].

The most important factors for depicting the development of hydrocephalus following ICH are the localisation of the haemorrhage and its opening to the ventricular system[14]. Hydrocephalus can easily develop following the compressions of aquaductus cerebri in small thalamic haemorrhages and fourth ventricle and basal systems in cerebellar haemorrhages, yet it is quite rare in ganglionic haemorrhages.

In the 6 patients with hydrocephalus, 4 had thalamic and 2 had cerebellar haemorrhages, all close to the ventricles. Opening of haemorrhage to the ventricle was present in 5 (83.3%) of the 6 patients who developed hydrocephalus. However this was only present in 12 (29.3%) of the 41 patients who did not develop hydrocephalus; this difference was statistically significant ($p<0.05$). In one study, the frequency of hydrocephalus following supratentorial haemorrhages was 50% [13]. This seems to be a quite high rate. In the present study, the rate of hydrocephalus was 10% for supratentorial haemorrhages and 20% for infratentorial haemorrhages; the overall incidence was 12.8%.

There is no consensus in the literature for the effects of hydrocephalus on survival and disability after ICH. The hospital mortality was reported to be 2% for ICH patients without hydrocephalus whereas it was 50% for those having hydrocephalus [13]. Another study reported the hospital mortality rate to be 73% for patients who develop hydrocephalus after ICH [3]. However, other reports claim that hydrocephalus does not increase mortality rates [4, 15]. In our study, hydrocephalus did not affect hospital mortality significantly. When evaluated with daily life activity scales, patients without hydrocephalus had a better functional outcome, yet the difference was not statistically significant.

For hydrocephalus developing after ICH, EVD is a rapid and effective treatment. Its main advantage is that it can even be performed in the emergency room without removing the patient from the bed. However, there is no consensus in the literature, in terms of the benefit of the procedure. Some studies have stated that EVD does not lead to a better prognosis [3, 13], these studies did not report in detail when EVD was performed following hydrocephalus. It is well known that long-term increased intracranial pressure results in irreversible damage of the brain. However, EVD cannot reverse the size of the parenchymal bleeding, the ischaemic changes surrounding the haemorrhage or the adverse effects of the intraventricular haemorrhage on the patient's clinical outcome.

In this study, in patients with hydrocephalus, EVD was performed within hours after investigating the factors that could aggravate the clinical situation and carefully eliminating them. Deterioration due to hydrocephalus developing after ICH was observed within the first four days (in 4 of 6 patients, within 2 days). We believe that the low mortality rates and good functional outcomes in our study are related to performing EVD shortly after the development of hydrocephalus. This success also belongs to the close work and collaboration between the Neurology and Neurosurgery Departments.

The small number of patients and the lack of controls in our study restrict the applicability of the results. Further studies with larger patient populations are needed to clarify our observations.

Sommario *Non c'è consenso in letteratura sugli effetti dell'idrocefalo conseguente a emorragia intracerebrale (ICH) su sopravvivenza e disabilità e sui vantaggi di un drenaggio ventricolare esterno (EVD). In questo studio prospettico in aperto abbiamo investigato decorso clinico, reperti radiologici e punteggi di outcome in 47 pazienti ricoverati consecutivamente nella nostra clinica per ICH spontanea. Un idrocefalo si sviluppò in 6 pazienti su 47 (13%). L'EVD fu effettuato nei 6 pazienti con idrocefalo, in un paziente, inoltre, venne condotto un intervento sulla lesione a causa di un grosso ematoma cerebellare. Nei pazienti che svilupparono idrocefalo l'emorragia intraventricolare risultò più frequente (83% contro 12%; p<0.05) e la lesione era in prossimità del sistema ventricolare. La mortalità durante la degenza e l'outcome funzionale non risultarono significativamente diversi nei due gruppi di pazienti con o senza idrocefalo. I nostri risultati dimostrano che lo sviluppo di idrocefalo ostruttivo può essere previsto se l'ematoma è vicino al ventricolo o se comunica col ventricolo. L'EVD è una procedura salvavita ed efficace.*

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