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Lumbar puncture for treating acute hydrocephalus after aneurysmal subarachnoid haemorrhage

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ABSTRACT

Background: External ventricular drainage (EVD) for acute hydrocephalus after aneurysmal subarachnoid haemorrhage (aSAH) carries a risk of complications. We studied the proportion of patients in whom EVD can be avoided by treating acute hydrocephalus with ≥1 lumbar punctures (LP).

Methods: From a prospectively collected database, we retrieved data on all aSAH patients admitted between 2007 and 2017 who developed acute hydrocephalus (i.e. neurological deterioration and ventricular enlargement <72 h after aSAH). Our regime is to consider LP as initial treatment. We calculated the proportions of patients (with corresponding 95% confidence interval (CI)) who improved after the initial LP and the extent of clinical improvement, the proportions of patients who were treated with only ≥1 LP(s), and those of patients needing continuous external ventricular or external lumbar drainage, or permanent ventriculoperitoneal or lumboperitoneal drainage.

Results: Of 1391 consecutive aSAH patients, 473 (34%) had acute hydrocephalus, of whom 388 (82%) were treated. Of the 86 patients with LP as initial treatment, 70 (81% [95% CI 72–88]) showed initial improvement (with increase in median Glasgow Coma Score from 10 (IQR 7–12) to 12 (IQR 9–14) after initial LP), 39 (45% [95% CI 35–56]) improved with LP only, 41 (48% [95% CI 37–58]) needed continuous drainage and six (7% [95% CI 3–14]) needed permanent drainage.

Conclusion: Around half the patients treated with LP for deterioration from acute hydrocephalus after aSAH does not require continuous extraventicular or extralumbar drainage.

1. Introduction

Acute hydrocephalus occurs in up to 40% of patients with aneurysmal subarachnoid haemorrhage (aSAH) [1,2]. Extraventricular drainage (EVD) is the treatment for acute hydrocephalus in aSAH patients recommended by guidelines [3,4]. However, EVD catheter treatment carries a risk of complications, such as haemorrhages or infections, both in approximately 5–10% of patients [5–7]. In patients without a space occupying intracerebral or subdural extension of the haemorrhage and no obstruction of the third or fourth ventricle, lumbar puncture is an alternative treatment for acute hydrocephalus [8]. Our institutional approach is to consider lumbar puncture (LP) first before inserting an EVD. We assessed the clinical efficacy of LP as treatment of acute hydrocephalus after aSAH and the proportion of patients in whom EVD can be avoided by treating acute hydrocephalus with ≥1 LP.

Abbreviations: EVD, External Ventricular Drainage; aSAH, Aneurysmal Subarachnoid Haemorrhage; LP, Lumbar Puncture; CI, Confidence Interval; GCS, Glasgow Coma Scale; IQR, Interquartile Range; CTA, Computed Tomography Angiography; MRA, Magnetic Resonance Angiography; DSA, Digital Subtraction Angiography; UMCU, University Medical Center Utrecht; RBCI, Relative Bicaudate Index; GOS, Glasgow Outcome Scale; PAASH, Prognosis on Admission of Aneurysmal Subarachnoid Haemorrhage; ELD, External Lumbar Drainage; VP, Ventriculo-peritoneal; CSF, Cerebrospinal Fluid; CT, Computed Tomography.

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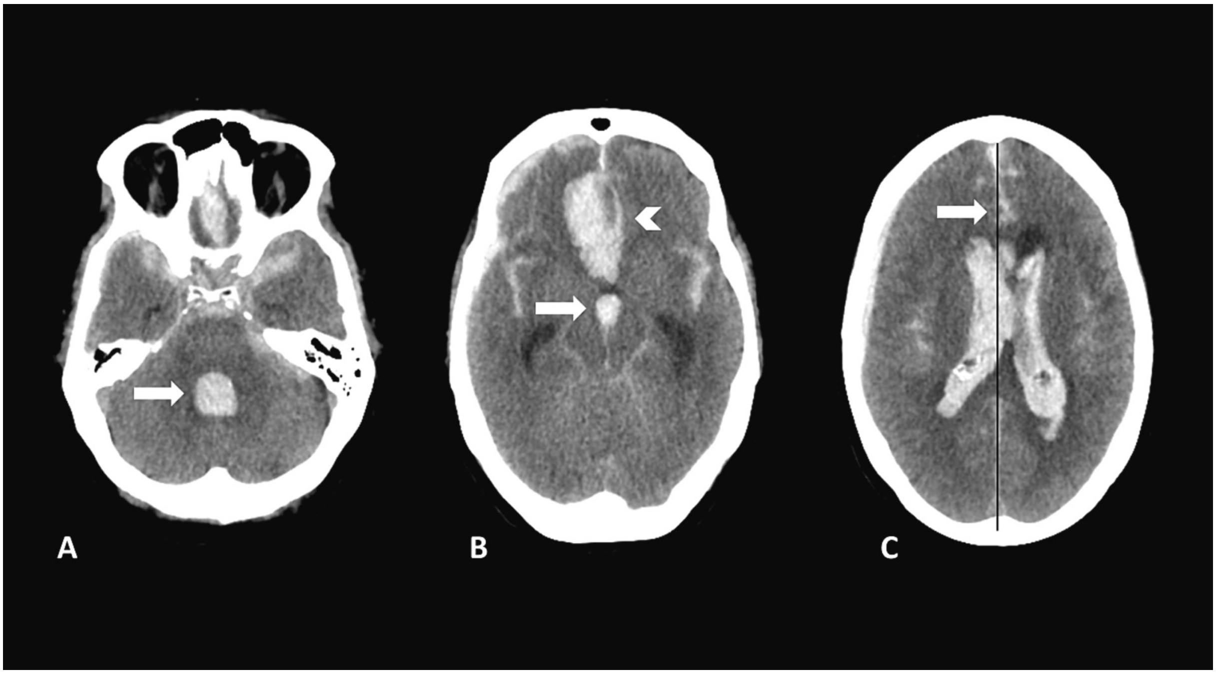

Fig. 1. CT scan of SAH patient showing absolute contraindications for lumbar puncture. A: complete filling of fourth ventricle with blood. B: complete filling of third ventricle with blood (closed arrow) and space-occupying intracerebral haematoma (closed arrowhead). C: midline shift caused by intracerebral haematoma.

2. Methods

From our prospectively collected database, we retrieved data of consecutive aSAH patients admitted between July 1st, 2007 and July 1st, 2017.

2.1. Inclusion and exclusion criteria

The inclusion criteria were: 1) subarachnoid haemorrhage from a proven aneurysm (by computed tomography angiography (CTA), magnetic resonance angiography (MRA), or digital subtraction angiography (DSA)); 2) admission to the University Medical Center Utrecht (UMCU) within 72 h after ictus; and 3) acute hydrocephalus (defined as a neurological deterioration (i.e. decrease of at least one point on Glasgow Coma Scale (GCS)) and relative bicaudate index (RBCI) >1 on CT within 72 h after aSAH) [11].

2.2. Standard of care

In our institution, there is a 30 years tradition to first consider LP as treatment for patients deteriorating from acute hydrocephalus, before inserting an EVD [5], although there is some practice variation with some of the clinicians feeling more confident with LP than others. When LP is indicated, we aim to remove approximately 25–30 cc of CSF. According to our institutional protocol initial treatment through LP is strictly contraindicated in case of complete filling of the third or fourth ventricle with blood or a space occupying intracerebral or subdural haematoma, causing midline shift (Fig. 1). In patients with poor condition from the outset, we usually prefer an EVD as standard treatment.

2.3. Data collection

The following data were extracted: age, sex, GCS score (on admission, before LP, within 6 h after LP), amount of extravasated subarachnoid blood according to the Hijdra score on admission [10],(6) bicaudate index (on admission, on last CT before LP, again if CT was performed <24 h after LP), number of LPs, EVD insertion, time of EVD insertion, permanent drainage (ventriculoperitoneal or lumboperitoneal shunt) and Glasgow Outcome Scale (GOS) score at 3 months [12]. Poor outcome was defined as a GOS score of 1–3 at 3 months. We derived Prognosis on Admission of Aneurysmal Subarachnoid Haemorrhage (PAASH) score from GCS and relative BCI from BCI [9,11].

2.4. Statistical analysis

First, we calculated within the group of patients who had LP as first line treatment the proportion (with 95% CI) of patients who showed clinical improvement after initial LP, and the extent of the clinical improvement through GCS. Wilcoxon signed ranked test was used to compare GCS before and after initial LP. Second, we calculated the proportion of patients treated with one or more LPs only, and the proportion of patients needing continuous drainage (through either EVD or External Lumbar Drainage (ELD)), or permanent drainage.

The institutional research ethics board decided that no formal assessment was needed because of the retrospective design of the study.

3. Results

Of 1391 aSAH patients admitted during the study period, 473 (34%) had acute hydrocephalus, of whom 388 were treated (82%) (Fig. 2).

In 86 patients (22% [95% CI 18–27]) the initial treatment was LP, and in 85 patients (18%) no intervention was performed. Reasons for no intervention were: spontaneous improvement of mild hydrocephalus ($n = 44$) or withdrawal of care because of poor prognosis ($n = 41$).

3.1. Initial treatment with lumbar puncture

Table 1 shows clinical characteristics of the 86 patients with LP as initial treatment. Of these 86 patients, 70 (81% [95% CI 72–88]) showed clinical improvement after the first LP. Median GCS score increased from 10 (IQR 7–12) before initial LP to 12 (IQR 9–14) after LP ($p < 0.05$), while median rBCI improved from 1.33 ($n = 86$) before to 1.25 ($n = 33$) after initial LP (Fig. 3). Fig. 2 shows the clinical course of those 86 patients. Of them, hydrocephalus resolved after treatment with LP in 39 patients (45% [95% CI 35–56]), of whom 34 (40% [95% CI 30–50]) only required one LP, while the remaining 5 (6% [95% CI 3–13]) required

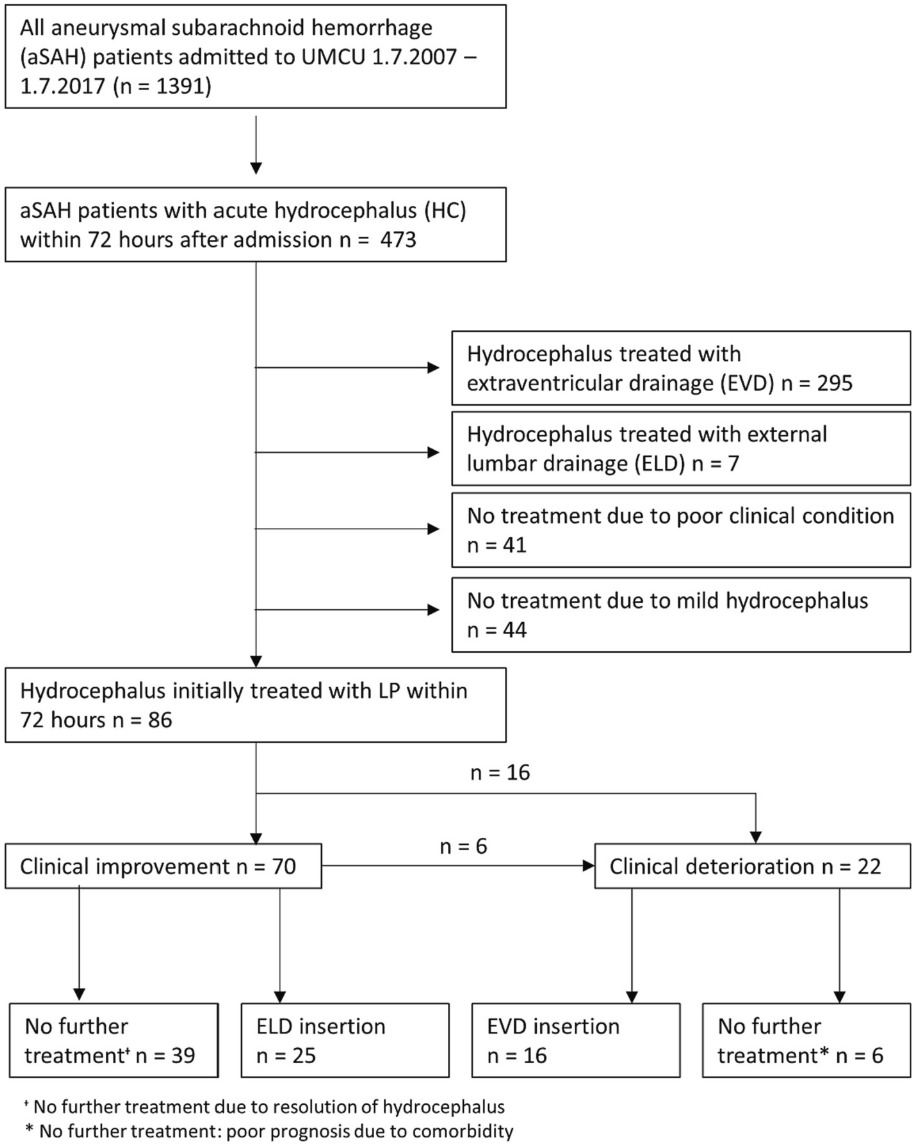

Fig. 2. Flowchart of study population.

two LPs. Twenty-five patients (29% [95% CI 21–39]) showed insufficient clinical improvement after LP(s) and were eventually treated through ELD. Twenty-two patients (26% [95% CI 18–36]) showed clinical deterioration, 6 (7% [95% CI 3–14]) of whom after initial improvement. Of them, 16 (19% [95% CI 12–28]) were treated through EVD. In the remaining 6 patients (7% [95% CI 3–14]), all treatment was halted due to comorbidities beyond hydrocephalus.

3.2. Chronic shunt-dependent hydrocephalus

In our cohort of 86 patients treated through LP, six patients (7% [95% CI 3–14]) eventually developed chronic hydrocephalus and were treated through VP-shunting. Of these, 2 patients were treated by LP only, 2 patients were treated by LP and subsequent ELD and 2 patients were treated with LP and subsequent EVD. Median time between ictus and VP-shunting was 32 days (range 22–48 days).

4. Discussion

In our cohort, 34% of aSAH patients had hydrocephalus during the first 72 h after admission, which is in line with previous estimates of incidence of acute hydrocephalus after aSAH.(1,2) In one out of every 10 patients with acute hydrocephalus, patients improved without any intervention. Almost half the patients who were initially treated with LP for deterioration from acute hydrocephalus improved without further need for external drainage. In our study population, only 7% of patients treated with LPs eventually developed shunt-dependent hydrocephalus, which is lower than proportions reported in the literature [13]. However, because we did not include patients with massive intraventricular haemorrhage or blood in the 4th ventricle (Fig. 1), we cannot conclude that LP may decrease the risk of shunt-dependency. Treatment of acute hydrocephalus was considered only in patients with a decreased level of consciousness and enlarged ventricles. Thus, we do not think that the good prognosis in patients treated with LP is explained by treatment of very mild instances of hydrocephalus.

Acute hydrocephalus is an independent risk factor for cognitive deficits following aSAH [14]. One might assume that the pressure lowering from LP is less than EVD and therefore patients remain at higher risk of cognitive deficits after LP. Two small series of patients from two decades ago showed that patients treated through LP or EVD for acute hydrocephalus were both at risk for developing cognitive deficits [14,15]. How these risks compare requires further study.

This study has limitations. Because of the retrospective design, the study is subject to selection bias. Also, this is a monocenter study and

Table 1
Characteristics of the aSAH patients treated for acute hydrocephalus withlumbar puncture.

Variable	All patients (n = 86)	No EVD placement (n = 70)	EVD placement (n = 16)
Females	60 (70%)	46 (66%)	14 (88%)
Age (median (range))	67 (32–88)	66 (35–88)	68 (32–80)
Aneurysm diameter (mm, mean (range))	6 (1–17)	5.6 (1–17)	6.7 (3−13)
Aneurysm location			
- Anterior circulation	51 (59%)	41 (59%)	10 (63%)
- Posterior circulation	35 (41%)	29 (41%)	6 (38%)
PAASH on admission			
- I	13 (15%)	12 (17%)	1 (6%)
- II	49 (57%)	42 (60%)	7 (44%)
- III	9 (11%)	6 (9%)	3 (19%)
- IV	8 (9%)	6 (9%)	2 (13%)
- V	7 (8%)	4 (6%)	3 (19%)
Improvement after initial LP	70 (81%)	64 (91%)	6 (38%)
More than one LP performed	25 (29%)	20 (29%)	5 (31%)
GCS before LP (median (IQR))	10 (7–12)	10 (7–12)	9 (7–10)
GCS after LP (median (IQR))	12 (9–14)	13 (10–14)	10 (7–11)
Hijdra sum score (median (IQR))	23 (16–29)	23 (16–28)	26 (18–30)
RBCI before LP (median (IQR)) (n = 86)	1.33 (1.17–1.47)	1.33 (1.19–1.46)	1.32 (1.15–1.48)
RBCI after LP (median (IQR)) (n = 33)	1.25 (1.05–1.47)	1.25 (1.01–1.47)	1.29 (1.08–1.65)
GOS 3 months			
1	16 (19%)	13 (19%)	3 (19%)
2	3 (4%)	2 (3%)	1 (6%)
3	21 (24%)	15 (21%)	7 (44%)
4	21 (24%)	18 (26%)	3 (19%)
5	25 (29%)	22 (31%)	2 (13%)
Poor outcome at 3 months	40 (47%)	29 (41%)	11 (69%)
Shunt-dependency (VP-shunt)	6 (7%)	4 (6%)	2 (13%)

LP, lumbar puncture; PAASH, Prognosis on Admission of Aneurysmal Subarachnoid Haemorrhage score; RBCI, relative bicaudate index; GOS, Glasgow Outcome Scale; VP, ventriculoperitoneal.

therefore the results may not be directly generalizable to other centers. Third, although according to our institutional protocol LP should be considered in patients with acute hydrocephalus after SAH, there is inevitably practice variation because some of the clinicians feel more confident with LP than others. The strength of this study is that we presented data of a consecutive patient series over a long study period.

For clinical practice, our results imply that patients deteriorating from hydrocephalus after aSAH can be treated by only lumbar puncture if a patient shows no absolute contraindications on plain head computed tomography (CT). Further treatment through ELD or EVD can be

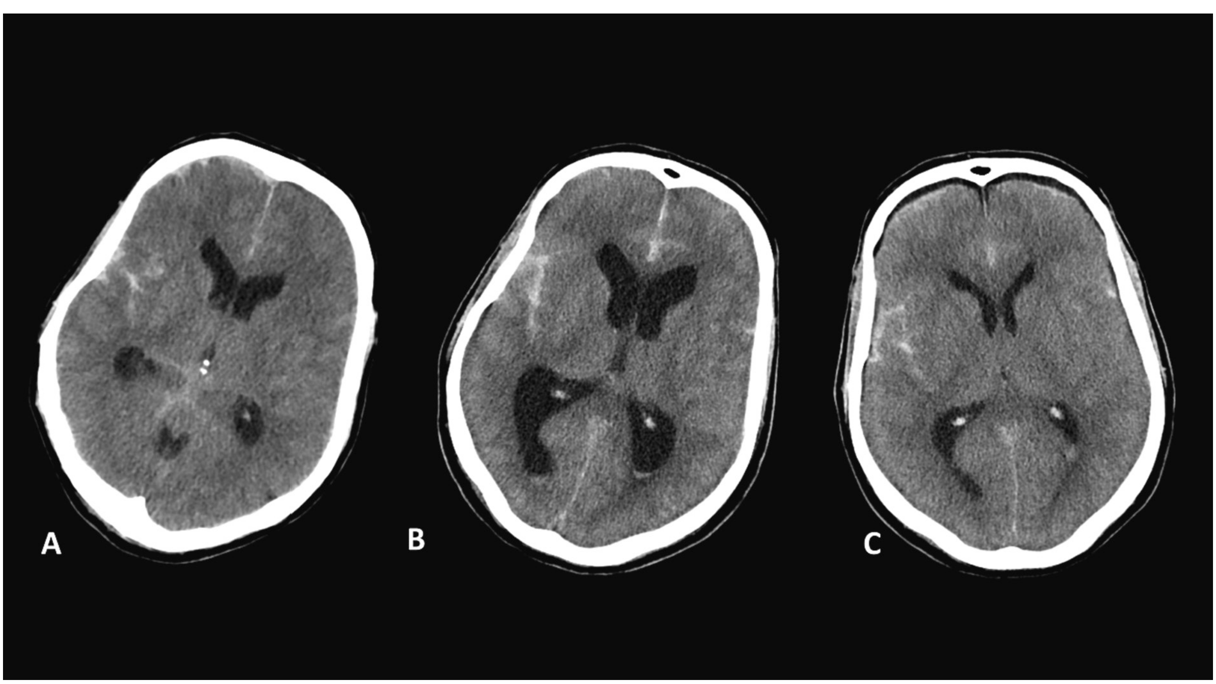

Fig. 3. Case illustration of LP-treated SAH patient. A: CT scan upon admission. Glasgow Coma Scale on admission was E3M6V5, imaging shows slight ventricular enlargement. CT-angiography (not shown here) revealed aneurysm of internal carotid artery (ICA), treated the same day by endovascular coiling. B: CT scan made 12 h post-coiling after clinical deterioration to E1M5V2, showing substantial ventricular enlargement due to hydrocephalus. Patient is treated through single LP, upon which patient improved to E3M6V4. C: CT scan made 7 h after LP; hydrocephalus has resolved.

avoided in almost half of these patients and should depend on clinical improvement after one or multiple LPs. Although 22 patients initially treated with LP deteriorated and needed an EVD, and therefore adequate hydrocephalus treatment was delayed, we believe that the advantage of avoiding EVD in 69 patients (74%) outweighed this disadvantage.

Further studies are needed to clarify whether treatment with LP, with potentially lesser or shorter reduction of intracranial pressure, or external drainage with risk of infectious or haemorrhagic complications is better in terms of cognitive outcome after SAH.

Informed consent and patient details

The institutional research ethics of board of our institution decided that no formal assessment was needed because of the retrospective design of the study. No individual patient consent was sought after because all patient data was previously collected and anonymized.

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Declaration of Competing Interest

The authors report no relevant conflict of interest.

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