Acta Anaesth. Bel., 2024, 75 | Suppl. 1: 1-5

Masterthesis / Original study

Localization of subarachnoidal hemorrhage and outcome: a retrospective, single center analysis

I. Bollen[1], X. Willaert[1], L. Stockx[2], T. De Beule[1], D. Mesotten[1], T. Fivez[1]

[1]Department of Anaesthesiology & Intensive Care Medicine, ZOL-Genk, Genk, Belgium; [2]Department of Medical Imaging, division Interventional Radiology, ZOL-Genk, Genk, Belgium.

Corresponding author: Tom Fivez, MD PhD. Department of Anaesthesiology & Intensive Care Medicine, Ziekenhuis Oost Limburg Genk, Synaps Park 1, 3600 Genk, Belgium. Email: tom.fivez@zol.be

Abstract

The outcome of acute subarachnoidal haemorrhage (aSAH) is highly variable and depends on the severity of the aSAH. The brain is characterized by an anterior and posterior cerebral circulation, which are interconnected through the circulus of Willis. An ischemic stroke in the posterior circulation has a different presentation and outcome, compared with an ischemic stroke in the anterior circulation.
We hypothesized that aSAH in the posterior circulation results in a worse outcome, compared with an aSAH of the anterior circulation.
This retrospective single center study analyzed patients who underwent a surgical procedure for aSAH from January 2017 until December 2021 at the Ziekenhuis Oost- Limburg' ZOL, Genk, Belgium. Length of ICU and hospital stay and hospital mortality were the main outcome variables.
Patients with an aSAH in the posterior circulation had a higher World Federation of Neurosurgical Societies (WFNS) and Fisher grade on admission. Higher WFNS grade resulted in longer duration of stay in ICU and hospital, and in a higher mortality rate. However, in multivariable logistic regression analysis the localization of the aSAH was not independently associated with mortality.
While patients with an aSAH, deriving from an aneurysm in the posterior circulation, had a higher severity of stroke upon admission and a more complicated trajectory in the hospital the posterior localization was not independently associated with worse outcome.

Keywords: **Aneurysmal subarachnoid hemorrhage, outcome, critical care.**

Introduction

Survival after acute subarachnoid haemorrhage (aSAH) has increased over the last decades due to better diagnosis, early aneurysm repair and advanced intensive care support[1]. Globally the incidence has also decreased from 10 per 100000 person-years in 1980 to 6 per 100000 person-years in 2010[2,3]. Nevertheless, the outcome can vary between full recovery and death or severe neurologic disability. The management of aneurysm can be done either by surgical clipping or by endovascular coiling[4,5,6]. A previous single center study by our group showed that severe grade aSAH resulted in higher short term healthcare costs and lower functional outcomes at 1 year[7].

In ischemic stroke the ischemic posterior circulation stroke differs strongly from an ischemic anterior circulation stroke. The clinical presentation of a ischemic posterior circulation stroke is often stuttering, with fewer cortical symptoms. Vertigo, dizziness, diplopia, headache, unilateral limb weakness, alteration in consciousness are more often at the forefront[8,9]. Also the outcome of ischemic posterior circulation stroke is more variable. Patients with posterior circulation strokes may have an unfavorable 3-month outcome despite relatively low National Institutes of Health Stroke Scale (NIHSS) scores[10]. Unfortunately, clinical

Ethical approoement: All protocols were approved by the institutional board of Ziekenhuis Oost-Limburg. Informed Consent was waived by institutional board and ethical committee of Ziekenhuis Oost-Limburg due to retrospective nature of the study.

and imaging grading scales, such as the Hunt Hess scale, WFNS scale and Modified Fischer scale, do not take into account the localisation of the aneurysm[11,12].

The brain is characterized by an anterior and posterior cerebral circulation, which are interconnected through the circulus of Willis. The anterior cerebral circulation is the blood flow to the anterior part of the brain through the internal carotid, which branches into the anterior cerebral artery and continues into the middle cerebral artery. The posterior cerebral circulation is responsible for the blood supply to posterior portion of the brain, comprising the occipital lobes, the cerebellum and brainstem. The vertebral arteries fuse into the basilar artery. The basilar artery then branches into the left and right posterior cerebral arteries.

In this retrospective analysis we evaluated if localisation (anterior versus posterior cerebral circulation) of the aneurysm after an aSAH would affect hospital mortality.

Materials and methods

Data collection

This retrospective single center study analyzed patients who experienced an aSAH and underwent a surgical procedure (clipping or endovascular repair) from January 2017 until December 2021 at the Ziekenhuis Oost- Limburg' ZOL, Genk, Belgium. It is a follow-up study of Timmers M et al[7]. Approval by the ethics committee was waived by the ethics committee itself at it was a retrospective analysis which are not in the scope of the Law of 7th May 2004.

Over this period 225 patients were screened for eligibility. Fourteen patients were excluded because they underwent an elective endovascular therapy without an aSAH. Hence, 211 patients were included in the analysis. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines on retrospective analyses was used as a guidance.

Through examination of the hospital records the following patient baseline characteristics were collected: sex, age, body mass index, pre-aSAH overall function (three grades: independent, partially dependent, care dependent), aneurysm localization and maximal diameter, World Federation of Neurosurgical Societies (WFNS) grade and the Fisher and modified Fisher (mFisher) score, as well as type of endovascular therapy, classified as coiling, clipping, flow disruptor, flow diverter or a combination of these types.

The localization of the aneurysm was classified into either posterior cerebral circulation (basilar artery, posterior communicating artery and posterior cerebral artery) or anterior cerebral circulation (internal carotid artery, anterior cerebral artery, middle cerebral artery, anterior communicating artery). Multi-location aneurysms over the two cerebral circulations were neither classified nor taken into account.

Post-procedural variables comprised: need of mechanical ventilation and its duration (in hours), need of vasopressor support and its duration (in hours) and the presence of vasospasm systematically investigated by transcranial color-coded duplex sonography. Treatment aggressiveness was assessed by the need for placement of ventricular drainage and the need for decompressive craniectomy. Length of intensive care unit (ICU) and hospital stay (both in days) and hospital mortality were the outcome variables.

Statistical analyses

Categorical data were presented as numbers and percentages, and compared by a chi square or Fisher exact test. Normally distributed data were represented as mean (SD) and compared by student's t-test or one-way ANOVA, while non-Gaussian data were represented as median (IQR) and compared using the Mann-Whitney/ Kruskal-Wallis test. Ordinal data (WFNS, Fisher and mFisher) were not converted to numerical variables. A logistic multivariable model was constructed to test whether aneurysm localization could independently contribute to the risk of mortality. Two-sided p-values of <0.05 were deemed statistically significant. Analyses were conducted in JMP Pro, version 17.0.0 (SAS Institute Inc, Cary, NC, USA).

Results

Baseline characteristics

The baseline characteristics of the total patient population are described in Table I. In 73 patients (35%) the aneurysm was localized in the posterior circulation. The patients with an aSAH of the posterior circulation were younger, had a higher proportion of females and had a higher WFNS and Fisher grade.

Localization

Four (2%) patients had multi-location aneurysms and in 1 patients the aneurysm localization was not recorded. The anterior localization consisted of 82 (39%) patients with anterior cerebral artery aneurysm, 37 (18%) patients with an aneurysm of the middle cerebral artery and 14 (7%) patients with an internal carotid artery aneurysm.

Table I. — Baseline characteristics of the patient population.

	Overall population	Posterior circulation (n=77)	Anterior circulation (n=139)	p-value
Sex, female, n (%)	144 (69)	59 (81)	85 (63)	0.01
Age, years, mean (SD)	58 (14)	56 (14)	61 (13)	0.027
BMI, kg/m², mean (SD) Missing n=8	26 (5)	26 (5)	25 (5)	0.17
Hypertension pre-aSAH, n (%) Missing n=2	71 (34)	29 (40)	42 (32)	0.23
Pre-aSAH function Missing n=5				0.69
Independent, n (%)	201 (97)	70 (99)	128 (97)	
Partially care dependent, n (%)	4(2)	1 (1)	3 (2)	
Care dependent, n (%)	1 (0.5)	0 (0)	1 (1)	
WFNS grade Missing n=4				0.02
Grade 1, n (%)	90 (43)	21 (29)	67 (52)	
Grade 2, n (%)	34 (16)	15 (21)	19 (15)	
Grade 3, n (%)	9 (4)	4 (5)	5 (4)	
Grade 4, n (%)	20 (10)	7 (10)	12 (9)	
Grade 5, n (%)	54 (26)	26 (36)	27 (21)	
Fisher grade Missing n=4				0.01
Grade 1, n (%)	9 (4)	5 (7)	3 (2)	
Grade 2, n (%)	27 (13)	4 (5)	22 (17)	
Grade 3, n (%)	40 (19)	11 (15)	29 (22)	
Grade 4, n (%)	131 (63)	53 (73)	76 (58)	
mFisher grade Missing n=4				0.12
Grade 1, n (%)	36 (17)	9 (12)	25 (19)	
Grade 2, n (%)	33 (16)	15 (21)	17 (13)	
Grade 3, n (%)	49 (24)	13 (18)	36 (28)	
Grade 4, n (%)	89 43)	36 (49)	52 (40)	

Outcome

Outcome differed as a function of the WFNS grade, with a poorer outcome in the higher grades (Table II). ICU length of stay, hospital length of stay and mortality were also higher in the higher Fisher and mFisher grades (for all $p<0.001$).

Discussion

Although stroke caused by an ischemic event or acute bleeding is more common than a subarachnoidal bleeding, the latter is clinically and economically as important due to the higher morbidity and mortality[13,14]. Outcome after aSAH has been investigated extensively. It is well demonstrated that SAH itself is the main determinant for outcome as premorbid functioning scored by the Charlson Co-morbidity Index did not affect outcome in patients with SAB[15,16].

In this retrospective analysis we analysed the outcome of 211 patients with SAB. Unlike our hypothesis, localisation of the aneurysm was not an independent factor of mortality after aSAH. Nevertheless, an aSAH by an aneurysm was associated with higher WFNS grades, more complications and poorer outcome.

In this study the WFNS classification was the sole independent predictor for hospital mortality. The WFNS score is mainly driven by the Glasgow Coma Scale (GCS). The effect of cerebral haemorrhage on level of consciousness is in the acute phase determined by the brain compression. The post-acute phase also vasospasm comes into play to set the final neurological outcome. In this respect it differs from the ischemic stroke, in which the latter factors rarely play a role. In ischemic stroke NIHSS, age and pre-stroke modified Rankin Scale (mRS), as a reduced features set, fairly reliably predicted functional outcome, 3 months after an ischemic stroke in the anterior as well as the posterior circulation[17].

This study has several limitations. First, it is a retrospective analysis in a single center, thus impairing its generalisability and external validity. Second, it is a small dataset with low numbers of patients in certain subgroups. This does not allow reliable estimations in multivariable analyses under the rule of thumb of one predictive variable for every ten events. Third, a bias cannot be excluded

Table II. — Outcome as a function of the WFNS grade.

	Outcome			Post-procedural events			
WFNS grade	ICU stay (days)	Hospital stay (days)	Mortality	Duration of mechanical ventilation (Hours)	Duration of vasopressors (Hours)	VED need	Decompression need
Grade 1 (n=90)	6 (5-10)	16 (12-20)	1 (1%)	0 (0-0)	0(0-0)	15%	0%
Grade 2 (n=33)	9 (6-17)	22 (17-26)	2 (6%)	0 (0-25)	7,5 (0-79)	62%	3%
Grade 3 (n=9)	12 (8-26)	21 (13-42)	2 (22%)	0 (0-141)	0(0-128)	44%	22%
Grade 4 (n=18)	24 (13-35)	50 (24-69)	4 (22%)	194 (5-591)	53(0-253)	100%	0%
Grade 5 (n=49)	26 (13-37)	46 (17-67)	20 (41%)	230 (11-783)	79(0-162)	100%	23%
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

despite the missingness of crucial variables being <10% as the patients were selected through the surgical procedures and not through aSAH by itself and by the lack of strict data definitions for the different variables. Fourth, institutional case volume may also have played an important role in terms of the efficacy of the procedure and outcome[18-20]. Finally, this study design does not let us to appreciate the interaction between the different factors such as localization, severity of aSAH and the outcome.

In conclusion, aSAH derived from a posterior cerebral circulation aneurysm is associated with a worse presentation on admission and a poorer short term outcome.

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