Results of interdisciplinary management of 693 patients with aneurysmal subarachnoid hemorrhage: Clinical outcome and relevant prognostic factors

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A B S T R A C T

Objectives: Aneurysmal subarachnoid hemorrhage (aSAH) is associated with high rates of morbidities and fatalities. The continuous evolution of neurosurgical, endovascular and neuro-intensive cares has improved the overall mortality. In this study we sought to evaluate the clinical outcome after aSAH from a single tertiary center.

Patients and Methods: We retrospectively identified and reviewed all consecutive patients with aSAH treated at our center between 2007 and 2016. Records were made of the initial clinical and radiological findings, treatment modalities, medical complications and length of hospitalization as well as the early and most recent clinical outcome.

Results: 693 consecutive patients with aSAH were reviewed (34.2% males, mean age 56.1 ± 14.1 years). The mean diameter of the ruptured aneurysms was 5.8 ± 3.6 mm. A total of 265 (38.2%) patients had poor Hunt and Hess (HH) grade. Supportive care was provided in 73 cases. Endovascular or surgical management of the ruptured aneurysm was performed in 77% and 23% of the remaining cases, respectively. Cerebral vasospasm (CVS) was recorded in 177 (25.5%) cases, of which 42.7% had poor outcome. There were 134 (19.3%) early mortalities. Good clinical outcome (mRS ≤ 2) was achieved in 59.5% of the total cohort and 73.7% of the survivors). Variables with significant association with the clinical outcome included age at presentation, HH grade, early aneurysm re-rupture, parenchymal hemorrhage (PH) and MCA-aneurysms. There was a trend for worse outcome with larger ruptured aneurysms, CVS, and intraventricular hemorrhage.

Conclusion: The management of aSAH remains challenging but good clinical outcome can be achieved in a substantial subset of patients. Age, initial clinical condition, early aneurysm re-rupture, PH and MCA-aneurysm are important prognostic factors. Early detection and appropriate treatment of CVS are crucial for successful management.

1. Introduction

Aneurysmal subarachnoid hemorrhage (aSAH) is an uncommon but often a devastating form of stroke with high rates of disabilities [1–5]. The socioeconomic burden attributed to loss of productive life years after aSAH are comparable to those after an ischemic stroke due to the younger age of the affected patients [1,6,7]. In the U.K the total cost of healthcare for patients with aneurysmal SAH in 2005 was estimated at £168.2 of which in-patient hospital care formed the major expense at £98.7 million, surgical operations £25.4 million, and £10.6 million on rehabilitation (121 million SEK). The total non-health care costs including care received from economically active and inactive cares, the

loss of productivity etc. was £342 million with the total economic burden reaching £510.2 million per year. Despite some recent reports of decreasing mortalities after aSAH, which may be attributed to the continuous improvement in the surgical, interventional and intensive care management of these patients, the mortality and morbidity after aSAH remains stubbornly high [8–12]. The aims of this study were to review the clinical outcome of patients with aSAH treated at our center over last decade and identify the relevant prognostic factors.

2. Materials and methods

The study protocol was submitted to and approved by the local ethic

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2.1. Population

This is a single center retrospective analysis of all consecutive patients with aSAH admitted to Klinikum Stuttgart between January 1st 2007 and December 31st 2016. Eligible patients were identified based on a computer generated list including all acute admissions due to spontaneous SAH. The results were then crosschecked with the respective discharge summaries, interventional and surgical reports as well as with all available imaging studies to identify a total of 693 patients with confirmed aSAH.

2.2. Variables and outcome measures

Records were made of the acute presentation including the clinical condition expressed in Hunt and Hess (HH) grades [13], amount of SAH on the initial imaging in Fisher grades [14], evidence of acute hydrocephalus, treatment modality of the ruptured aneurysm, evidence of cerebral vasospasm (CVS) and other relevant clinical complication. The clinical outcome was recorded according to the modified Rankin Scale (mRS) at discharge and latest known condition (i.e. the latest clinical follow-up or condition at discharge for the cases where no further records were available). A good outcome was defined as mRS 0–2 and poor outcome as mRS 3–6. In a previous publication from the same dataset, the size and morphology of the ruptured aneurysms were reviewed [15].

2.3. Statistical analysis

Numerical variables are expressed in mean ± SD (min-max), ordinal variables in median (Interquartile range) and categorical variables as percentages. Fisher's exact test was used to test for independence of dichotomized outcome and categorical variables. The corresponding odds ratios and 95%-confidence intervals were calculated. Variables with a p-value less than 0.1 in the univariate analysis were entered into a multivariate logistic regression to identify independent prognostic factors. P-values less than 0.05 were considered statistically significant. Statistical analysis was performed using Stata/IC 14.2 for Windows (StataCorp LP, College Station, Texas, USA).

3. Results

Between January 1st 2007 and December 31st 2016 a total of 693 patients with confirmed aSAH were identified (237 males, 34.2%) with a mean age of 56.1 ± 14 years for the total population (median: 54.3 years, range 3 months-96 years). The mean age for the female patients was 57.3 ± 14.2 years compared to 53.8 ± 13.6 years for the male patients. The median HH grade was 3 (IQR: 2) and the median Fisher grade was 4 (IQR: 1) (Table 1).

Intraventricular hemorrhage (IVH) was evident in 416 (60%) cases, while parenchymal hemorrhage (PH) was recorded in 186 (26.9%) cases. Ruptured middle cerebral artery (MCA) aneurysms were more frequently associated with PH in comparison to the other anatomic locations (48.8% for MCA vs. 18.3%, 27.6% and 3.5% for the internal carotid artery, anterior cerebral artery and posterior circulation, respectively; p < 0.0001). Acute hydrocephalus was evident on the initial cross sectional imaging in 232 (33.5%) of the cases and cerebrospinal fluid (CSF) diversion was ultimately required in 427 (61.6%) patients. Decompressive craniectomy was performed in 67 (9.7%) cases. Early aneurysm re-rupture prior to treatment was recorded in 37 cases.

Angiographic imaging was available in 667 cases. The most frequent anatomic locations were: the anterior communicating artery (AcomA) complex (n = 226, 33.9%), the MCA-bifurcation (n = 137, 20.5%) and

Table 1
Baseline characteristics of the study population. There is a clear female dominance in all age groups over 30 years. The clinical condition at admission was fairly distributed among the Hunt and Hess grades. The majority of patients, on the other hand, scored high on the Fisher scale due to either intraventricular hemorrhage or parenchymal hemorrhage.

		F (n = 456)	M (n = 237)	Total (n = 693)
Age groups	< 20 years	2 (0.4%)	1 (0.4%)	3 (0.4%)
	20–30 years	8 (1.8%)	8 (3.4%)	16 (2.3%)
	31–40 years	36 (7.9%)	22 (9.3%)	58 (8.4%)
	41–50 years	101 (22.1%)	65 (27.4%)	166 (24.0%)
	51–61 years	135 (29.6%)	67 (28.3%)	202 (29.1%)
	61–70 years	72 (15.8%)	42 (17.7%)	114 (16.5%)
	71–80 years	68 (14.9%)	27 (11.4%)	95 (13.7%)
	> 80 years	34 (7.5%)	5 (2.1%)	39 (5.6%)
Hunt and Hess grade	1	90 (19.7%)	57 (24.1%)	147 (21.2%)
	2	102 (22.4%)	53 (22.4%)	155 (22.4%)
	3	90 (19.7%)	35 (14.8%)	125 (18.0%)
	4	70 (15.4%)	31 (13.1%)	101 (14.6%)
	5	104 (22.8%)	60 (25.3%)	164 (23.7%)
Fisher grade	1	13 (2.9%)	18 (7.6%)	31 (4.5%)
	2	47 (10.3%)	23 (9.7%)	70 (10.1%)
	3	70 (15.4%)	44 (18.6%)	114 (16.5%)
	4	326 (71.5%)	151 (63.7%)	477 (68.8%)

the posterior communicating artery (PcomA) (n = 95, 14.2%). The mean diameter of the ruptured aneurysm was 5.8 ± 3.6 mm (range 0.8–41 mm, median: 5 mm). Details of the aneurysm size, location and morphology have been already published [15].

Expectant management with supportive care was provided in 73 cases due to the very poor clinical condition and/or advanced age with multiple co-morbidities, of which 70 (94.6%) died after a mean of 3 ± 4 days. A total 152 (23.3%) microsurgical and 498 (76.7%) endovascular interventions were performed during the first hospitalization for securing the ruptured aneurysm. The decision to treat was taken using a multidisciplinary team approach. The treatment modality was determined after discussion between the lead neurosurgeon, the lead interventional neuroradiologist, and the patient and/or relatives. Details of the treatment modalities, procedural complications and occlusion rates are the subjects of a separate paper, which is currently under review.

CVS evident on transcranial Doppler (TCD) or angiography was documented in 177 (25.5%) of the treated patients. Beside the routine administration of intravenous nimodipine and mild elevation of blood pressure, invasive procedures were performed in 121 (68.4%) cases including stellate ganglion block, endovascular spasmolysis or both in 23 (13%), 56 (31.6%) and 42 (23.7%) cases, respectively. Delayed cerebral ischemia (DCI) was documented in 35 (19.8%) of patients with evident CVS. Central nervous system (CNS) infections were documented in 29 (4.7%) cases and were mostly related to CSF-shunting. The most common non-neurological medical complications were pulmonary und urinary infections (15.9%), mostly in form of nosocomial pneumonia.

The mean length of hospitalization was 24 ± 16 days and 22 ± 12 days for the microsurgical and endovascular treatment groups, respectively. Patients with good clinical condition at discharge (mRS 0–2) were hospitalized for an average of 19 ± 8 days, those with poor condition at discharge (mRS 3–5) for 29 ± 15 days. Early mortalities occurred after a mean of 7 ± 12 days from the date of SAH.

The early mortality rate was 19.4% (134 patients, including 70 patients who received only supportive care). Seven patients died during follow-up. Among the survivors, 443 (79.2%) patients had clinical follow-ups > 90 days after the hemorrhage (the mean latency between the hemorrhage and latest known condition was 27 ± 28 months, range 114 months). According to our latest records, 412 (73.7%) of all survivors had a good functional outcome (mRS ≤ 2) (Fig. 1).

Results of the univariate analysis are summarized in Table 2.