Prediction of outcome of subarachnoid hemorrhage

A proposed scoring system

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ABSTRACT

Objective: The aim of this study was to identify factors that affect the outcome of patients with aneurysmal subarachnoid hemorrhage treated at King Khalid University Hospital (KKUH), Riyadh, Kingdom of Saudi Arabia.

Methods: The medical records of 30 consecutive patients with verified ruptured cerebral aneurysm treated at KKUH between 1993 and 1996 were reviewed looking for factors that affect the outcome of surgery. Statistically significant factors were selected to design a scoring system for prediction of the outcome. This scoring system was then used to predict the outcome of the next 40 patients between 1997 and 2000.

Results: The preoperative Hunt and Hess grade, amount of subarachnoid hemorrhage in computerized tomography scan, aneurysm size and progressive hydrocephalus were the most significant factors that affect the outcome. There was significant association between the score value and the outcome, patients with low scores had negligible morbidity and mortality.

Conclusion: The scoring system is simple, easily applicable and can be used to predict the outcome of patients with aneurysmal subarachnoid hemorrhage with a high degree of accuracy.

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Despite recent improvements in surgical and medical management, aneurysmal subarachnoid hemorrhage (SAH) still has considerable morbidity and the overall mortality of the disease did not change much from approximately 40% in the 1960s to 30-35% in the 1990's. On the other hand, the surgical mortality has dramatically fallen from 37-45% to less than 15% during the same period of time.[1-4] Identification of prognostic factors and reliable prognosis for patients with aneurysmal SAH is of importance to both neurosurgeons and the patient himself and his family. The objective of this study is to analyze factors that might influence the outcome of surgery for patients with aneurysmal SAH treated at King Khalid University Hospital (KKUH), Riyadh, Kingdom of Saudi Arabia. From these factors, we proposed a scoring system that can be used to predict the outcome of such patients.

Methods. The study included 70 consecutive patients with SAH due to ruptured cerebral aneurysm treated at KKUH by surgical clipping of the aneurysm. It was conducted in 2 phases; in the first phase, we reviewed the medical records of patients who had aneurysmal SAH and had surgical clipping of the aneurysms during the period from 1993 to 1997 (30 patients). The details of their medical history, and neurological assessment including the clinical grade of SAH according to Hunt

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and Hess (H&H) grading system[5] immediately before surgery was recorded. The radiological findings seen on computerized tomography (CT) brain scan and 4 vessel cerebral angiography (particularly the amount of SAH, the number, size, and location of the aneurysm as well as presence of cerebral vasospasm) were recorded. The outcome at 6 months was documented using Glasgow Outcome Score (GOS),[6] the outcome was considered satisfactory if the patient had good outcome or mild disability, and unsatisfactory if the patient had severe disability, was vegetative or dead. Factors such as age, sex, preexisting hypertension (HTN), amount of SAH, location and size of the aneurysm, angiographic vasospasm and pre-operative H&H grade were correlated with the outcome using univariate analysis and Chi-square test. Factors that showed significant correlation with the outcome were labeled as (risk factors) and were used to design the scoring system. Based on those risk factors, positive and negative marks were given to each factor, for example, thick SAH as seen on CT scan was given +2 and thin SAH was given -2 and so on, as shown in **Table 1**. The total score (the algebraic sum of points for each patient) was classified into 3 risk groups; Low risk (total score ≤-2) where satisfactory outcome is expected, high risk (total score > +2) where unsatisfactory outcome is expected and intermediate risk group (total score -2 to +2) where the outcome is unpredictable. In the second phase of the study we used the scoring system to predict the outcome of patients treated in the following 4 years, 1997 to 2000 (40 patients).

Table 1 - Scoring system.

Risk factor	Score
Preoperative H & H grade (p value 0.001)	
Grade I & II (good grade)	-2
Grade III	+2
Grade IV & V	+3
Amount of SAH in CT scan (p value 0.01)	
Thin SAH	-2
Thick SAH	+2
Hydrocephalus (p value 0.004)	
Absent	-2
Present	+2
Aneurysm size (p value 0.01)	
Small aneurysm(≤15mm)	-2
Large aneurysm (>15mm)	+2

The lowest score is -8 and the highest is +9.
If the total score is:
≤-2 satisfactory outcomes are expected (Low risk group),
> +2 unsatisfactory outcome is expected (High risk group),
in between the outcome is unpredictable (Intermediate risk group)
H&H - Hunt & Hess grading system, SAH - subarachnoid hemorrhage, CT - computerized tomography

Table 2 - Radiologic findings.

Method	Finding	n	(%)
CT-findings	Thin SAH	25	(35.7)
	Thick SAH	45	(64.3)
	ICH	18	(25.7)
	IVH	10	(14.3)
	Hydrocephalus	17	(24.3)
Angiographic findings	Single aneurysm	64	(91)
	Multiple aneurysm	6	(9)
	Small aneurysm(<15mm)	30	(43)
	Large aneurysm	40	(57)
	Anterior circulation	70	(96)
	Posterior circulation	3	(4)
	Vasospasm	45	(64)

CT - computerized tomography, SAH - subarachnoid hemorrhage, ICH - intracerebral hemorrhage, IVH - intra ventricular hemorrhage

Results. The total number of patients in this study was 70 patients, 41 males (59%) and 29 females (41%), the male to female ratio was 1.4:1. The age ranged from 10-70 years; the mean age was 40 years. Twenty patients (29%) had preexisting hypertension, 10 of them had preexisting medical problems (5 patients had diabetes mellitus, 2 had polycystic kidney disease, 2 had brucellosis and one had congestive heart failure), and one patient was pregnant in her second trimester. Clinically 44 patients (63%) had meningism, 34 patients (49%) had altered consciousness, 9 patients (13%) had focal motor weakness, 6 patients (8.6%) had dysphasia, 4 patients (5.7%) had focal cranial nerve palsy, and 3 patients (4.3%) had abnormal posturing at the time of admission. The radiological findings are summarized in **Table 2**. The time intervals between the initial bleed, and surgery ranged from 2-46 days; the median is 13 days. Thirty-one patients (44%) had surgery within 10 days of the bleeding and 39 patients (56%) had surgery after 10 days. Six patients (8.6%) had rebleeding before surgery, 2 of them rebled twice. Postoperative complications included 9 patients (13%) with brain infarction, 9 patients (13%) with progressive hydrocephalus treated with ventriculo-peritoneal shunts, one patient (1.4%) developed extradural hematoma, one had bone flap infection and 2 patients developed deep

Table 3 - Correlation of outcome with risk group.

Risk group	Outcome		Total
	Satisfactory	Unsatisfactory	
Low risk (score ≤ -2)	20	-	**20**
Intermediate risk (score – 2 to +2)	10 (77%)	3 (23%)	**13**
High risk (score > +2)	1 (14%)	6 (86%)	**7**
TOTAL	**31**	**9**	**40**

vein thrombosis. The outcome at 6 months was satisfactory in 54 patients (77%) and unsatisfactory in 16 patients (23%), 4 of them (5.7%) had moderate disability and were independent, 4 had severe disability (2 were vegetative), and 8 patients (11%) died.

Discussion. The final outcome of the management of a ruptured cerebral aneurysm is far from easy to predict at the time of admission. Factors that are consistently associated with poor outcome in patients with aneurysmal SAH are a poor neurological grade on admission, amount of blood on early CT scan, angiographic vasospasm and rebleeding.[7-9] Other factors such as age, sex, preexisting medical diseases, aneurysm size and location may be associated with poor outcome; however, there is inconclusive evidence of their effect on the outcome.[10] Analysis of the different variables for patients in the study revealed that H&H grade, hydrocephalus, thickness of SAH, and aneurysm size were the most significant factors that affected the outcome.

It is well documented in the literature that aneurysmal SAH is more common in females than males.[2,11,12] The male to female ratio in this study was inverted at 1.4:1, revealing higher incidence of aneurysmal SAH in males, this was attributed to the prevalence of middle age males (working population) among the non-Saudis in our series. The gender related differences in the occurrence of intracranial aneurysms are probably secondary to hormonal factors.[12] The level of consciousness is considered the most important factor that determines the outcome of aneurysmal SAH patients.[13] Sundt et al[14] reported very low morbidity (4%) and mortality (3%) for good grade patients, Rosenhorn et al[15] reported 13% as operative mortality in good grade patients and 34% in grade III-V patients, while in the international cooperative study, Kassel et al,[2] the surgical mortality was 10-12% in alert patients operated upon before day 10 after SAH and 3-5% after day 10. In our study, there was significant correlation (p=0.001) between preoperative H&H grade and the outcome; out of 51 patients with good H&H grade, 46 patients (90%) had good outcome and 5 patients (10%) had unsatisfactory outcome, 2 of them died (4%). On the other hand, only 43% of grade III and 40% of grade IV and V patients had satisfactory outcome. Further analysis showed significant correlation between H&H grade and the presence of intracerebral hemorrhage (p=0.007); development of hydrocephalus (p=0.01) and the development of delayed ischemia (p=0.003). All these factors are known as bad prognostic factors and negatively affect the outcome of patients with SAH.

It is quite clear that small aneurysms are easier to dissect and clip; as the aneurysm enlarges, its neck becomes broader and encroaches on the parent vessel and the origin of its perforators. Also, there is increased tendency for large aneurysms to become thrombosed and this prevents proper clip application. As a result of these processes, operation becomes more difficult and carries more risk of complications, hence, the prognosis of large aneurysms is less favorable than smaller ones.[16,17] The fact that patients harboring small aneurysms do better was evident in our study, as 91% of patients with small aneurysms had satisfactory outcome contrary to 66% in patients with large aneurysms (p=0.01).

The development of hydrocephalus following SAH is a well-known complication of ruptured cerebral aneurysms.[18,19] The incidence of hydrocephalus following aneurysmal SAH has been variously reported in the literature; ranging from 6-34%.[18] Patients with intraventricular hemorrhage (IVH) or voluminous hemorrhage in the basal cisterns have a significant higher risk of developing hydrocephalus. Saveland et al[19] demonstrated a close correlation between the H&H clinical grade and the development of hydrocephalus. Pietila et al[18] found that hydrocephalus was more frequent following rupture of anterior communicating artery aneurysms as well as posterior circulation aneurysms. They attributed it to wide subarachnoid spaces in these cisterns that accommodate large volume of blood and offer little resistance to bleeding aneurysms. In addition, anterior communicating artery and posterior circulation aneurysms are more often associated with IVH. The incidence of hydrocephalus in our study was 24% and it was significantly associated with poor outcome (p 0.004), 9 patients required ventriculo-peritoneal shunts.

The presence of angiographic vasospasm is variously quoted in the literature, ranging from 6-65% of cases; this big variation is attributed to the timing of angiography.[20] Fisher et al[21] established the correlation between the amount of SAH as seen in CT scan and the development of cerebral vasospasm. The incidence of angiographic vasospasm in our study was 64%; the mean timing of angiography was 10 days after SAH (range 1-43 days). Although cerebral vasospasm has its crucial effect on the prognosis of patients with SAH,[2,4,14,15] the final outcome of patients in our study was not correlated with the presence of angiographic vasospasm. The explanation for this is that we delay surgery until the period of maximum vasospasm is over, 56% of our patients had late surgery (10 days or more after SAH).

The poor prognosis following re-bleeding from cerebral aneurysms is well known in the literature.[2,14,15,22] The incidence of re-bleeding varies from 8% up to 30% in some reports.[23] In our study 6 patients (9%) had re-bleeding, there was a trend of worsening outcome among those who rebled, however, it did not reach statistical significance probably because of the small number of cases.

The mortality rate in our study was 11% as well as the morbidity; 4 patients developed moderate disability and were independent and 4 patients were severely disabled, 2 of them were vegetative. The causes of death were brain infarction in 5 patients, re-bleeding due to incomplete clipping in one patient, primary brain damage due to SAH in one patient and surgical

complication (occlusion of a major vessel) in one patient. The low mortality rate in our series is due to the fact that 73% of patients included in this study were in good H&H grade preoperatively, and we do early surgery for young patients with good H&H grade and delay the operation for those with poor H&H grade until the period of maximum vasospasm is over and their clinical condition improves.

As the final outcome of patients with aneurysmal SAH is unpredictable and there is no accurate measure to predict the outcome of such patients, we proposed a scoring system to identify patients at higher risk of morbidity and mortality. It incorporates the 4 risk factors found to have significant association with the outcome, these are; the H&H clinical grade, the amount of SAH in CT scan, the size of the aneurysm, and the development of progressive hydrocephalus. The risk classification (low, intermediate, and high risk) proposed herein was found to have significant association with outcome. Patients with low scores (≤-2) can be identified with a negligible morbidity and mortality (as seen in **Table 3**), all patients in the low risk group had satisfactory outcome. As the score increases the incidence of unsatisfactory outcome is likelier, 86% of patients with scores > +2 had unsatisfactory outcome.

In conclusion, this scoring system is a simple and easily applicable and can be repeated quickly; however, it is a subject of modification and we should keep in consideration the impact of the surgeon's skill on the outcome of aneurysm surgery.

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