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Original Research Paper

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OUTCOME ASSESSMENT IN PATIENTS WITH ANTERIOR CIRCULATION INTRACRANIAL ANEURYSMS TREATED WITH MICROSURGICAL CLIPPING - A FOLLOW UP STUDY

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ABSTRACT

BACKGROUND: Aneurysms of the cerebral vasculature is a Common Devastating neurosurgical problem. They become problematic after rupture leading to parenchymal haemorrhage, or more often subarachnoid haemorrhage (SAH). The focus of this study is aneurysms in the region of anterior communicating artery (Acom), the intracranial part of internal carotid artery aneurysm (ICA) and the middle cerebral artery (MCA). Multiple preoperative, intraoperative and postoperative parameters and events that influence the surgical outcome of these aneurysms. **MATERIALS AND METHODS:** In this study, 65 patients with anterior circulation intracranial aneurysms who were operated were studied to compare surgical outcome. Multiple pre-operative, intra-operative and post-operative factors were studied. Follow up was done at 3 and 6 months and functional independence of the patient was assessed using Glasgow outcome score(GOS). **RESULTS-** Patients with higher Fischer's grade was seen to have higher chances of postoperative vasospasm. In our series 33 i.e. 50.77% patients had some degree of hydrocephalus preoperatively whereas only 15 i.e. 23.08% patients needed CSF shunting postoperatively. n=9 (13.84%) patients underwent re-exploration in the post op period and n= 7 (10.8%) had poor GOS score of 1 at 3 and 6 months. **CONCLUSION-** The postoperative parameters which significantly correlated with poor GOS score at 3 months and 6 months of follow up were vasospasm, postoperative infarct, ventilatory support duration, GCS on POD 2 of < 15 & ICU stay duration > 7 days, associated intraventricular/parenchymal bleed, need for CSF diversion, and need for re-exploration. The outcome did not significantly depend on patient's age, gender, location of aneurysm, timing for surgery i.e. interval between SAH and surgery, method of securing aneurysms, intraoperative method of securing the aneurysm.

KEYWORDS : Clipping, Intracranial Aneurysm, Outcome

INTRODUCTION

An aneurysm is an abnormal dilatation of an artery, and in the brain commonly arises at a branch site on a parent artery. Aneurysms are usually discovered after they rupture, producing subarachnoid haemorrhage (SAH) which is a very disastrous and fatal emergency requiring immediate intervention. Rinkel and colleagues comprehensively reviewed 23 studies including more than 50,000 patients and noted a prevalence, on average, of 0.4% in retrospective autopsy studies, 3.6% in prospective autopsy studies, 3.7% in retrospective angiography studies, and 6.0% in prospective angiography studies.[1]

In an Indian study One thousand human brains of both sexes were examined. Aneurysms were found in 10 specimens (1%). The incidence of aneurysms was 1.6% in females and 0.8% in males. All the aneurysms were saccular. The aneurysms varied in size.2 Annual incidence of aneurysmal SAH between 6 and 16/100,000 population, about 76,500-204,100 new cases occur in India each year.[3]

The prevailing practice patterns in the management of Intracranial aneurysm are through Surgical clipping and Endovascular Treatment. The focus of this study is aneurysms in the region of anterior communicating artery (Acom), Anterior cerebral artery (ACA), the internal carotid artery (ICA) and the middle cerebral artery (MCA) managed with open surgical clipping of the aneurysm. Multiple preoperative, intraoperative and postoperative parameters and events influence the surgical outcome of these aneurysms. Studying the outcome of these aneurysms and investigating and assessing the factors which affect their respective outcomes may help to perform better by taking care of these factors and executing better control for their prevention with better technical performance and postoperative care

MATERIAL AND METHODS

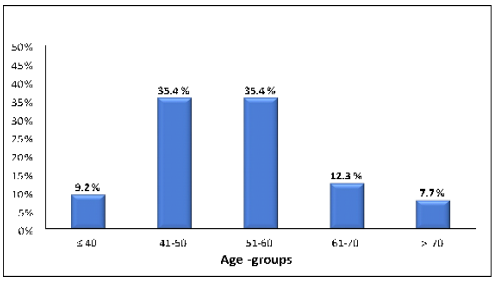
This is a Prospective and Retrospective study of 65 patients admitted and operated for anterior circulation intracranial aneurysms at Department of Neurosurgery, Christian Medical College and Hospital, Ludhiana for a total period of 4 years. The study included a prospective group of patients admitted and operated for anterior circulation intracranial aneurysms from May 2018 to April 2019 and kept under follow up of 6 months period, and a retrospective group of the patients operated for anterior circulation aneurysms operated in the last 3 years (2014-2017). Each patient was given choice for endovascular treatment if he/she wishes and opts for the same. Informed and written consent was obtained from each patient for the surgery in view of non-availability of endovascular treatment. Inclusion criteria: All patients with Acom, ACA OR MCA OR ICA aneurysm with WFNS grade 1,2,3,4 who underwent or had previously undergone surgical management in the Department of Neurosurgery, Christian Medical College, Ludhiana. Exclusion criteria: All patients with Acom, ACA OR MCA OR ICA aneurysm with WFNS grade 5. Gaint aneurysms are also excluded.

RESULT AND ANALYSIS:

The data was collected and analysed, and the results are as follows: Total number of patients included in the study were 65. The mean age of presentation was 53±11.13 years. The Age

group distribution was as follows with less than 40 years' age group were 6(9.2%), 41- 50 and 51-60 years were 23 (35.4%) each. The number in age group in 61-70 were 8 (12.3%) and patients above 70 years were 5 (7.7%). Among all patients, 25 (38.5%) were males and rest 40 (61.5%) majority were females.

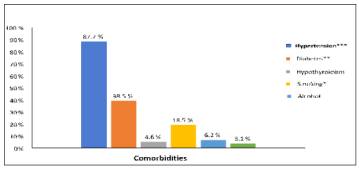
Figure 1 – Age group distribution of patients.



Presenting symptom was Headache in 58(89.2%), altered sensorium in 32(49.2%), vomiting in 34(52.3%), paresis in 6(9.2%) and seizure in 11(16.9%) of patients. Preop GCS was 7 in 4(6.2%), 1 each (1.5%) with GCS of 8 and 9, 5(7.7 %) patients with GCS of 10, 2 (3.1 %) patients with GCS of 11, 8(12.3% patients with GCS of 12, 16(24.6%) patient with GCS of 13, 15(23.1%) patients with GCS of 14 and 13(20.2%) patient were with pre op GCS of 15.

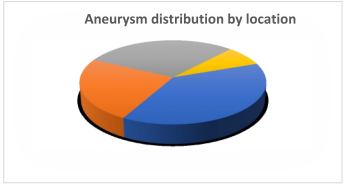
The distribution of comorbidities was as follows- majority 57(87.7%) had hypertension, 25(38.5%) had diabetes, 3(4.6%) had hypothyroidism, 12(18.5 %) patients were chronic smokers and 4(6.2%) had history of alcoholism. Hypertension was the most common associated co morbidity.

Figure 2 – Showing Co-morbidities associated in patients with anterior circulation intracranial aneurysms



Fischer's grade was as follows with 23 (35.4%) patients were in Fischer's grade 2, 12 (18.5%) patients were in Fischer's grade 3, and majority 30 (46.2%) patients were in Fischer's grade 4. Time of presentation was as follows with majority 58 (89.2%) of the patients presented within 7 days of rupture, 5 (7.7%) patients presented within 8-14 days and rest 2 (3.1.%) patient took more than 14 days to arrive to hospital. Pre op vasospasm was not present in 32(49.2%) of patients and present in 33 (50.8%) of the patients. The distribution of patients according to the location of aneurysms were as follows with 6(9.2%) patient with ACA aneurysm, majority 30(46.2%) had ACOM aneurysm,19(29.2%) patients had MCA aneurysm,23(35.4%)) had ICA aneurysm.

Figure 3 – Location of Aneurysm distribution in anterior circulation intracranial aneurysms



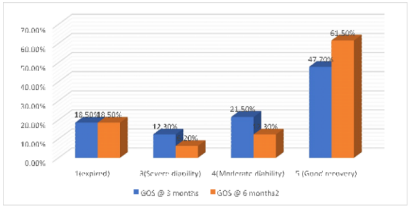
pre op parenchymal or ventricular bleed was not present in 35(53.8%) patients,8(12.3%) patients had only pre op parenchymal bleed whereas 11(16.9%) patients had both isolated ventricular and parenchymal bleed respectively. 45 (69.2%) patient had no associated pre op hydrocephalus whereas rest 20(30.8) patients had associated pre op hydrocephalus.

Distribution of patients as per aneurysm size. Majority 46 (70.8%) patients had <7 mm aneurysms and rest 16 (24.6%) patients had aneurysms in the range of 7-14mm and 3(4.6%) patients had aneurysm size of >14mm.Giant aneurysms were not included in the study as per exclusion criteria of the study protocol. PreOP WFNS in 16 (24.6%) of patients had a WFNS score of 1 on presentation, 29 (44.6%) had score of 2, 7 (10.8%) patients had score of 3 and rest 13 (20%) patient were allotted the WFNS grade of [4].

Procedure done was only clipping in 51 (78.5%), wrapping only in 2 (3.1 %) of patients and both clipping and wrapping in 12 (18.5%) of the patients. Majority of patients were in the clipping subgroup. Intra operative rupture of aneurysm occurred in 42(64.6%) of the patients and it did not occur in the rest 23(35.4%) of the patients.

Temporary clipping was not done in 17(26.2%) of patients, it was done for <5 mins in 39(60%), for 5-10 mins was done in 4(6.2%) and for > 10 min in rest 5 (7.7%) patients. Post OP day 2 GCS score was as follows with 2(3.1%) patients with score of 4, 3(4.6%) had score of 5, 5(7.7%) had score of 6, 6(9.2 %) had score of 7, 3(4.6%) had score of 8, 1(1.5%) had score of 12, 6(9.2 %) had score of 13, 20(30.8%) had score of 14, 19(29.2%) patients had score of 15. Post op ICU stay varied with majority 50(76.9%) patients stay duration of < 7 days whereas the rest 15(23.1%) patients had an ICU stay duration of more than 7 days. Motor deficits were present in 25 (38.5%) of the patients, speech deficits in 18(27.7%) of the patients. Neurocognitive impairment was found to be in 10 (15.4%) of the patients. GCS score at discharge in Majority i.e. 47(72.3%) patients had score of 15, 3(4.6%) with 14, 1(1.5%) with 10 and 7 each, 2 (3.1%) with 6 and 3(4.6%) patients were discharged at a score of 5. Post op early infarcts were 17 (26.2%) and post op late infarcts were 4 (6.2%) and both early and late infarcts were present in 6(9.2%) of the patients. Post op CFS diversion was required in 15(23.1%) of the patients and no CSF diversionary procedure was required in rest 50(76.9%). Also post-operative re exploration was required in 9(13.8%) patients and the rest 56(86.2%) of patients did not require any further exploration.

Figure 4– Bar Chart showing Outcome Score Comparison at 3 And 6 Months.



Postop GOS Score comparisons at 3 months and 6 months: At 3 months 31 (47.7%) of patients,majority had a GOS score of 5, 14(21.5%) had score of 4, 8(12.3%) had score of 3 and rest 12(18.5%) had expired with GOS score of 1. At 6 months 41 (63.08%) of patients,majority had a GOS score of 5, 8(12.31%) had score of 4, 4(6.15%) had score of 3 and rest 12(18.5%) had expired with GOS score of [1].

The co-relation post op GOS with various observed factors pre and postop are as follows with various statistical interpretations. (Described in detail in Table 1 and 2) Pre-operative GCS of 13.5±1.2 (Mean±SD) was associated with GOS of 5 at 3 months (P <0.001) and 13.6±1.1 (Mean±SD) at 6 months respectively (P <0.001). On univariate regression analysis poor preop GCS score was associated with 49% chances of poor outcome score at 3 months (p=<0.001,β=0.7), and 46 % chances of poor GOS scores at 6 months (p=<0.001, β=-0.7, C.I = 0.3-0.6)). A poor Pre op WFNS score on linear

regression amounts to a 5 times risk of having poor outcome scores. (β= 1.6, p=<0.001, C.I = 2.4 –11.3). On linear regression analysis Pre op vasospasm was associated with 18 times risk of poor GOS outcome scores at 3 months, and 29 times risk of at 6 months (β coefficient = 2.8, p=<0.001). Patients with higher Fischer's grade showed increasing trend for motor deficits on discharge i.e. 9 times more risk for motor deficits on discharge (Coefficient (β)= 2.2, p=0.003). Higher grade Fisher's was also seen to impose 2.7 times more chances of speech deficits (p=0.009, Coefficient (β)= 1, C. I=1.2-5.8). On regression analysis, Higher grade Fisher's was also seen to impose 4.1 times more chances of motor deficits on discharge (p=0.001, Coefficient (β)= 1.4, C. I=1.9-8.7). Patient's with higher Fischer's grade were at 4.5 times risk of poor GOS at 3 months (p=0.001, Coefficient (β)= 1.5, C.I=1.8-10), and 16 times risk of poor GOS scores at 6 months of follow up(p=0.005, Coefficient (β)= 2.7, C.I=2.3-11).

Majority patient's in our operative series underwent surgery >3 days post-ictal. The number of patients undergoing surgery at < 7 days, 7 – 14 days and > 14 days were 58(89.23%), 5(7.69%) & 02(3.08%) respectively. 33 (i.e. 50.77%) patients had some degree of hydrocephalus preoperatively whereas only (15 i.e. 23.08%) patients needed CSF shunting postoperatively. 45% of patients with preoperative hydrocephalus had persistent hydrocephalus postoperatively requiring CSF diversion. Pre op hydrocephalus on logistic regression analysis was seen to predict speech deficit at discharge (4.6 times more risk), motor deficit at discharge (5.8 times more risk), poor GOS score at 3 months of follow up (4.8 times more risk), and poor GOS score at 6 months of follow up (5.4 times more risk). Post-operative CSF diversion on logistic regression analysis was seen to predict speech deficit at discharge (4.5 times more risk), motor deficit at discharge (11.3 times more risk), poor GOS score at 3 months of follow up (12.5 times more risk), and poor GOS score at 6 months of follow up (12.2 times more risk).

Preoperative associated bleed was seen to predict speech deficit at discharge (4.5 times more risk), motor deficits at discharge (8.3 times more risk), poor GOS score at 3 months of follow up (13 times more risk), and poor GOS score at 6 months of follow up (38 times more risk).

The best outcome was seen in patient who were not clipped temporarily at all with n=12 (70.6%) patients having a GOS of 5 at 3 months and n=14 (82.4%) having GOS 5 at 6 months (p=<0.001).

On logistic regression analysis temporary clipping of more than 5 mins was seen to predict speech deficit at discharge with 4.6 times more risk (Coefficient (β)=3.2, p=0.004).

Vasospasm was seen to be a significant predictor of on discharge speech deficit with 39 percent more chances (Coefficient (β)= 3.680, p= 0.008) of having motor deficit on discharge.

On linear regression analysis the presence of postoperative early infarct best predicted motor deficit on discharge with a (β- coefficient of 3.6). Whereas on logistic regression postoperative early infarct was seen to have 39 times more risk of motor deficit on discharge and postoperative late infarct with 5 times more risk.

Logistic regression analysis for factors correlating with speech deficit showed presence of postoperative early infarct to have 25 times more risk and postoperative late infarct with 20 times more risk of speech deficits. Also, presence of preoperative vasospasm conferred 13 times more risk of having speech deficits (β=2.5, P=0.008).

Postoperative early infarct was associated with poor GOS with 12 times risk of having poorer outcomes in early infarct cases at 3 months, on linear regression analysis (Coefficient (β) = 3.1 p=0.031) and 5.2 times risk of having poor outcome scores at 6 months (Coefficient (β) = 1.6 p=0.009). Postoperative late infarct was associated with poor GOS with 12.5 times risk of having poorer outcomes in late infarct cases at 3 months, on linear regression analysis (Coefficient (β) = 2.0 p=0.008) and 6 times risk of having poor outcome scores at 6 months (Coefficient (β) = 1.7 p=0.014).

Patients with on discharge speech deficit has 33 percent chances of having poor outcome and those with higher Fischer's grade had 39 times chances of having poor outcome GOS at 6 months. Post op re-exploration was associated with 14 times risk of on discharge speech deficits on regression analysis (Coefficient (β) = 2.6 p=0.002). On linear regression analysis the pre-operative GCS score was seen to be the best predictor of GOS at 6 months with Coefficient (β) of -0.481 C.I 0.382- 1.002 and 61 percent chances of having poorer outcome scores with low pre op GCS (p =0.051).

GOS 5 was associated with mean POD2 GCS of 14.1±1.5(Mean±SD), GOS 4 with 13.2±2.4, GOS 3 with 8.8±4.0 and GOS 1 with 6.9±3.2 (p<0.001) thereby clearly indicating the co-relation between them. POD 2 GCS score on logistic regression analysis was seen to strongly predict speech deficit at discharge (44 times more risk), motor deficit at discharge (40 times more risk), poor GOS score at 3 months of follow up (33 times more risk), and poor GOS score at 6 months of follow up (46 times more risk). (p=0.004)

Post-operative ventilator support duration of more than 7 days on logistic regression analysis was seen to predict speech deficit at discharge (1.3 times more risk), motor deficit at discharge (1.8 times more risk), poor GOS score at 3 months of follow up (1.4 times more risk), and poor GOS score at 6 months of follow up (1.4 times more risk). ICU stay of more than 7 days was seen to correlate well with motor deficit, speech deficit and neurocognitive impairment during discharge time. Similarly, on logistic regression it was seen to predict motor deficit (6 times more risk), speech deficit (20 times more risk) and neurocognitive impairment (4.5 times more risk), poor GOS score at 3 months with 21 times risk and correlated with poor GOS score at 6 months with 20 times risk.(P=0.002)

The location of aneurysm within the anterior circulation was not seen to significantly affect the outcome in terms of deficits and outcome on univariate of multivariate analysis.In our study findings were suggestive of poor outcome by location in order DADA>ICA>MCA>AcomA aneurysms.

At 3 months 31 (47.7%) of patients had a GOS score of 5, 14(21.5%) had score of 4, 8(12.3%) had score of 3 and rest 12(18.5%) had expired with GOS score of 1 (P<0.05). At 6 months 40 (61.5%) of patients had a GOS score of 5, 8(12.3%) had score of 4, 4(6.2%) had score of 3 and rest 12(18.5%) had expired with GOS score of 1(P<0.05)

Table 1: Regression analysis of studied parameters with GOS at 3 months.

GOS at 3 months					
	Coefficient(β)	p-value	Odds ratio	95% C.I.	
				Lower	Upper
Preop GCS score	-0.701	<0.001	0.496	0.339	0.726
WNFS score	1.658	<0.001	5.250	2.431	11.336
Prevasospasm	2.890	<0.001	18.000	3.682	87.995
Preop-Bleed	2.635	<0.001	13.949	3.487	55.799

Fisher's grade	1.509	0.001	4.524	1.873	10.927
Preop hydrocephalus	1.587	0.007	4.889	1.557	15.353
Aneurysm size (>7mm)	1.732	0.004	5.653	1.761	18.144
POD GCS score	-0.549	<0.001	0.579	0.463	0.725
Postop ventilator support duration	0.366	<0.001	1.442	1.203	1.730
Postop ICU stay (>7 days)	3.045	<0.001	21.000	4.810	91.687
On discharge motor deficit	3.889	<0.001	48.857	9.211	259.158
On discharge speech deficit	4.454	<0.001	86.000	14.333	516.017
Postop early infarct	2.528	<0.001	12.528	3.239	48.461
Postop late infarct	2.020	0.008	7.538	1.701	33.405
Postop CSF diversion	2.528	<0.001	12.528	3.239	48.461

Table 2: Regression analysis of studied parameters with GOS at 6 months.

GOS at 6 months					
	Coefficient(β)	p-value	Odds ratio	95%C.I.	
				Lower	Upper
Preop GCS score	-0.775	<0.001	0.461	0.306	0.693
WNFS score	1.659	<0.001	5.254	2.421	11.405
Pre-vasospasm	3.373	0.002	29.176	3.555	239.478
Preop-Bleed	3.660	0.001	38.857	4.692	321.782
Fisher's grade	2.788	0.005	16.241	2.373	111.153
Preop hydrocephalus	1.692	0.005	5.429	1.650	17.860
POD GCS score	-0.605	<0.001	0.546	0.424	0.705
Postop ventilator support duration	0.390	<0.001	1.478	1.227	1.779
Postop ICU stay (>7 days)	3.004	<0.001	20.167	4.839	84.042
On discharge motor deficit	4.239	<0.001	69.333	8.106	593.056
Discharge GCS score	-0.545	<0.001	0.580	0.432	0.778
On discharge speech deficit	3.330	<0.001	27.950	6.531	119.606
Postop early infarct	1.650	0.009	5.206	1.499	18.077
Postop late infarct	1.792	0.014	6.000	1.440	25.004
Postop CSF diversion	2.508	<0.001	12.286	3.223	46.831

DISCUSSION

The recovery of the patient from an Aneurysmal SAH and recovery after surgery is of par importance as there is associated morbidity and mortality associated with surgery and therefore it is imperative to understand the outcome dependent on various factors associated with the outcome.

The mean age in our study was 53±11.13 years with a female gender predominance which was similar to study by Hidetoshi Matsukawa it was evident that the mean age was 62 ± 12 years and 650 aneurysms (78%) were observed in women, however the Post-Operative GOS at 3 months and 6 month were not depend on the age at presentation, gender. However, ruptured aneurysms are most commonly diagnosed in old persons usually older than 70 years of age4. Similar findings regarding no gender dependence on outcome were noted in a study by Kongable et al who reported that although women suffering from SAH were older and harbour more aneurysms, the 3-month outcome for women and men with ruptured aneurysms is the same[5].

The distribution of comorbidities in our study majority 57(87.7%) had hypertension. It has been shown by a study published by Juvela et al that cigarette smoking is associated with occurrence of multiple intracranial aneurysms6. The same is evident by our case series as n = 10 (83%) patients who were chronic smokers had multiple intracranial aneurysms. Our study showed no statistically significant difference in outcome of patients operated for multiple v/s single ruptured intracranial aneurysm. This could be due to that fact that there were relatively lesser cases of multiple aneurysm, thereby not being significant to produce co-relation.

In our study significant correlation between the GOS at 3 months and 6 months could be seen between preoperative GCS score, WFNS grading, Preop Vasospasm, Fisher Grade, with higher Fischer's grade showed increasing trend for motor deficits on discharge. In Study by Zheng K et al, CT Fisher's grade, alcohol consumption, aneurysm diameter, surgical procedure and operation time were identified as possible prognostic factors, the association between possible prognostic factors and outcome were analyzed, using univariate and multivariate analysis. CT Fisher's grade 3 to 5 (OR=5.641, 95%CI: 2.032 to 15.643, P=0.001), and anterior circulation location (OR=6.234, 95%CI: 1.996 to 19.472, P=0.002) were found to be independent prognostic factors of unfavourable prognosis.[7]

Rosengart et al in their study identified unfavourable outcome on the GOS 3 months after surgical treatment of aneurysmal SAH as associated with greater SAH clot thickness on admission CT.8 Our results pointed out that aneurysm size does affect the surgical outcome as patients with size less than 7 mm had a GOS score of 5 in 54.3% patients at 3 months (P-0.019) and 73.9% patients at 6 months (P – 0.006) of follow up. Patients fraction in poorer outcome groups increased in statistically significant proportions as aneurysm size increased.

On linear regression analysis it was evident that for aneurysms size of > 7 mm there were 5.6 times risk of having a poor GOS score at 3 months (p=0.004, B coefficient=1.7, C. I-1.76-18.1). The cause of such association could be that larger size aneurysms were associated with higher Fischer's grade and vasospasm in our study which may have resulted in above mentioned outcomes and significant co-relation. Our study results are in accordance with, metaanalysis done by Raaymakers TW etal on Mortality and morbidity of surgery for unruptured intracranial aneurysms[9]

The location of aneurysm within the anterior circulation was not seen to significantly affect the outcome in terms of deficits and outcome on univariate of multivariate analysis. In our study findings were suggestive of poor outcome by location in order DACA>ICA>MCA>AcomA aneurysms.

A significant correlation with GOS outcome was noted with the timing of the surgery, preoperative hydrocephalus, Preoperative associated bleed. Significant correlation of

outcome noted with intraoperative clipping time, intraoperative rupture of aneurysm, vasospasm, post-operative infarct, post-operative re- exploration, post-operative day 2 (POD2) GCS.

Sivashanmugam Dhandapani in his study on impact of elective temporary clipping on intraoperative rupture and outcome after surgery for ruptured anterior circulation aneurysms observed that temporary clipping decreased the occurrence of intraoperative rupture and the time to application of temporary clip, thus leading to better outcome. While repeated elective clipping within total clipping time of 20 min did not influence outcome, repeated rescue clipping and total clipping time of at least 20 min had significant impact on outcome. [10]

Batjer et al found an increased mortality rate after intraoperative rupture (IOR) and confirmed a worsened outcome after IOR in survivors.11,12 Others however could not confirm an increased incident of NND (new neurological deficit) or worsened after IOR in their study groups.13,14,15 Other factors like SAH, vasospasm may also play a role. However, it is understood that deterioration can be produced by rupture during the pre-exposure phase.

Leipzig in his extensive review has attempted to correlate outcome with the severity of intraoperative rupture. 16 He observed that of those experiencing a major IOR one-half sustained a stroke before discharge, and one-third died. The rates of mortality (12.5%) and stroke (28.1%) were substantially less for patients experiencing a moderate IOR. In patients with minor intraoperative rupture, half recovered without serious deficit. Of note, more than 50% of all patients with IOR in this series experienced a good outcome (without significant deficits). 16 Jan Van Gijn et al studied the effects of acute hydrocephalus in patients with spontaneous SAH and the outcome after shunting. 17 They could not find significant benefit of shunting and said that shunted patients were, on average, in a worse condition than unoperated patients, and it could be expected that the outcome would also be worse in this group.

In another review study of BRAT trial by Hasan A Zaidi, it was observed that On multivariate analysis, intraventricular haemorrhage and intraparenchymal haemorrhage were independent risk factors for shunt dependency ($P < .05$) and patients who did not undergo shunting in post op period had higher GOS scores and were more likely to be functionally independent and to return to work within 72 months of surgery ($P < .05$). [18]

Jingjing lu in his study observed that 30% of patients with acute hydrocephalus following aneurysmal SAH recover spontaneously. In the majority of patients with persistent hydrocephalus, lamina terminalis fenestration performed during aneurysm clipping is effective. Ventriculoperitoneal shunting can be considered in the remaining patients. [19]

In our series 33 i.e. 50.77% patients had some degree of hydrocephalus preoperatively whereas only 15 i.e. 23.08% patients needed CSF shunting postoperatively. 45% of patients with preoperative hydrocephalus had persistent hydrocephalus postoperatively requiring CSF diversion. Preoperative presence of hydrocephalus was seen to be significantly related to higher Fischer's grade, grade IV producing significant p value of <0.001.

In a multivariable analysis by Rosengart et al, unfavourable outcome was associated with more SAH on admission computed tomography and intracerebral hematoma or intraventricular haemorrhage. 8 In a study by Bing Zhao, it was observed that Patients with a WFNS grade of V, intraventricular haemorrhage, brain herniation were more likely to have a poor outcome after early surgery. 20 Ana Rodriguez et al demonstrated that worse outcomes were associated with aneurysm rupture, poor grade, giant size and hemicraniectomy.[21]

In present series only 9 patients underwent re-exploration with Decompressive hemicraniectomy for infarcts/ cerebral edema/Intracranial hematoma. However, on linear regression it was seen to be one of the factors correlating with poor GOS score at 3 months and 6 months which might just be due to the fact that same patients had extensive infarcts leading to disability and had poor GOS score.

On linear regression analysis ICU stay of more than 7 days was seen to correlate well with motor deficit, speech deficit and neurocognitive impairment during discharge time. Similarly, on logistic regression it was seen to predict motor deficit (6 times more risk), speech deficit (20 times more risk) and neurocognitive impairment (4.5 times more risk). Also, it correlated with poor GOS score at 3 months with 21 times risk and correlated with poor GOS score at 6 months with 20 times risk. These findings indicate that the stay in ICU for more time needed long periods of monitoring which may be in view of vasospasm or other complications such as infarcts and need for CSF diversion or re-exploration etc.

CONCLUSION

On the basis of our findings we may conclude that the outcome after the operative treatment of non-giant saccular intracranial aneurysms with SAH of WFNS grade 1-4 depended significantly ($p<0.05$) on patients pre op GCS score, GCS on POD 2, Fischer's grade, intraoperative temporary clipping/intra-operative rupture, associated intraventricular/parenchymal bleed, postoperative ICU stay of > 7 days, preoperative hydrocephalus, need for CSF diversion, need for re-exploration and vasospasm. Cigarette smoking was significantly associated with occurrence of multiple aneurysm($p<0.05$).The postoperative parameters which significantly correlated with poor GOS score at 3 months and 6 months of follow up were vasospasm, postoperative infarct, ventilatory support duration, GCS on POD 2 of < 15 & ICU stay duration > 7 days, associated intraventricular/parenchymal bleed, need for CSF diversion, and need for re-exploration. The outcome did not significantly depend on patient's age, gender, location of aneurysm, intraoperative method of securing the aneurysm and timing for surgery i.e. interval between SAH and surgery.

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