Predictors of surgical outcome among patients with spontaneous supratentorial intracerebral hemorrhage: A prospective single institutional study

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Abstract

Introduction: Intracerebral hemorrhage (ICH) is a potentially devastating neurologic emergency with long-term functional independence achieved in only limited patients with good prognostic factors. The objective of this study is to identify the predictors of functional outcome in terms of modified Rankin Scale (mRS) following craniotomy and evacuation of spontaneous supratentorial intracerebral hemorrhage.

Methods and Materials: This is a prospective study of forty patients conducted at the College of Medical Sciences (CMS) from May 2019 to April 2020 with three months follow-up. Patients of spontaneous supratentorial intracerebral hemorrhage with features of raised intracranial pressure and deteriorating Glasgow Coma Score underwent surgical evacuation. The various predictors of outcome like Glasgow Coma Score and pupillary inequality at presentation, age, location of hematoma, clot volume, comorbidities, intraventricular extension and involvement of dominant hemisphere were documented and compared with outcome in terms of modified Rankin Scale (mRS).

Results: The mortality rate at three months was 25% (32% in deep seated and 13.3% in lobar intracerebral hemorrhage) and higher in patients with poor Glasgow Coma Score and pupillary inequality at presentation, volume >100 ml, intraventricular extension and patients undergoing decompressive craniectomy. Twenty patients (50%) had a favorable outcome (mRS 1-3) at follow-up, while 20 (50%) had a poor outcome (mRS 4-6). Unfavorable outcome was significantly higher among deep seated hematoma, age>70 years, poor Glasgow Coma Score and pupillary inequality at presentation, clot volume >100 ml, pre-existing comorbidity, patients undergoing decompressive craniectomy and involvement of dominant hemisphere.

Conclusion: Surgical evacuation of spontaneous supratentorial ICH is associated with high mortality in patients with poor GCS and pupillary inequality at presentation, and large clot volume with intraventricular extension. However, young patients with good premorbid status, moderate volume of hematoma, not involving dominant hemisphere and moderate to good GCS have good functional outcome.

Key words: Craniotomy, Evacuation, Modified Rankin Scale, Predictors, Spontaneous Intracerebral hemorrhage.

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Introduction

Intracerebral hemorrhage (ICH) is the second most common form of stroke accounting for approximately 10 to 20% of all strokes cases and leading to severe disability or death.[1] The case fatality rate of ICH is high (40% at one month and 54% at one year), and only 12% to 39% of survivors can achieve long-term functional independence.[2] Hypertension is the most common cause of non-lobar spontaneous ICH whereas cerebral amyloid angiopathy accounts for majority of spontaneous lobar ICH in elderly population.[3,4] Other risk factors include smoking, excessive alcohol consumption and use of anticoagulant, antithrombotic, and sympathomimetic agents.[5,6]

Indications for surgical evacuation of spontaneous supratentorial ICH have not been clearly defined and controversy remains between best medical management

versus surgery.[7] Current practice favors surgical intervention in the following situations: superficial hemorrhage, clot volume between 20-80 ml, worsening neurological status, relatively young patients and hemorrhage causing midline shift/raised ICP. The rationale for craniotomy and evacuation of hematoma is to reduce tissue damage by clot relieving local ischemia and reducing raised intracranial pressure (ICP).[8] Some studies like STICH II trial showed significant improvement following early surgery for lobar ICHs. Similarly in another trial better functional outcome was observed following surgical evacuation of subcortical and putaminal ICH compared to conservatively treated group.[9,10] However due to lack of sufficiently robust evidence has made it difficult to establish clear criteria for ICH evacuation based on the location.[11,12] [12] Recently various minimally invasive surgery (MIS) have been deployed for the surgical management of spontaneous ICH like Endoscopic evacuation of hematoma, Stereotactic aspiration and Stereotactic thrombolysis. In one of the meta-analysis conducted by Scaggiante et al demonstrated that selective patients with supratentorial ICH benefit from MIS over medical management or conventional craniotomy.[13] Similarly, in another study MIS led to a notable reduction of rebleeding rate and an effective improvement of the patient's quality of life by contrast with standard craniotomy.[14]

Factors responsible for poor patient outcome following craniotomy and evacuation of hematoma includes large ICH volume, deep seated hematoma, intraventricular extension, poor neurological status, pupillary inequality, presence of co-morbidities and advanced age.[6] Given the profound morbidity and mortality associated with ICH, these clinical predictors of poor patient outcome are of important prognostic value. The main aim of this study is to identify those predictors of outcome in patients who have undergone craniotomy and evacuation of spontaneous supratentorial ICH that will ultimately help to modify the management of ICH on an individual basis.

Methods and Materials

It is a prospective single institutional study conducted in the Department of Neurosurgery, College of Medical Sciences (CMS), Chitwan, Nepal from May 2019 to April 2020 after clearance from the ethical committee (College of Medical Sciences Teaching Hospital). Informed consent was taken from patients fulfilling the inclusion criteria after explaining the details of the procedure, outcome, and risks.

Sample size was calculated using the formula N= [Z^2 **x** p (p-1)]/E^2 and later using N/[1+(N-1)/Population] for 70 people to give a sample size of 40.

Patients with following characteristics were included in the study: Spontaneous supratentorial ICH (lobar or deep- Thalamic and Basal ganglia) of all age groups, patients with features of elevated ICP and deteriorating GCS and patients with midline shift and mass effect on CT scan.

Patients with following characteristics were excluded from the study: ICH due to tumor, trauma or vascular malformation, spontaneous infratentorial (brainstem and cerebellar) ICH and patients with bilaterally unresponsive pupils.

Initial evaluation is done by brief medical history including hypertension, diabetes, previous myocardial infarction, previous stroke and intake of any drugs followed by complete neurological assessment. Radiological evaluation is done with non-contrast CT brain and CT Angiography when needed to rule out any vascular malformation. Based on the CT imaging, the hematoma was defined as either lobar or deep-seated. Lobar hematoma incorporated hemorrhages in the frontal, parietal, temporal and occipital lobes originating from the cortex and subcortical white matter. Deep-seated hematomas comprised hemorrhages originating from the basal ganglia and thalamus.

A standard craniotomy and evacuation of ICH was done. Decompressive craniectomy with expansion duroplasty was done in eight cases with patients having brain swelling. Post-operatively patients shifted to neurosurgical ICU. Patients were followed up for at least three months and assessment made on the basis of modified Rankin Scale (mRS) score. A mRS score of 0 to 3 was considered a favorable outcome, while poor outcome was defined as a mRS score 4 to 6. The various predictors that influence the outcome of surgery like GCS at presentation, age, location of hematoma, clot volume, medical comorbidities, intraventricular extensions, pupillary inequality at presentation and involvement of dominant hemisphere were documented and compared with outcome in terms of mRS.

Statistical analysis was carried out using IBM SPSS 22 in descriptive and inferential statistical form. In the descriptive statistics Microsoft Word and Excel was used to generate diagrams, graphs and tables. Descriptive statistics of the quantitative data were presented by frequency, percentage. In the inferential statistics, to find the significant association in categorical variables, Pearson's chi-square test was used. P-value <0.05 was considered statistically significant.

Results

Patient demographics:

Forty patients underwent craniotomy and evacuation of spontaneous supra-tentorial ICH during this study period (May 2019 to April 2020). The mean age of patients was 59.52 ± 12.61 years with a range of 30 to 80 years. Of these, 12 patients were above 70 years and 28

were below 70 years. 52.5 % of the enrolled patients were female whereas 47.5% were male.

Majority of the patients presented with GCS between 9 and 12 (52.5%) followed by 27.5 % of patients with poor GCS (<8) and remaining 20 % with good GCS (13-15). Hypertension was the most common risk factors among 31 patients with pre-existing co-morbidity. Other risk factors were Diabetes mellitus, COPD, use of anticoagulants, previous infarction, and chronic alcoholism. 62.5% had deep seated hematoma (Basal ganglia/Thalamus) with intraventricular extension in 20% whereas; lobar (cortical and subcortical) hematoma was present in 37.5% patients. The mean preoperative hemorrhage volume of all patients was 80.45 ml with most of the patients (42.5%) having hematoma volume of 50-100 ml. 32.5% of patients had volume of more than 100 ml which signifies poor prognosis whereas, 25% had volume less than 50 ml. Eighteen patients (45%) had involvement of the dominant hemisphere and 15 patients (37.5%) presented with pupillary inequality.

In eight cases with brain swelling or anticipated brain swelling decompressive craniectomy with expansion duroplasty was done. Similarly, in two cases with intraventricular extension, External Ventricular Drain (EVD) placement was required following craniotomy and evacuation of hematoma. Hydrocephalus resolved subsequently and placement of Ventriculo-peritoneal (VP) shunt was not required. Five patients required Tracheostomy and prolonged ventilator support.

Mortality and functional outcome:

The overall mortality rate at three months was 25%, highest among patients with age >70 years (42%). Mortality was 32% in patients with deep-seated ICH and 13.3% in lobar ICH. Other parameters with higher mortality were GCS < 8 at presentation, clot volume >100 ml, intraventricular extension, patients undergoing decompressive craniectomy and patients who presented with pupillary inequality ($p<0.05$). Similarly, mortality rate was found to be higher in patients with pre-existing co-morbidities and involvement of dominant hemisphere but the difference was not statistically significant. Mortality with respect to various patient characteristics is mentioned in table 1.

Of all included patients, 20 (50%) had a favorable outcome (mRS 1 to 3) at follow-up, while 20 (50%) had a poor outcome (mRS 4 to 6). Poor/Unfavorable outcome was significantly higher among deep seated hematoma, age>70 years, poor GCS (<8) at the time of presentation, clot volume >100ml, patients undergoing decompressive craniectomy, involvement of dominant hemisphere, presence of co-morbidities and pupillary inequality ($p<0.05$). No statistical difference was noted regarding long term functional outcome between the two groups with regard to sex and intra-ventricular extension of hematoma. Functional outcome in terms of mRS is mentioned in table 2.

Parameters	Total (N=40)	Alive (N=30)	Death (N=10)	P-value
Age (years)				
< 70	28	23	5	0.43
≥ 70	12	7	5	
GCS				
<8	11	6	5	0.023
9-12	21	16	5	
13-15	8	8	0	
Clot Volume				
<50 ml	10	9	1	0.02
50-100 ml	17	15	2	
>100 ml	13	6	7	
Sex				
Male	19	13	6	0.361
Female	21	17	4	
Comorbidities				
Yes	31	22	9	0.274
No	9	8	1	
Intraventricular extension				
Yes	8	4	4	0.047
No	32	26	6	

Decompressive craniectomy				
Yes	8	4	4	0.047
No	32	26	6	
Dominant Hemisphere				
Yes	18	13	5	0.714
No	22	17	5	
Pupillary Inequality				
Yes	15	8	7	0.01
No	25	22	3	
Location				
Thalamus/Basal ganglia	25	17	8	0.187
Lobar	15	13	2	

Table 1: Post-operative mortality in relation to various patient characteristics

Parameters	Favorable outcome (N=20)	Unfavorable outcome (N=20)	P-value
Age (years)			
< 70	17	11	0.01
≥ 70	3	9	
GCS			
<8	1	10	
9-12	11	10	<0.001
13-15	8	0	
Clot Volume			
<50 ml	8	2	
50-100 ml	11	6	<0.001
>100 ml	1	12	
Sex			
Male	8	11	0.342
Female	12	9	
Comorbidities			
Yes	13	18	0.045
No	7	2	
Intraventricular extension			
Yes	8	4	0.114
No	32	26	
Decompressive craniectomy			
Yes	0	8	0.002
No	20	12	
Dominant Hemisphere			
Yes	6	12	0.045
No	14	8	
Pupillary Inequality			
Yes	4	11	0.02
No	16	9	
Location			
Thalamus/Basal ganglia	9	16	0.02
Lobar	11	4	

Table 2: Clinical data in relation to functional outcome (modified Rankin Scale) at follow-up

Discussion

Spontaneous ICH is a major cause of stroke with catastrophic consequences. Controversy exists regarding the best surgical management versus conservative treatment. Large retrospective cohort studies have shown a significant improvement in mortality rates since 2000.[15,16] Several tools are available to predict outcomes in ICH. Due to the high morbidity and mortality rates after ICH, early detection of high-risk patients would be beneficial in directing the management course and goals of care. This study aims to discuss relevant characteristics that can serve as predictors of poor prognosis and examine their efficacy in predicting patient outcomes after craniotomy and evacuation of ICH.

Spontaneous ICH is common after the 5th decade of life owing to increase in incidence of hypertension, other co-morbidities and Amyloid angiopathy in elderly patients.[17] Old age is both a risk factor for ICH incidence and a predictor of worse outcome. The average age of 59.52 years in our study is comparable with other international studies.[18] A worldwide stroke epidemiology study revealed that early stroke case fatality (21days to one month) varied substantially among countries and study periods; the case fatality rate was 25-30% in high-income countries while it was 30-48% in low- to middle-income countries.[19] Three months mortality rate in our study was 25%. In a study by Hessington et al., overall mortality was 13% at 30 days and 17.9% at six months. Mortality was higher in patients ≥ 65 years old. The deep-seated location, intraventricular extension, pupillary abnormalities were attributed to higher mortality.[18] Decrease in the ICH fatality rate might be attributed to the improvement of critical care and patient selection. Low GCS at presentation, high clot volume with ventricular extension are attributed to higher mortality rate due to greater primary brain insult in these patients. Similarly, mortality rate was higher in patients undergoing decompressive craniectomy. This is mainly due to intraoperative brain swelling for which decompressive craniectomy and expansion duroplasty is indicated. In the cohort study by Fahlstrom et al., the 30 days mortality for the poor grade patients (GCS-Motor response 1 to 3) was as low as 21 to 50%, arguing for a lifesaving role of ICH surgery in combination with neurocritical care. This can be contrasted to the STICH cohort where a uniformly bad outcome was reported in comatose patients.[20, 21]

Fifty percent of operated patients in our study had a favorable outcome (mRS ≤ 3). Similar results were seen in Hessington et al. study (51%).[18] A large ICH volume and deep seated location have repeatedly been considered a negative prognostic factor and a powerful predictor of mortality.[22,23] One potential factor responsible for the poor surgical outcome in Basal ganglia/thalamic ICH is the additional brain injury inflicted by the surgery.[24] Surgical evacuation of ICH helps to reduce nervous tissue damage by relieving local ischemia or removal of noxious chemicals along with relieving raised ICP. Nevertheless, responses to surgery do not seem to be homogeneous. For example, large, surgically accessible clots (lobar) exerting a mass effect might benefit from early surgery; whereas deep seated hematoma with surgical approach paths that cross eloquent speech and motor regions probably do not.[9] Similarly, patients with poor GCS at presentation and pupillary inequality suggests greater primary brain injury and herniation leading to prolonged ventilator support. Most of these patients end up in vegetative state or bed bound. In addition, advanced age, pre-existing co-morbidities and involvement of dominant hemisphere are also accountable for long term poor functional outcome.[25,26,27] Intraventricular extensions of hematoma have been attributed to poor functional outcome by various studies but no statistically significant difference was observed in our study.

Limitations of the present study include relatively small sample size and this is a single institutional study. Similarly, follow-up period of three months is relatively short. Longer duration of follow up is required to assess long term prognosis for functional outcome in ICH patients. Another limitation of the study is the lack of details on medical management, such as specific systolic blood pressure levels or choice of antihypertensive medication, which might have added valuable information. The clinical decisions regarding surgical evacuation may also differ slightly among the treating neurosurgeons. Thus, some selection bias may exist.

Conclusion

Craniotomy and evacuation of spontaneous supratentorial ICH is associated with high mortality especially in patients with poor GCS and pupillary inequality at presentation, and large clot volume with intraventricular extension. However, young patients with good premorbid status, moderate volume of hematoma, not involving dominant hemisphere and moderate to good GCS have better long-term functional outcome. Thus, proper patient selection along with neurocritical care based on these predictors yields a favorable outcome among surgically treated spontaneous supratentorial ICH.

Conflict of Interest: None
Source(s) of support: None

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