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Original Article

Surgery Section

Intraoperative Prognostic Factors in Patients with Traumatic Acute Subdural Haematoma Undergoing Decompressive Craniectomy- A Pilot Study

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ABSTRACT

Introduction: Traumatic Acute Subdural Haematoma (TASH) remains one of the most lethal of all head injuries with high mortality and morbidity. The admission Glasgow Coma Score (GCS), age, pupillary response and size, hypoxia, hyperthermia, and raised Intra Cranial Pressure (ICP) are the conventional prognostic indicator markers for TASH. However, these markers do not represent secondary brain injury.

Aim: To identify the intraoperative prognostic markers and devise a scoring system based on these factors to aid in defining prognosis of patients with TASH undergoing Decompressive Craniectomy (DC).

Materials and Methods: This pilot study was conducted in the Department of Neurosurgery, Government Medical College Thrissur, Kerala, India, over a period of one year from July 2018 to August 2019. Total 100 patients who presented with TASH and underwent DC were included in the present study. Intraoperative factors such as hypotension, saturation fall, brain bulge, brain pulsations, clot volume and Sub Arachnoid Haemorrhage (SAH) size were recorded. The primary outcome on the 30th day as alive or dead and functional outcome by Modified Rankin scale on 60th day was recorded. Based on these factors a scoring system was devised. Parameters were assessed using Chi-square test.

Results: Among the 100 patients, 95 were males and five females with maximum cases (56) clustered between 36 to 50 years. Intraoperative fall in Blood Pressure (BP) lasting >5 minutes, fall in saturation of O_2, presence of brain bulge (moderate to severe), clot volume >30 mL, poor brain pulsation, presence of co-existant SAH and presence of brain contusion indicated unfavourable prognosis. Poor GCS score was associated with poor functional outcome of Modified Rankin Scale (MRS) 6. Based on intraoperative prognostic scoring, patients belonging to Grade A category had favourable prognosis (no death). Patents belonging to Grade C had poor prognosis (43 death).

Conclusion: Intraoperative factors should serve as vital prognostic tools, hand in hand with the conventional admission GCS and Computed Tomography (CT) while managing a patient with TASH undergoing DC. Such an approach would mirror the maximum damage suffered by brain due to injury which is inclusive of primary brain injury and secondary insults as well, suffered up to and until the time of a durotomy.

Keywords: Head injury, Intracranial pressure, Primary brain injury, Prognostic indicators

INTRODUCTION

Traumatic Acute Subdural Haematoma (TASH) is an engrained nosological entity which implies extra-cerebral accumulation of blood between the dura mater and the subarachnoid layer following acute head injury [1]. When combining all patients with Traumatic Brain Injury (TBI), 11% patients presented with a Subdural Haematoma (SDH) [2]. A recent study by Ryan CG et al., observed a lower mortality rate of 14% among patients with traumatic brain injury, which is lower than what was observed in studies from the late 1990s to the mid 2000s (22-26%) [3]. The most common mechanism of injury leading to traumatic SDH is fall from height and motor vehicle accidents (85%), followed by assault and bicycle crash (11%) [3]. It leads to increase in Intra Cranial Pressure (ICP), and is often complicated by co-existing intracranial lesions, including a variety of diffuse injuries, contusional haematomas and oedemas [4]. This study was an attempt to identify the intraoperative prognostic factors and to devise a surgical prognostic scoring system using intraoperative parameters alone in the management of traumatic brain injury patients with acute subdural haematoma.

In patients with traumatic acute subdural haematoma poor outcome is higher in elderly even after surgery [5]. In 2009, in a multivariate analysis of 256 patients with traumatic SDH, mechanism of injury was closely related with outcome as it was observed that the functional recovery was lowest (29.2%) in patients involved in motor vehicle accidents [6].

Glasgow coma scale is considered to be the most important factor that directly reflects brain damage and gives information on prognosis during the follow-up [7]. In patients with traumatic SDH undergoing Decompressive Craniectomy (DC) pupillary asymmetry (anisocoria) are often associated with poor neurological outome [8]. Rotterdam Computed Tomography (CT) score is a prognosticator in DC patients by combining individual CT parameters preferable for prognostic purposes in TBI [9,10]. A report by Seelig JM et al., of 82 patients with SDH who underwent surgery within 4 hours of injury had significantly lower mortality than patients who underwent surgery later, with mortality rates of 30% and 90%, respectively [11].

Brain bulge can be evaluated by direct inspection and palpation after opening the bone and duramater [12]. A five-point scale was used by Bristow and colleagues assessing brain relaxation from excellent to poor, including ideal, less ideal, tense, bulging and the worst conditions for surgery [13]. Recently, a four-point scale, has been used grading the brain as completely relaxed, satisfactorily relaxed, firm, and bulging [14]. Intraoperative Hypotension (IH) is defined as any Systolic Blood Pressure (SBP) <90 mmHg (irrespective of duration of the episode). Secondary damage to the injured brain can occur as a result of hypoxia, hypotension, hypercarbia and hypocarbia, increased ICP and hyperglycaemia, all leading to poor outcome [15].

Regular variations in blood flow into and throughout the brain that are synchronous with the heart beat occurs due to systolic increase in blood pressure over the cardiac cycle. These pulsations in flow and pressure are in turn transferred into brain tissue since the brain is contained within the skull. Large changes in ICP and in the biomechanical properties of the brain can lead to significant changes in pressure and flow pulsatility hence investigators have found it a useful marker in certain diseases, particularly TBI [16].

Significant changes in post-traumatic haematomas and the appearance of new haematomas may occur without changes in the clinical status of the patient, from the time of first CT scan to the time of surgery [17]. Tong WS et al., reported that early progressive haemorrhage occurred in approximately 30-42.3% of head injured patients, and it occurs most commonly in intraparenchymal contusion or haematoma [18]. Hence, intraoperative volume assessment of haematoma volume should be considered. Microvessels in the region of injury (penumbra) receive kinetic energy from the impact that is sufficient to induce a series of maladaptive molecular changes that leads to delayed formation of petechial haemorrhages which then coalesce to produce haemorrhagic progression [19]. In their study, Vignesh RS et al., observed that SDH with associated contusion or SAH had a worse prognosis than SDH alone and they commented that early surgery in these cases may improve the prognosis [20].

The objectives of this study was to assess the relationship of selected intraoperative factors with the outcome in patients undergoing DC for TASH, further, to devise a concise scoring system using those surgical parameters for prognostication of outcome and to assess the primary outcome on the 30^{th} day as alive or dead and functional outcome by Modified Rankin Scale (MRS) on 60^{th} day and to determine correlation between the obtained score and the primary and functional outcome.

MATERIALS AND METHODS

This pilot study was a cross-sectional study conducted in the Department of Neurosurgery, Government Medical college, Thrissur, India, over a period of one year from July 2018 to August 2019 after obtaining informed consent and ethical clearance (B6-8772/2016/MCTCR(10).

Inclusion criteria: Patients with age 13 years and above, TASH without contusion or intraventricular haemorhage in preoperative CT scan, patients with no evidence of preoperative hypotension (BP >90/60 without inotropes) patients with no evidence of preoperative fall in SpO_2 (>95% without O_2 before induction) and patients with no preoperative clinical evidence of brain stem dysfunction were included.

Exclusion criteria: Patients with severe life threatening musculoskeletal/spine/thoracoabdominal injuries, brain stem dysfunction and conservatively managed patients with TASH were excluded.

Sample size calculation: The sample size was calculated using the formula [21]-

$n=4PQ/L^2$

Taking P=51.35%; Q=100-P, L=Relative precision (20% of previous prevalence). Total 100 patients with TASH who underwent DC were included.

After consent process, data regarding the demographic characteristics such as age, sex, mode of injury, clinical evaluation pertaining to GCS, pupil, pulse, respiration, brain stem reflexes, CT findings and SpO_2 blood pressure were recorded. Need for surgery was decided, based on brain trauma foundation guidelines 2012 [22]. Fronto-subtempo-parieto-occipital DC and opening of dura mater is the most common technique that avoids brain herniation through craniectomy defect, and prevents venous infarctions that causes brain swelling [23]. Intraoperative factors such as hypotension, saturation fall, brain bulge, brain pulsations, clot volume and Sub Arachnoid Haemorrhage (SAH) size were assessed [Table/Fig-1]. Relationship of these factors with the outcome was assessed. The primary outcome on the 30^{th} day as alive or dead and functional outcome by Modified Rankin scale [24] on 60^{th} day was recorded. A scoring system was devised based on the following parameters. The intraoperative prognostic score is as follows.

Parameter/Score	2	1	0
Duration of blood pressure fall	No	Less than 5 min	More than 5 min
Duration of SpO_2 fall	no	Less than 5 min	More than 5 min
Degree of brain bulge after clot evacuation	No surface below the inner table	Moderate surface below the outer table	Severe- surface out of the bone margins
Brain pulsations	Good	Moderate	Absent
Clot volume	Upto 30 mL	30 to 75 mL	>75 mL
Sub arachnoid haemorrhage	No	Focal <2 cm	Diffuse
Burst lobe/contusion Yes/no	No	Small <1 cm	Large >1 cm

[Table/Fig-1]: Intraoperative score.

Intraoperative prognostic score was based on the previous studies [12-20].

The sum of individual points was taken up and categorised in to three grades as:

Grade A: 12 to 14

Grade B: 8 to 11

Grade C: less than 8

Modified Rankin Scale (MRS) [24]:

- 0-No symptoms.
- 1-No significant disability.
- 2-Slight disability.
- 3-Moderate disability
- 4-Moderately severe disability.
- 5-Severe disability.
- 6-Dead.

STATISTICAL ANALYSIS

Data collected from each individual was entered in excel worksheet after coding of variables and appropriate analysis done with help of MS excel and SPSS version 20. Qualitative data was analysed with proportion and chi-square test.

RESULTS

Among the 100 patients, 95 were males and 5 females [Table/Fig-2]. Age wise distribution varied from 25 years to 65 years with maximum cases (56) clustered between 36 years to 50 years [Table/Fig-2]. Most of the patients (77) were admitted following road traffic accidents, 20 patients with fall from height and rest 3 were with history of assault [Table/Fig-2].

Association of intraoperative factors and outcome.

Clot volume and outcome: Out of 55 patients who died, 29 patients had clot volume of more than 75 mL [Table/Fig-4]. Hence, it was associated with poor outcome. Chi-square test showed p-value <0.05 which was statistically significant [Table/Fig-3, and 4].

Sub Arachnoid Haemorrhage (SAH) and outcome: All patients with diffuse SAH died. Among the survivors, SAH was absent in 30 patients and focal SAH was found in 15 patients [Table/Fig-4].

Demography	
Gender	
Male	95
Female	5
Age group (years)	
25 to 30	27
36 to 50	56
51 to 65	17
Mode of injury	
RTA	77
Fall	20
Assault	3

[Table/Fig-2]: Demographic data.
RTA: Road traffic accident

Parameter	Score 2	Score 1	Score 0	Alive	Dead	p-value
Clot volume	6	47	47	45	55	<0.05
Sub arachnoid haemorrhage	45	44	11	45	55	<0.01
Duration of blood pressure fall	66	18	16	45	55	<0.01
Duration of SpO_2 fall	90	10	0	45	55	<0.01
Brain bulge	6	68	26	45	55	<0.01
Brain pulsations	12	60	28	45	55	<0.01
Contusion	24	50	26	45	55	<0.01

[Table/Fig-3]: Association of Intraoperative prognostic factors and outcome.
p-value <0.01 was statistically significant

Parameter	Score	Alive	Dead	p-value
Clot volume	2 (Upto 30 mL)	6	0	<0.05
	1 (30-75 mL)	21	26	
	0 (>75 mL)	18	29	
SAH	2 (No SAH)	30	15	<0.01
	1 (Small <1 cm)	15	29	
	0 (Large >1 cm)	0	11	
Duration of BP fall	2 (No)	42	24	<0.01
	1 (<5 Minutes)	0	18	
	0 (>5 Minutes)	3	13	
Duration of SpO_2 fall	2 (No)	45	45	<0.01
	1 (<5 Minutes)	0	10	
	0 (>5 Minutes)	0	0	
Brain bulge	2 (Nil)	3	3	<0.01
	1 (Moderate)	39	29	
	0 (Severe)	3	23	
Brain pulsations	2 (Good)	9	3	<0.01
	1 (Moderate)	36	24	
	0 (Absent)	0	28	
Contusion	2 (Nil)	18	6	<0.01
	1 (Small <1 cm)	24	26	
	0 (Large >1 cm)	3	23	

[Table/Fig-4]: Summary of intraoperative prognostic factors and outcome.
p-value <0.01 was statistically significant

Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-3,4].

Blood pressure and outcome: IH was found in 34 patients and 31 patients who had BP fall died reflecting a mortality of 91% [Table/Fig-4]. Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-3, and 4].

SpO_2 and outcome: There was no SpO_2 fall in patients who survived the trauma. Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-3, and 4].

Brain bulge and outcome: About 23 patients who died had severe brain bulge. Chi-square test showed p-value <0.01 which was statistically significant. Hence, there is significant association between brain bulge and outcome [Table/Fig-3,4].

Brain pulsation and outcome: Brain pulsation was absent in 28 patients who had died [Table/Fig-4]. No patients who survived had absent brain pulsation. Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-3,4].

Contusion and outcome: Out of 55 patients who died, 49 patients has been associated with brain contusion. Only 3 among the survivors had severe brain contusion [Table/Fig-4]. Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-3,4].

Summary of intraoperative prognostic factors and outcome: Contrary to the expectation the mortality in patients with GCS 13 to 15 is 3 out of 6 patients (50 %) which is higher than in patients with GCS 9 to 12, 8 out of 23 patients (34%). Chi-square test showed p-value >0.05 (0.072) which was not statistically significant [Table/Fig-5]. Anisocoria was observed in 56% patients.

Outcome	GCS score 3 to 8	GCS score 9 to 12	GCS score 13 to 15
Alive	27	15	3
Dead	44	8	3

[Table/Fig-5]: Association between preoperative GCS and final outcome.
Chi-square test showed p-value >0.05; GCS: Glasgow coma scale

Intraoperative score and survival at 30th: There was no mortality among patients with intraoperative Grade A score. Mortality was 26% (12 among 45 patients) and 87% (43 among 49) in patients with Grade B and Grade C score, respectively. So, higher the grade better is the survival. Chi-square test showed p-value <0.01 which was statistically significant [Table/Fig-6].

Grade	Grade A	Grade B	Grade C
Alive	6	33	6
Dead	0	12	43

[Table/Fig-6]: Association between intraoperative prognostic score and primary outcome.
Chi-square test showed p-value <0.01

Intraoperative score and MRS on day 60th: Association between intraoperative score and functional outcome (Modified Rankin Scale) MRS at day 60 in patients with GCS between 3 and 8 [Table/Fig-7]. Association between intraoperative score and functional outcome (Modified Rankin Scale) MRS at day 60 in patients with GCS between 9 and 12 [Table/Fig-8]. Association between intraoperative score and functional outcome (Modified Rankin Scale) MRS at day 60 in patients with GCS between 13 and 15 [Table/Fig-9]. MRS in all GCS group shows consistently that patients with Grade C has poor MRS score of 6 while grade A patients have a better outcome. Chi-square test showed p-value <0.01 which was statistically significant.

MRS	MRS 0	MRS 1	MRS 2	MRS 3	MRS 4	MRS 5	MRS 6
Grade A	0	0	0	0	0	0	0
Grade B	3	6	9	0	0	3	12
Grade C	3	0	0	0	3	0	32

[Table/Fig-7]: Association between intraoperative score and functional outcome (Modified Rankin Scale) MRS at day 60 in patients with GCS between 3 and 8.
Chi-square test showed p-value <0.01; MRS: Modified rankin scale

MRS	MRS 0	MRS 1	MRS 2	MRS 3	MRS 4	MRS 5	MRS 6
Grade A	0	0	0	3	0	0	0
Grade B	3	6	3	0	0	0	0
Grade C	0	0	0	0	0	0	8

[Table/Fig-8]: Association between intraoperative score and MRS at day 60 in patients with GCS between 9 and 12.
Chi-square test showed p-value <0.01; MRS: Modified rankin scale

MRS	MRS 0	MRS 1	MRS 2	MRS 3	MRS 4	MRS 5	MRS 6
Grade A	3	0	0	0	0	0	0
Grade B	0	0	0	0	0	0	0
Grade C	0	0	0	0	0	0	3

[Table/Fig-9]: Association between intraoperative score and MRS at day 60 in patients with GCS between 13 and 15.
Chi-square test showed p-value <0.01; MRS: Modified Rankin Scale

DISCUSSION

The present study aimed at identifying intraoperative prognostic factors in patients with TASH undergoing decompressive craniectomy.

Among the 100 patients in the study group, there were 95 males and 5 females. In their study, Ryan CG et al., found that TASH was predominantly seen in males (63%) [3]. Similar pattern of male predominance (73%) was observed by Prahaladu P et al., in an observational study done at a level I trauma center [21]. Current study findings were in concordance with both those studies. The age distribution in this study ranged from 21 years to 62 years. Most patients belonged to age group between 36 years to 50 years. The Prahaladu P et al., noted that acute SDH was more common in a younger age group ranging from 20 to 40 years [21]. Contrary to this, Huang YH et al., in their series of patients with TASH, found that the mean age group in their study was 78.9 years [9]. This study seemed tending towards agreement with the Prahaladu P et al., study [21]. In patients with traumatic acute subdural haematoma poor outcome is higher in elderly even after surgery [5]. The most common mode of injury in this study was RTA followed by fall from height. In 2009, in a multivariate analysis of 256 patients with traumatic SDH, mechanism of injury was closely related with outcome as it was observed that the functional recovery was lowest (29.2 %) in patients involved in motor vehicle accidents [6]. Such a trend was also observed in Stening WA et al., study which demonstrated that road traffic victims had a higher mortality rate (87%) when compared with other accidents (61%) [25].

Anisocoria was observed in 56% patients. Faleiro RM et al., noted that 32% patients in their study group comprised of 89 patients with TASH had anisocoria, thus identifying it as a prominent preoperative prognostic indicator indirectly suggested raised ICP [26]. These findings were ratified by Taussky P study on TASH where they found that 33% of their study cohort had anisocoria [27]. This study showed a higher incidence of anisocoria compared to these studies.

Most patients in the present study group had GCS score ranging from 3 to 8. There was no statistically significant relationship between GCS score and outcome noted (p-value=0.072). Several studies acclaim GCS as a significant preoperative prognostic indicator in TASH. However few studies refute this theory. Narayan RK et al., have shown an unfavorable prognosis in 77% of patients with GCS scores between 3 and 5 [28]. Potts MB et al., argue that the GCS has significant predictive value only in patients undergoing DC in the specific age group between 35 and 49 years, with statistical significance (p-value=0.011) [29]. The present study did not found a statistically significant association with preoperative GCS score and outcome, similar to the findings of Potts MB et al., [29].

A 94% patients in this study was identified to have clot volume of >30 mL at the time of surgery. All the 6 patients who had clot volume <30 mL had good outcome. This suggests that patients with lower clot volume during time of surgery has favourable prognosis when compared to their peers with clot volume >30 mL.

As for IH, fall in BP for >5 minutes was observed in 16 patients in this study, of which only 3 patients had favorable outcome. Among the 66 patients with no IH, 63.3% patients had favorable outcome. Sharma D et al., 30 in their study noted that the prevalence of IH observed was significantly higher than what was observed in other contemporary studies (in children 41-52%, adults 32-46%) [30-32]. In the current study, statistically significant observation p-value <0.001 suggested a strong association between IH and outcome in TASH. Absence of IH suggests favourable prognosis.

In the present study, moderate brain bulge was seen in 68 patients among whom 39 patients had favourable outcome. Among the 26 patients with severe brain bulge, 88% patients had unfavourable outcome. A 50% of patients with no brain bulge had favourable prognosis. Thus, it can be noted that there is a statistically significant association between brain bulge and prognosis. Presence of moderate and severe brain bulge is associated with worse prognosis. Though the concept of 'brain bulge' and 'brain relaxation' has been quoted in literature, no studies till date have explored the possibility of recognising brain bulge as an intraoperative prognostic indicator.

A 60% of patients in the present study group had moderate brain pulsations. Among them, 60% had good prognosis. In contrast, 75% patients with good brain pulsations showed favourable outcome. The study showed that there was a statistically significant association between brain pulsation and outcome in DC for TASH, with good brain pulsations resulting in excellent prognosis.

A total of 76 patients in the present study had brain contusion among whom, 50 patients had contusion of size <1 cm and 26 patients had a size >1 cm. Among those 76 patients, 49 (64.4%) patients had unfavourable outcome. Worse outcome was seen in patients with contusion size >1 cm when compared to those with contusion size <1 cm. A 75% of patients with no contusion had favourable outcome. Thus, it can be inferred that there is a statistically significant relationship between brain contusion and prognosis, the presence of which diminishes favourable outcome.

The admission GCS score, age, pupillary response and size, hypoxia, hyperthermia and raised ICP are the conventional prognostic indicator markers for TASH. However, as the time taken from the imaging and clinical evaluation to the final surgical intervention is highly variable in a tertiary care setup, factors such as admission GCS and CT status would technically only be a reflection of the PAST status of brain injury. Theoretically, intraoperative factors would serve as surrogate markers reflecting the current status of a patient, while undergoing craniectomy which takes into consideration all the insults that have occurred prior to evacuation of clot. Therefore, intraoperative factors are better prognostic indicators than the admission GCS and CT while managing a patient with TASH. These indicators mirror the maximum damage suffered by brain due to injury which is inclusive of primary brain injury and secondary insults as well, suffered up to and until the time of a durotomy [31,32].

Limitation(s)

This was a pilot study considering the intraoperative prognostic factors. Another limitation of the present study was short-term follow-up and the small number of patients. Larger sample size and studies from many more centres will be required to strongly validate its utility.

CONCLUSION(S)

Intraoperative factors are better prognostic tools as they show maximum damage suffered by brain. Intraoperative factors should serve as vital prognostic tools, hand in hand with the conventional admission GCS and CT while managing a patient with TASH undergoing DC. Such an approach would mirror the maximum damage suffered by brain due to injury which is inclusive of primary brain injury and secondary insults as well, suffered up to and until the time of a durotomy.

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