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Original Article

Neurological outcome in patients of traumatic subarachnoid haemorrhage: A study of prognostic factors & role of MRI

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ABSTRACT

Objective: Our present study aims to investigate various prognostic factors associated with the neurological outcome among patients of post-traumatic SAH on the basis of clinical findings and CT scan evidence. We studied further to establish sequences of MRI as a diagnostic tool for detection of fresh tSAH and contusions.

Methods: A prospective study was conducted in which 117 patients were enrolled for study. Data of initial severity, GCS, CT & MRI scan (FLAIR/GRE) findings, Fisher grading, Marshall classification and GOS on discharge were collected. Amount of blood, anatomical sites of SAH, MRI changes were recorded. GOS on discharge and after one month was compared. Statistical analysis of data was done.

Results: tSAH was found more common in adolescent male in RTA. Most common anatomical site was sulcal spaces over convexity. Contusion was the most commonly associated pathology. Univariate analysis of data showed significant correlation of prognosis with GCS, Fisher grade, presence of SDH and fresh SAH on MRI scans. Death rate was maximum in Fisher grade III (6.06%) relating SAH thickness. On MRI sequence, 12 patients had evidence of fresh SAH and contusions.

Conclusions: The outcome of tSAH depends on the GCS at admission, amount and distribution of SAH. MRI is a good diagnostic tool.

1. Introduction

Traumatic brain injury is common cause of morbidity and mortality worldwide. Incidence and pattern of traumatic brain injury varies in developed and developing countries. Subarachnoid haemorrhage refers to blood in subarachnoid space that lies between arachnoid and pia meninges, covering brain. It is often associated with concurrent intracranial injury component. Individuals at higher risk for tSAH are those who

Abbreviations: GCS, Glasgow coma scale; tSAH, Traumatic subarachnoid haemorrhage; GOS, Glasgow outcome scale; CI, confidence interval; RTA, road traffic accident.

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are at higher risk for blunt head trauma. This includes adolescents, low-income individuals, men, and individuals with a history of substance abuse. Our present study aims to investigate prognostic factors associated with the neurological outcome among patients of post-traumatic SAH.

2. Patients and methods

The present study was conducted in SMS Medical College and Hospital, Jaipur during September 2012 to April 2013. All patients of head injuries with SAH (117/850) were included irrespective of their age and sex. After obtaining their informed and written consent, either from patient or their legal heir, exclusion criteria (metabolic disorder/altered coagulation profile/cardiac disease & co morbid illness) were applied. GCS at admission and discharge, GOS at discharge and at one month of follow-up were noted of eligible patients. CT scan at the time of admission along with MRI of brain with GRE and FLAIR images were done. Standard treatment guideline was followed as per requirement. Data regarding head injuries other than SAH and other system injuries were also recorded on a predesigned, semi structured pro forma. Fisher grading and Morris–Marshall grading were also assessed and used for statistical analysis.

2.1. *Statistical analysis*

All data thus obtained were entered in excel sheet to prepare master sheet and were subjected to statistical analysis. Continuous variables were summarised as mean and standard deviations while qualitative data were summarised as percentage. Parametric tests were used for analysis of continuous variable whereas Chi-square and other noparametric tests were used for qualitative data and ordinal scale data. Multivariate linear regression was also done to find out predictors of outcome in exclusive SAH. *P* value less than 0.05 was taken as significant. All the calculations were done by using Medcalc 14.0.0 version software.

3. Results & discussion

We had 850 patients of head injury from 1st September 2012 to April 2013, out of which 117 patients had tSAH, an incidence rate of 13.76% amongst patients of head trauma. George et al[1] reported 32% patients of tSAH in their study. Chieregato et al[2] had 37% tSAH amongst admitted patients of head injury. Common age group affected in present study is between 21 and 30 years with male predominance (90.59%)(Table 1). In Franco et al[3] study, median age group for tSAH is 43 years with male predominance (75%) and Chieregato et al (Table 3) had around 70% male dominance. We had around 50.41%, 23.07%, 21.36% patients in mild, moderate and severe category of head injury, respectively, whereas Chieregato et al had 59%, 14%, 25.5% patients in these three types of head injury. For tSAH in different anatomical distribution literature had different views as per their findings. In the present study, maximum patients with poor GOS, had mixed and diffuse sulcal SAH. Although we had few patients of basal SAH (3.42%) & IVH (5.98%), they all had poor GCS on presentation. González Pérez et al[4] and Gaetani et al[5] noted poor outcome in basal cisterns

Table 1 – Results at discharge.

Parameters		Outcome (on discharge)			*P* value[a]
		Favourable	Unfavourable	Mortality	
Number	Male	75/106 (70.75%)	31/106 (29.24%)	12 (11.32%)	0.671
	Female	9/11 (81.81%)	2/1 1(18.18%)	0	
GCS on admission	Mild	57/59 (96.61%)	2/59 (3.38%)	1 (1.69%)	0.000
	Moderate	21/27 (70.77%)	6/27 (22.22%)	2 (7.40%)	
	Severe	6/25 (24%)	19/25 (76%)	7 (28%)	
	Critical	0/6	6/6 (100%)	2 (33.33%)	
Fisher grading	I	Nil	Nil	Nil	0.00
	II	47/56 (83.92%0	9/56 (16.07%)	3 (5.35%)	
	III (1 absconded)	31/46 (67.39%)	15/46 (32.61%)	6 (13.04%)	
	IV	6/15 (40%)	9/15 (60%)	3 (20%)	
Morris–Marshall classification	0	0	0		0.147
	I	19/37 (51.35%)	18/37 (48.65%)	3 (8.10%)	
	II	29/53 (54.71%)	23/53 (43.39%)	5 (9.43%)	
	III	4/10 (40%)	6/10 (60%)	2 (20%)	
	IV	3/17 (17.64%)	14/17 (82.35%)	2 (11.76%)	
Associated brain injury	EDH	8/10 (80%)	2/10 (20%)	1 (10%)	0.841
	SDH	10/19 (52.63%)	9/19 (47.36%)	4 (21.05%)	0.016
	Contusion	37/50 (74%)	13/50 (26%)	4 (8%)	0.362
Anatomical location of SAH	Sulcal	51/70 (72.85%)	19/70 (27.14%)	7 (10%)	0.505
	Diffuse SAH	30/46 (65.21%)	16/46 (34.78%)	6 (13.04%)	0.860
	Basal cistern	0	4/4 (100%)	1 (25%)	NA
	IVH	5/12 (41.66%)	7/12 (%)	3 (25%)	0.048
MRI study for SAH	Fresh SAH	7/9 (77.77%)	2/9 (22.22%)	0	0.976
	Fresh Contusion	2/3 (66.66%)	1/3 (33.33%)	0	NA

[a] Chi-square test.

Table 2 – Results at one month.

Parameters		Outcome (AT 1 month)		P value[a]
		Favourable	Unfavourable	
Number	Male	75/117 (64.10%)	31/117 (26.49%)	0.869
	Female	9/117 (7.69%)	2/117 (1.70%)	
GCS on admission	Mild	57/117 (48.71%)	2/117 (1.70%)	0.000
	Moderate	21/117 (17.95%)	6/117 (5.13%)	
	Severe	6/117 (5.13%)	19/117 (16.24%)	
	Critical	0/117	6/117 (5.13%)	
Fisher grading	I	Nil	Nil	0.00
	II	48/117 (41.02%)	9/117 (7.69%)	
	III(1 absconded)	30/117 (25.64%)	15/117 (12.82%)	
	IV	6/117 (5.13%)	9/117 (7.69%)	
Morris–Marshall classification	0	0	0	1.000
	I	27/117 (23.07%)	10/117 (8.54%)	
	II	39/117 (33.33%)	14/117 (11.96%)	
	III	6/117 (5.13′%)	4/117 (3.41%)	
	IV	12/117 (10.25%)	5/117 (4.27%)	
Associated brain injury	EDH	8/117 (6.84%)	2/117 (1.70%)	0.841
	SDH	10/117 (8.55%)	9/117 (7.69%)	0.016
	Contusion	37/117 (31.62%)	13/117 (11.11%)	0.362
Anatomical location of SAH	Sulcal	52/117 (44.44%)	18/117 (15.38%)	0.505
	Diffuse SAH	31/117 (26.50%)	15/117 (12.82%)	0.860
	Basal cistern	0	4/117 (3.42%)	NA
	IVH	5/117 (4.27%)	7/117 (5.98%)	0.048
MRI study for SAH	Fresh SAH	7/117 (5.98%)	2/117 (1.71%)	0.976
	Fresh contusion	3/117 (2.56%)	0	NA

[a] Chi-square test.

and convexity SAH. Chieregato et al had 32% of basal SAH on initial scan. Blood in basal cistern and few of mixed pattern SAH patients also made worse impact on outcome. Franco et al observed 43% mortality in basal SAH and 47% in other SAH, respectively, although these data were noted six months after injury. Wong et al[1] and George et al did not notice impact on outcome because of anatomical distribution. Paiva et al[6] showed that mortality was significantly high in thick cisternal clot >1 mm and recovery rate in patients of IVH was quite slow. We had nearly similar observation in the present study. Wong et al, George et al and Gaetani et al suggested the value of thickness of clot/amount of bleeding as important parameter in deciding morbidity and mortality. George et al also noticed other important prognostic factor such as age, thickness of subdural haematoma and mass effect. Franco et al reported worse prognosis in patients of tSAH in their series and put the possibility that death is due to severity of initial mechanical damage rather than delayed effects of vasospasm or secondary brain damage. George et al measured thickness of blood meticulously and said that 4 mm thickness is associated with favourable outcome and 7 mm thickness is associated with unfavourable outcome. Nazar Husain et al[7] showed good correlation of clinical condition on admission, distribution of blood in brain and associated injury. Chieregato et al said that initial Glasgow coma scale, amount of blood and associated parenchymal damage contribute to outcome. Regarding outcome Chieregato et al had 70% patients with good recovery, 9% had moderate disability, 13% death and 19% with unfavourable outcome respectively. George et al had 63% favourable outcome in their study. In present study, we had 72% favourable and 28% unfavourable outcome.

MRI sequences were done in most of the patients after initial CT scan was performed. Our purpose was to detect evidence of fresh SAH or contusion growth as compared to initial CT scan .We did MRI in 77 out of 117 patients of tSAH, out of which 12 (15.58%) patients showed either fresh SAH or contusion growth in FLAIR/GRE images in early phase of SAH (Figs. 1 and 2). On univariate regression analysis with GC scale, this was found to be statistically significant (p value 0.040). This proves that MRI done in early phase of head injury is sometimes more sensitive than plane CT to detect fresh SAH and contusion growth.[8] Fainardi et al[9] put emphasis on repeat CT scan after 12–24 h in patients of all traumatic brain injury for early detection of developing fresh haematoma or other evolving intracranial lesion. Mattioli et al[10] suggested that Traumatic SAH is associated with more severe CT findings and a worse patient outcome. Jung-Ho Shin et al[11] demonstrated that poor outcomes among patients with tSAH at admission are related to GCS score, CT change and contusions presence. The GCS score and presence of contusions also predicted significant lesion progression, thus linking CT changes with a prognosis of poor outcomes. We noticed that tSAH is often found with other intracranial injuries .In particular there was high incidence of associated subdural haematoma and contusion with SAH, in which patients had poor GOS. Associated brain injury and other system injury were found to have independent bearing on outcome. On univariate analysis, factors like SAH in basal cistern, IVH, Fisher grading, GCS on admission, associated brain injury (SDH) (Table 2) were found significant but on multivariate logistic regression analysis, all factors were excluded except GCS on admission, which was found to have significant impact on overall outcome in tSAH and associated

Table 3 – Discussion.

Parameters	Chieregato et al[2]	Paiva w s et al[5]	Wong gk et al[6]	George et al[3]	Gaetani et al[7]	Franco Servadei et al[1]	Z.wu et al[8]	M González pérez et al[9]	Jung-Ho Shin et al[10]	Present study
Number	141	121	661	214	148	750	20	98	90	117
GCS on admission	Significant in univariate and multivariate analysis	–						Significant prognostic factor	Significant in univariate and multivariate analysis	Significant in univariate and multivariate analysis.
Fisher grading	Significant in univariate and multivariate analysis ($p < 0.001$)	High mortality in cisternal clot>1 mm	Maximum thickness (mm) of clot independently associated with neurological outcome	<4 mm-favourable outcome>7 mm-unfavourable outcome				–	Unfavourable outcome in 20/30 (67%). significant in univariate analysis	Significant in univariate and bivariate analysis.
Morris–Marshall classification	Significant in univariate analysis		–					–	Significant in univariate analysis	Significant in univariate and bivariate analysis.
Associated brain injury		–	–	SDH is contributory to mortality				–		SDH significant in univariate analysis.
Anatomical location of SAH and mortality		IVH had worst prognosis.	Anatomical location has no impact on outcome	Anatomical location has no impact on outcome	Maximum in basal cistern and convexity SAH	43% mortality in basal SAH		Cisternal and convexity indicates a worse prognosis.		50% mortality in mixed/diffuse SAH. High morbidity in basal cistern &IVH
No. of patients in GOS	70% good recovery,9% moderate disability,13% death and 19% with unfavourable outcome.	45% favourable and 55% unfavourable outcome	–	63% favourable outcome				–		71.79% favourable and 27.35% unfavourable.
CT change:	(24.1%) had significant CT lesion progression, and 66 patients (46.8%) had some lesion progression.	–	–					–	Present in 17/90 patients. absent in 73/90.	Not included in study because simultaneous studies not possible due to patient factors

(*continued on next page*)

Table 3 – (continued)

Parameters	Chieregato et al[2]	Paiva w s et al[5]	Wong gk et al[6]	George et al[3]	Gaetani et al[7]	Franco Servadei et al[1]	Z.wu et al[8]	M González pérez et al[9]	Jung-Ho Shin et al[10]	Present study
MRI study for SAH	–	–	–				SWI is better than CT in detecting IVH and small amounts of SAH.	–	–	12 patients with detection of fresh SAH & contusion.
Conclusion	Initial GCS,amount of blood and associated parenchymal damage contribute to outcome.	1) Recovery rate and daily life activities were lower in patients with IVH. 2) Mortality rate was proportionally greater in patients who had cisternal clots >1 mm.	1) Thickness of clot is important for morbidity and mortality. 2) Anatomical location has no impact on outcome.	Thickness of clot,age,SDH and mass effect is important for morbidity and mortality	Thickness of clot is important for morbidity and mortality	Death is due to severity of initial mechanical damage.	SWI is complimentary to CT	Cisternal and convexity indicates a worse prognosis.	To improve the outcomes in tSAH patients, attention will need to be focused on inhibiting contusion growth and on minimizing the effects of tSAH on the brain.	1) GCS is most important prognostic factor. 2) FLAIR/GRE sequence of MRI has high sensitivity in detection of SAH.

parenchymal damage with tSAH. Variables showing significant relationship with survival viz. Age, sex, SAH in basal cistern, IVH, Fisher grading, GCS on admission were entered in the statistical model in stepwise manner. Probability of exclusion from model was kept >0.01, while probability of retaining in model was kept <0.05. All above mentioned variables, except for GCS on admission, were excluded from model. Probability of overall model fit was found 0.0001 and odds ratio of only variable retained in the model, i.e. GCS on admission was 1.9872 with 90% CI of 1.0940–3.6099. Percent of cases, correctly classified by this model was 95.12% (75% for death and 97.30% for survival). RDC curve showed AUC of 0.966 with 95% CI of 0.857–0.998. Equation obtained as follows: Survival $(Y) = 0.68674 \times$ GCS on admission $(x) - 3.8547$. Multivariate linear regression analysis was done for prediction of GCS on discharge and all the variables same as used for survival prediction, were entered in the model as independent variables, in stepwise manner. Probability of exclusion and inclusion in the model were kept same as in previous regression analysis for survival. Coefficient of determination (R^2) was 0.9127 for this model and bleed in basal cistern, Fisher grading and GC scale on admission were found significant predictors and were retained in the model. Analysis of variants showed significant results for this model. Prediction equation was obtained as follows: GCS on discharge $(Y) = 0.7144 - 3.4503 \times$ (bleed in basal cistern) $+ 0.8393 \times$ (Fisher grading) $+ 0.8447 \times$ (GC scale on admission).

4. Conclusion

In present study, main focus was to observe neurological outcome in cases of post-traumatic SAH. As post-traumatic SAH is often associated with other intracranial injury, it is often difficult to study tSAH in isolation. During study, age group most commonly suffered was 21–30 years with male predominance. Vehicle and other road traffic accident were the leading cause of tSAH, followed by physical assault and other causes. Fischer grading II was the most common finding on CT scan. Majority of patients was in mild category of head injury. Very few patients had isolated SAH pattern. Majority of patients had other intracranial injury with few patient of multisystem injury as well. Brain contusion was leading radiological finding, whereas ICH and infarct were the least associated component. In tSAH, convexities and sulcal spaces were maximally involved. Other sites were sylvian fissure, basal cistern with intraventricular extension. Although very few patients had basal cistern and intraventricular component. Around 4% cases, patients were operated for extradural haematoma and 3% for contusion, respectively. Chest injury and craniofacial injury were found associated with tSAH. During follow-up, nearly 15% patients showed good recovery. They were able to regain routine household activity independently. All these patients were in Fisher grade II .On the basis of GOS, they all had grade IV during hospital stay, while on follow-up their grading was V. Around 59% patients had mild head injury component with GOS IV. Even this number reduced during follow-up (44%). It showed that patient who sustained mild head injury component with GOS IV on admission, had fairly good recovery after 1 month. Fishers

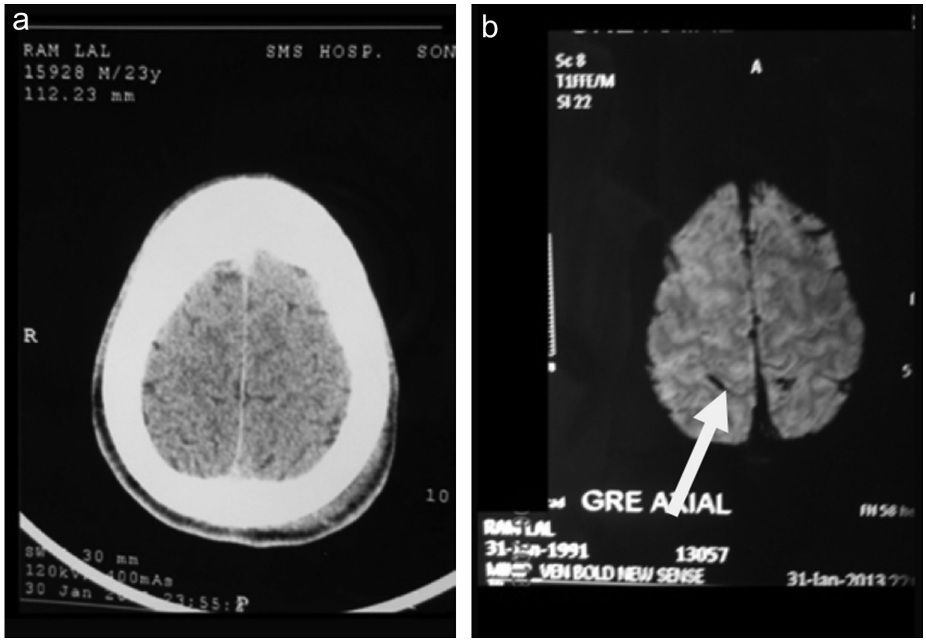

Fig. 1 – (a) Comparison of CT and (b) MRI (GRE) images showing fresh SAH in both parietal region.

grade II had 46% of patient with GOS IV (mildly disabled) in hospital. Out of this 16% patients had good recovery. Thus, number of Fisher grade II with GOS grade IV was reduced during follow-up (33%). Patients of moderate and severe head injury group did not show remarkable improvement. They remained nearly same after 1 month. Statistically their number did not change significantly. Fisher grading III and IV had same results in terms of improvement and majority of these patients remained in unfavourable group during follow-up. Moderate and severe head injury had worst and unfavourable outcome. Most of them were disabled during hospital stay and during follow-up. They were dependent on family members with poor cognitive function with associated morbid condition. During follow-up, around 28% and 13% patients were vegetative and severely disabled, respectively. Fischer grading III had worst outcome. These patients had maximum mortality, vegetative state and maximum severe disability than other Fisher grades. Recovery rate and daily life activity was quite low with tSAH in basal cisterns and IVH .We have not encountered any incidence of hydrocephalus in our patients so far. On radiological assessment, we noticed that MRI FLAIR and GRE sequence had very good detection rate for IVH. FLAIR sequence, as proven previously[7] had good sensitivity for detection of acute SAH in first 48 h, which is nearly equal to CT scan.

So we conclude that GCS on admission is the single most important outcome predictor. During follow-up, majority of patients, who suffered Fisher grade III and IV had poor

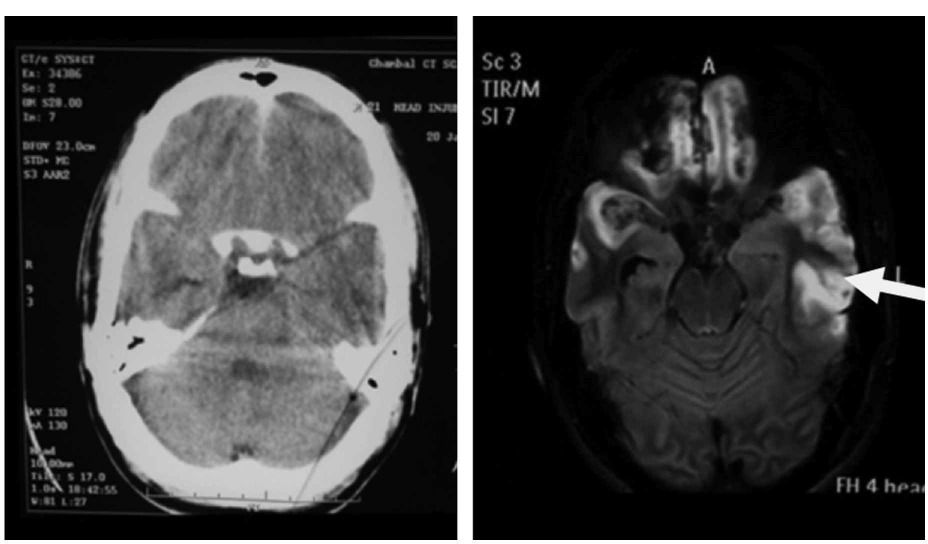

Fig. 2 – Comparison of CT and MRI (FLAIR) images showing development of fresh contusion and SAH, which was not evident in CT scan.

neurological outcome. Moderate and severe head injury with tSAH had unfavourable outcome. FLAIR/GRE sequence had good sensitivity for detection of acute SAH in first 48 h, which is complimentary to CT scan and needs further studies to establish its role in tSAH.

Conflicts of interest

All authors have none to declare.

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