Original Article

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Radiology Section

Midline Shift and Haematoma Thickness as a Prognostic Factor of Mortality in Patients with Acute Subdural Haematoma

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ABSTRACT

Introduction: Acute Subdural Haematoma (ASDH) is a type of intracranial haematoma, which has the highest mortality rate. The ASDH generally presents as a secondary consequence of Traumatic Brain Injury (TBI) and can be classified as traumatic or non traumatic and acute or chronic.

Aim: To assess the Midline Shift (MLS) and Subdural Haematoma (SDH) thickness as a prognostic factor of mortality on initial cranial Computed Tomography (CT) scan of patients with ASDH.

Materials and Methods: This cross-sectional study analysed the computed CT of 61 patients who were admitted due to traumatic SDH in Sri Devaraj Urs Medical College, Kolar, Karnataka, India. Thickness of MLS (mm) and SDH (mm) were estimated from the CT scan (SIEMENS SOMATOM Emotion 16 Slice) of patients admitted during the study period from June to August 2021. The thickness of the SDH and MLS were compared separately with the survival status. The Area Under the Curve (AUC) was estimated from the Receiver Operating Characteristic (ROC) curve. The sensitivity, specificity, predictive values and diagnostic accuracy of the screening test along with their 95% Confidence Interval (CI) were presented. The p-value <0.05 was considered statistically significant.

Results: The predictive validity of MLS (mm) was excellent (AUC=0.936) and that of SDH thickness (mm) was fair (AUC=0.799) in predicting survival. The cut-off value derived from the ROC curve for MLS was 3.95 mm and for SDH thickness was 3.35 mm; above which the number of people died was more and was statistically significant (p<0.001). The sensitivity and specificity of the MLS in predicting the survival was 90.32% and 90.00%, respectively and sensitivity and specificity of the SDH thickness was 74.19% and 76.67%, respectively.

Conclusion: The sensitivity and specificity of MLS was found to be superior when compared to the SDH thickness. The cut-off value derived from ROC curve for MLS was 3.95 mm and for SDH was 3.35 mm, above which the chance of survival was poor.

Keywords: Brain oedema, Road accidents, Receiver operating characteristic curve, Sensitivity, Specificity, Traumatic brain injury

INTRODUCTION

The ASDH are often seen as a secondary consequence of TBI and have the highest mortality rate among intracranial haematomas [1]. Radiologically, ASDH on CT is defined as an extra-axial, crescent-shaped hyperdense collection between the dura and the brain parenchyma, diagnosed within 14 days after TBI [2]. It is classified as traumatic or non traumatic and acute or chronic. The trauma may cause acceleration or deceleration forces, which rupture the veins bridging the dura and cerebral cortex resulting in the development of ASDH. It might also develop due to the rupture of superior cortical arteries or dural venous sinuses. The brain tissue might get damaged in association with brain concussions, cerebral oedema, and diffuse axonal lesions apart from ASDH, which might worsen the prognosis [3].

The mortality rate of ASDH ranges from 40-70% despite the advancement in management techniques, as reported in the previous studies [4,5]. Often the decision for surgery is controversial due to the difficulty in determining the prognosis [6]. The factors like age, Glasgow Coma Scale (GCS) score at admission, degree of traumatic injuries and pupillary response are associated with the prognosis of such patients [7]. Literature has shown that the radiological findings on CT like Haematoma Thickness (HT) and MLS play an important role in assessing the prognosis and determining surgical management [8,9]. Data from earlier studies recommended a cut-off of maximum SDH thickness to be 1 cm and 0.5 cm in adults and children respectively to decide on surgery [10,11]. The degree of midline shift may act as another important factor in determining the treatment [12]. An earlier study has found that a difference greater than 3 mm between MLS and HT is associated with higher fatality [5].

However, studies on the evaluation of these parameters in developing countries like India are scarce, thus, additional studies for external validation are required [7]. Hence, the present study was aimed to assess the MLS and thickness of SDH as a prognostic factor of mortality on initial cranial CT scans of patients with ASDH.

MATERIALS AND METHODS

This cross-sectional study was conducted on the patients who underwent cranial CT scans due to traumatic SDH in Sri Devaraj Urs Medical College, Kolar, Karnataka, India. The duration of the study was three months from June to August 2021. The study was approved by the Institutional Review Board and the Ethics Committee of the hospital and data confidentiality was maintained. (DMC/KLR/IEC352/2020-21 dated 28-10-2020). All the eligible 61 subjects visited during the study period were included by convenient sampling.

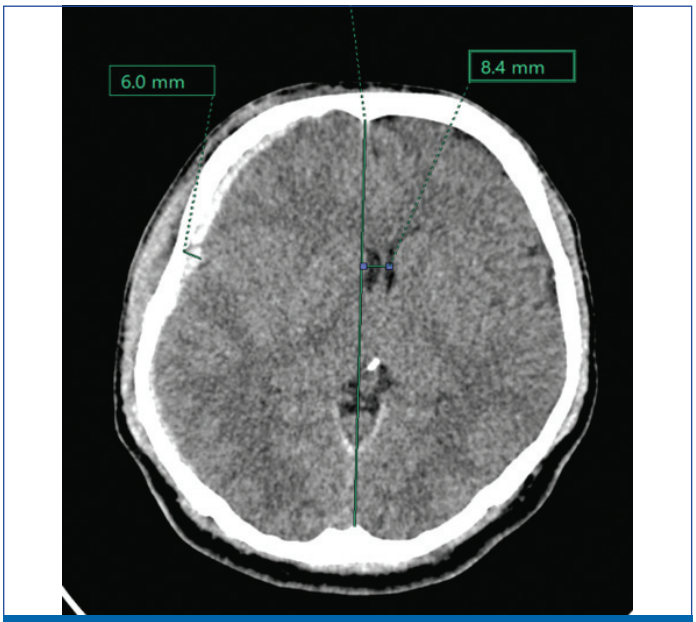
Inclusion and exclusion criteria: Cranial CT scan of all adult patients (>15 years) with traumatic SDH were included in the study. The excluded patients were of age group (<15 years) and non traumatic SDH patients.

Study Procedure

All the data including the age, gender and survival status were collected from the electronic database and MLS (mm), and the thickness of SDH (mm) were estimated from the CT scan (SIEMENS SOMATOM Emotion 16 Slice) of patients admitted during the

study duration. The MLS was measured using standard Window Widths (WW) and Window Levels (WL) at the level of the frontal horns to evaluate brain parenchyma (WW 86, WL 30). The MLS was measured (in millimetres) as the displacement of the septum pellucidum about the midline [13]. To minimise the underestimation of HT SDH was evaluated with adjusted WW and WL (WW 300, WL 120). The SDH was evaluated with adjusted WW and WL to minimise the underestimation of HT (WW 300, WL 120) [Table/Fig-1,2]. A single blinded examiner who was not aware of the survival status analysed the CT scans. The thickness of the SDH and MLS was compared separately with the survival status.

[Table/Fig-1]: The CT brain axial sections showing SDH measuring 8 mm in maximum thickness along the right frontotemporal lobe and a Midline Shift (MLS) of 5-7 mm towards the left-side.



[Table/Fig-2]: The CT brain axial sections showing SDH measuring 6 mm in maximum thickness along the right frontotemporal lobe and a Midline Shift (MLS) of 8.4 mm towards the left-side.

STATISTICAL ANALYSIS

Patient survival was considered as the primary outcome variable. The MLS (mm) and SDH (mm) were considered secondary outcome variables. Descriptive statistics were used to analyse the data following the study's objectives. Data were expressed as the mean, minimum and maximum and percentage, where appropriate. All quantitative variables were checked for normal distribution. Non normally distributed quantitative variables were summarised by the median and Interquartile Range (IQR) were compared between study groups using Mann Whitney u test (2 groups). And the count variables were analysed by the Chi-square, expressed as numbers. The AUC of the ROC curve was used to evaluate the model's distinguishability of nomograms. The sensitivity, specificity, predictive values, and diagnostic accuracy of the screening test along with their 95% CI were presented. The p-value <0.05 was considered statistically significant. Data were analysed by using coGuide software, V.1.03 [14].

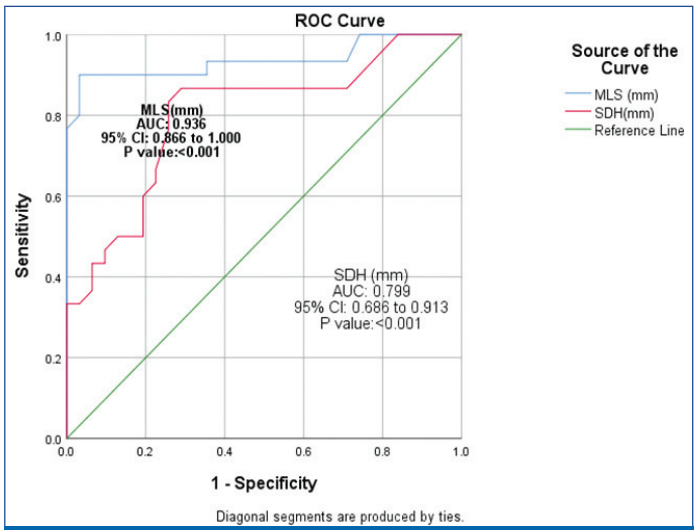
RESULTS

A total of 61 subjects were included in the final analysis. The mean age was 65.3±12.5 years, ranged between 20-89 years. Among the study population, 34 (55.74%) were males and remaining 27 (44.26%) were females. The mean MLS was 5.45±3.68 (mm), ranged between (1.60-14.60). The mean SDH was 3.62±1.56 (mm), ranged between (1.70-9) [Table/Fig-3].

Parameters	Summary
Age (years) (Mean±SD)	65.3±12.5 (ranged 20-89).
Gender n (%)	
Male	34 (55.74%)
Female	27 (44.26%)
MLS (mm) (Mean±SD)	5.45±3.68 (ranged 1.60 to 14.60)
SDH (mm) (Mean±SD)	3.62±1.56 (ranged 1.70 to 9)
Survival n (%)	
Yes	31 (50.82%)
No	30 (49.18%)
MLS and SDH difference	1.83±3.05 (ranged 3.10 to 10.70)

[Table/Fig-3]: Values of baseline parameter in study population (N=61).

The MLS (mm) had excellent predictive validity in predicting survival, as indicated by AUC of 0.936 (p-value <0.001). The SDH thickness (mm) had fair predictive validity in predicting survival as indicated by AUC of 0.799 (p-value <0.001) [Table/Fig-4].



[Table/Fig-4]: Predictive validity of MLS (mm) and SDH (mm) in predicting survival (ROC analysis).

There was a significant difference in the survival status of patients with a cut-off value of MLS 3.95 mm and SDH 3.35 mm (p-value <0.001). A 90% of the patients died with MLS of more than 3.95 mm. It was observed that when the MLS size exceeds that of SDH, the chances of survival was poor (p-value <0.001) [Table/Fig-5].

The MLS had a sensitivity of 90.32%, specificity of 90.00% and diagnostic accuracy of 90.16%. The SDH had a sensitivity of 74.19%, specificity of 76.67% and diagnostic accuracy of 75.41% [Table/Fig-6].

Parameters	Survival		p-value
	Yes (n=31)	No (n=30)	
MLS (mm)			
Low (<3.94)	28 (90.32%)	3 (10%)	<0.001*
High (≥3.95)	3 (9.68%)	27 (90%)	
SDH (mm)			
Low (<3.34)	23 (74.19%)	7 (23.33%)	<0.001*
High (≥3.35)	8 (25.81%)	23 (76.67%)	
MLS (mm) and SDH (mm)			
MLS (mm) > SDH (mm) (n=42)	15 (35.71%)	27 (64.29%)	<0.001*
MLS (mm) <SDH (mm) (n=19)	16 (84.21%)	3 (15.79%)	
MLS (mm) and SDH (mm)			
MLS (mm) (n=61)	2.6 (2,3.2)	7.7 (5.55,10.8)	<0.001†
SDH (mm) (n=61)	2.6 (2.3,3.4)	3.8 (3.38,5.35)	<0.001†

[Table/Fig-5]: Comparison of survival status with MLS (mm) and SDH (mm) (N=61).
*: Chi-square test; †: Mann-whitney U test

Parameters	Value (95% CI)	
	MLS (mm)	SDH (mm)
Sensitivity	90.32% (74.25%-97.96%)	74.19% (55.39%-88.14%)
Specificity	90.00% (73.47%-97.89%)	76.67% (57.72%-90.07%)
False positive rate	10.00% (2.11%-26.53%)	23.33% (9.93%-42.28%)
False negative rate	9.68% (2.04%-25.75%)	25.81% (11.86%-44.61%)
Positive predictive value	90.32% (74.25%-97.96%)	76.67% (57.72%-90.07%)
Negative predictive value	90.00% (73.47%-97.89%)	74.19% (55.39%-88.14%)
Diagnostic accuracy	90.16% (79.81%-96.30%)	75.41% (62.71%-85.54%)

[Table/Fig-6]: Predictive validity of MLS (mm) and SDH (mm) in predicting survival (N=61).

DISCUSSION

The study included 61 patients, with a mean age of 65.3±12.5 years and the majority were males (55.74%). The mean MLS was 5.45±3.68 mm and SDH was 3.62±1.56 mm. The mean MLS and SDH difference was 1.83±3.05 mm. The predictive validity of MLS (mm) was excellent and that of SDH was fair in predicting survival, as indicated by the AUC of 0.936 and 0.799, respectively. The cut-off value derived from the ROC curve for MLS was 3.95 mm and for HT was 3.35 mm, above which the chance of survival was poor. There was a statistically significant difference in the proportion of survival between those with MLS (mm) more than SDH (mm) and those with MLS (mm) less than SDH (mm).

The MLS showed an association with mortality and GCS score due to ASDH [15]. The mean ASDH diameter was found to be 11 mm and parallel to the degree of MLS [16]. A study by Son S et al., reported the mean haematoma size to be 5.8 mm and found it to be proportional to the amount of MLS. The size of the haematoma was found to be smaller in patients whose haematoma spontaneously resorbed or later deteriorated [17].

It was found that a disproportionate increase in MLS compared to maximal HT would result in complications in the brain tissues already inflicted by trauma and cause a worse prognosis [12]. In a study by Moussa WMM et al., they divided the maximal thickness of the SDH on the CT brain obtained preoperatively by the MLS at the same level, and formulated HT/MLS ratio. Their index had a mean of 0.93 and a value of 0.79 or less, which showed a correlation with a low Glasgow Outcome Scale (GOS), postoperatively [12]. Similarly, a strong correlation between MLS exceeding SDH thickness by 3 mm or more and mortality was found in another study [5]. Other authors also reported that MLS >3 mm about HT resulted in a high mortality rate in patients [7,18]. They assumed that MLS exceeding the HT suggests the presence of associated parenchymal lesions or cerebral oedema, which contributes to the worst clinical outcome [7,18]. A mortality rate of 81.8% was observed in the study by De Souza MR et al., within two weeks for such patients [7].

Bullock MR et al., claimed that ASDH cases with CT scan finding of MLS >5 mm and thickness >10 mm should be evacuated surgically, regardless of the GCS score [19]. Other studies reported that MLS and HT has a strong correlation to poor outcome and mental status [8,18]. A recent study did not find any significant difference between MLS, HT, and MLS/HT rates in their study subjects [20]. Similarly, another study did not find an independent association between mortality and MLS, haematoma volume, thickness, and obliteration of the basal cisterns, although univariate analyses showed a correlation between these variables and mortality [21].

It was observed that an increase in MLS and HV caused higher brain compression with raised intracranial pressure resulting in a reduction in functional recovery post-trauma. A correlation was found between the CT variables like MLS, Haematoma Volume (HV), and thickness with outcome [22]. Another study reported that in moderate and severe TBI, there was an association between the elevated degree of MLS and HV with poor outcomes. Unfavourable outcomes and higher odds of death were observed in association with SDH and contusions, which was significantly stronger than that with epidural haematoma [13]. Nelson DW et al., recommended the usage of MLS to predict the outcome of survival and also reported that HV can be substituted for MLS in CT scorings [23]. In a recent study, SDH ranged from 0.79-28.3 mm, and the MLS ranged from 1.5-16.9 mm in a nomogram formulated by the authors [24]. In another study, MLS and GCS scores were concluded as the strong outcome predictors of severely traumatic ASDH in elderly patients [25].

Limitation(s)

This study was conducted in a single centre which can affect the generalisability of the results.

CONCLUSION(S)

The sensitivity and specificity of MLS were found to be superior in predicting the survival of the patient when compared to the HT. There is less chance of survival when the MLS was more than 3.95 mm than the HT. For all future prediction models on cranial CT, a standardised method for measurement and a uniform definition of grading should also be applied.

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