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ORIGINAL ARTICLE

The Importance of Scalp Hematoma In Predicting Intracranial Injury in Elderly Patients with Minor Blunt Head Trauma

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Abstract

Introduction: Several widely employed criteria have been developed to determine indications for brain computed tomography (CT) in adult patients, such as the New Orleans Criteria and the Canadian CT Head Rule. However, a subgroup analysis of these criteria with appropriate sensitivity has not been performed in elderly population, and their reliability for this population is controversial. Therefore, there is a need for new studies that can predict intracranial injury (ICI) in elderly population. The purpose of this study was to evaluate the role of the site of trauma and size of scalp hematoma in determining ICI in the population aged over 65.

Methods: This prospective, observational study was conducted over approximately 3 years in the emergency department of a tertiary training and research hospital. Consecutive patients aged over 65 with minor head trauma were included in the study. In these patients, the area of head trauma, presence of scalp hematoma, and whether the size of the hematoma differed between patients with ICI and patients without ICI were calculated statistically. ROC curves were drawn to test the success of hematoma in differentiating patients with and without ICI. The two proportions t-test was used in the comparison of areas with head trauma.

Results: Of the 405 patients included in the study, 27 had ICI. The mean scalp hematoma diameter among the patients with ICI was 68±25 mm, compared to 16±21 mm in patients without ICI, and the difference was significant ($p<0.001$). A hematoma diameter of 29.5 mm in the frontal and parietal region, 48 mm in the occipital region, and 35 mm in the temporal region exhibited 100% negative predictive value in terms of ICI. The risk was higher in the temporal region compared to the frontal 22% (−0.223 [−0.375; −0.071]), occipital 15% (0.150 [−0.009; 0.311]), and parietal 20% 0.201 (0.044; 0.358) regions.

Discussion and Conclusion: In patients over 65 years of age with minor head trauma, the location and size of the scalp hematoma can be a useful parameter to predict ICI and can be used as a parameter to determine the indication for brain CT in this population.

Keywords: Craniocerebral trauma; emergency medicine; geriatrics; wounds and injuries.

Head trauma is a common reason for presentation to the emergency department, the great majority of such presentations consisting of minor head traumas[1,2]. There is no universally recognized definition for minor head trauma, although a Glasgow Coma Scale score of 14 or more, and whether the patient exhibits few or no symptoms, may be regarded as indicating head trauma. The final and gold standard test in the management of both major and minor head traumas is without contrast computed tomography (CT)[1]. However, its cost and the fact that it entails ionizing radiation mean that CT must be used carefully in selected patients[2]. It should also not be forgotten that

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intracranial bleeding is seen in only 5–15% of minor head traumas, and very few of these require emergency surgical intervention[3]. Various clinical decision-making criteria have, therefore, been produced to prevent unnecessary CT for patients with minor head trauma in the emergency departments[2,3]. The most widely employed among these are the New Orleans Criteria (NOC), the Canadian CT Head Rule (CCHR) criteria[4], and the National Emergency X-Radiography Utilization Study II (NEXUS II) criteria[5]. These have reduced the population in which CT is applied[6]. While NOC accepts patients over 60 years of age as risky, CCHR considers patients over 65 years of age to be risky[7]. However, Riccardi et al.,[8] observed no difference in the incidence of intracranial complications following minor head trauma in the 65–79 age group compared to the general population. Klang et al.,[2] maintained that the patient's age had no significant impact on the risk of intracranial bleeding. However, the number of such studies is insufficient, and the reliability of these criteria, which are still in use, in elderly and pediatric patients is controversial.

Another criterion employed in deciding on CT of the brain in head trauma is scalp hematoma. Under the NEXUS II criteria, the presence of scalp hematoma is regarded as representing a high risk in terms of ICI, although the size of the hematoma was not included in the evaluation[5]. To the best of our knowledge, studies investigating the relationship between the size of scalp hematoma and intracranial bleeding have largely involved the pediatric population, and the majority have determined an association between the presence and size of scalp hematoma and ICI[9,10]. However, our scan of the literature revealed no study investigating the relationship between scalp hematoma and ICI in elderly population. Scalp hematoma may be of diagnostic value in terms of ICI in elderly population as well as the pediatric population, which are not covered by widely used criteria such as the NOC and CCHR.

The purpose of this study was to determine the relationship between the site of trauma and size of scalp hematoma, and ICI in patients with minor head trauma aged over 65.

Materials and Methods

Study Design and Setting

This prospective observational study was carried out between December 2018 and June 2021 in the emergency department of a tertiary hospital receiving 300,000 annual emergency department visits. The appropriate permissions were received from the hospital ethical committee before the study commenced, and the methodology was approved under application number 2018-KAE-0220 and decision number 119. Each patient included in the study, or a relative was informed about the study in detail, and written consent to participate was received.

Study Population

Consecutive patients presenting to the emergency department due to blunt head trauma, with GCS scores of 14 or 15 and aged over 65 were included in the study. Patients using alcohol or stupefacients, or with high suspicion of skull base fracture (suspected or depressed skull fracture, otorrhea, rhinorrhea, battle sign, or raccoon eyes) were excluded from the study.

Study Protocol

All adult patients presenting with head trauma, aged over 65 with GCS 14–15 and no findings of skull base fracture following evaluation by the primary physician were included in the study. Sociodemographic characteristics such as age and gender, vital findings at presentation, GCS, and trauma mechanisms were recorded for all patients. Dangerous mechanism of trauma was defined as a motorized vehicle striking pedestrians, being thrown from a vehicle, or falling from more than 1 m or from higher than 5 steps. The regions subjected to trauma were first determined as frontal, temporal, parietal, or occipital. The trauma region was subsequently evaluated in terms of presence of scalp hematoma. The widest diameter of hematoma at scalp in patients with scalp hematoma was measured by manually in mm using a wide diameter compass and was recorded on the study form. The diameter of the largest hematoma was recorded in patients with multiple scalp hematomas. The NOC regards patients over 60 as a risk group and the CCHR those over 65[4]. Accordingly, results for CT and other imaging methods performed during the clinical flow were obtained from the hospital record system for all patients included in the study and recorded. CT brain reports prepared by radiologist physicians were examined. Presence or absence of intracranial bleeding and the type of injury if applicable were recorded. ICI was defined as all types of intracranial bleeding, all types of displaced skull fracture, cerebral edema, and diffuse axonal injury.

Outcome Measurements

The primary outcome of the study was the radiological presence or absence of ICI following minor head trauma in patients aged over 65. The diagnostic value of the location of the head trauma, and of the presence and size of scalp hematoma in predicting ICI was also investigated.

Statistical Analysis

The sample size was calculated using the G power 3.1.9.2 computer program. When calculating the sample size, in line with a similar previous study conducted before, the odds ratio was taken as 4.40[10]. The calculated sample size was 350, with an alpha value of 0.05 and a power of 0.95.

Descriptive statistics were expressed as frequency, percentage, mean, and standard deviation. Number and percentage were calculated for categorical variables, and mean and standard deviation values for numerical variables. Whether the presence of ICI differed significantly in independent groups was assessed using the Chi-square test. Whether hematoma diameter, a numerical variable, differed significantly in terms of the presence of ICI in independent groups was evaluated using Student's t-test. An ROC curve was drawn to evaluate the success of hematoma diameter in differentiating patients with and without ICI, and area under the curve and cutoff values were calculated. The two proportions t-test (Fisher's exact Monte Carlo simulation) was applied to compare head trauma regions in terms of risk. p<0.05 was regarded as significant for all analyses. Minitab, I. (2020) software (retrieved from http://www.minitab.com/en-US/products/minitab/) was used for two proportions t-test analyses. SPSS 24.0 software was used for all other analyses, and all calculated were performed at a 95% confidence interval.

Results

Four hundred and five patients aged over 65 presenting to the emergency department with minor head trauma were included in the study. The patients' mean age was 75±8 years, ranging between 65 and 99. ICI developed in 27 patients following minor head trauma, while no intracranial event occurred in 378. Dangerous trauma mechanism (p<0.001), anticoagulant drug use (p=0.031), presence of scalp hematoma (p<0.000), and hematoma diameter (p<0.001) were significant in minor trauma-related ICI development, while gender had no effect (p=0.507) (Table 1). Scalp hematoma was present in 199 patients, but not in the other 205. No ICI developed in any patient without scalp hematoma (Table 1).

Trauma was present in the frontal region in 189 patients, followed by the occipital region in 101, the parietal region in 83, and finally the temporal region in 32. The difference between the regions exposed to trauma was statistically significant. The region most frequently exposed to trauma in elderly patients was the frontal region, while the temporal region was least frequently exposed (p<0.001). The regions subjected to trauma, and hematoma and ICI development in those regions are shown in Table 2. ICI developed in 5 (2.6%) of the 189 patients exposed to trauma in the frontal region and in 8 (25%) of the 32 patients with temporal region trauma (Table 2).

A statistically significantly 22% difference in terms of ICI development was observed between trauma to the frontal regions and trauma to the temporal region (p<0.001) (Table 3). Statistically significantly different risks were also deter-

Table 1. The effect of the trauma mechanism and general patient characteristics on intracranial injury presentation

	ICI/No	ICI/Yes	Total	p
Dangerous mechanism/No (n)	304	13	317	<0.001
Dangerous mechanism/Yes (n)	74	14	88	
Total (n)	378	27	405	
Anticoagulant use/No (n)	246	12	258	0.031
Anticoagulant use/Yes (n)	132	15	147	
Total (n)	378	27	405	
Scalp hematoma/No (n)	206	0	206	<0.001
Scalp hematoma/Yes (n)	172	27	199	
Total (n)	378	27	405	
Female (n)	193	12	258	0.507
Male (n)	185	15	147	
Total (n)	378	27	405	
Hematoma size (mm)	16±21	68±25		<0.001

Table 2. The effect of the trauma region on scalp hematoma and intracranial injury development

	ICI		Total	ICI rate	p
	No	Yes			
Frontal					
No hematoma	97	0	97		<0.001
Hematoma	87	5	92		
Total	184	5	189	2.6%	
Temporal					
No hematoma	16	0	16		
Hematoma	8	8	16		
Total	24	8	32	25%	
Parietal					
No hematoma	42	0	42		
Hematoma	37	4	41		
Total	79	4	83	4.8%	
Occipital					
No hematoma	51	0	51		
Hematoma	40	10	50		
Total	91	10	101	9.9%	
Total	378	27	405		

ICI: Intracranial injury.

Table 3. Comparison of anatomical trauma areas in terms of intracranial injury risk

Area	N	Event (N)	Sample p	Estimation for difference Difference 95% CI for difference	p
Frontal	189	5	0.026	−0.223 (−0.375; −0.071)	<0.001
Temporal	32	8	0.250		
Frontal	189	5	0.026	−0.021 (−0.073; 0.0297)	0.462
Parietal	83	4	0.048		
Frontal	189	5	0.026	−0.072 (−0.135; −0.009)	0.011
Occipital	101	10	0.099		
Temporal	32	8	0.250	0.201 (0.044; 0.358)	0.004
Parietal	83	4	0.048		
Temporal	32	8	0.250	0.150 (−0.009; 0.311)	0.039
Occipital	101	10	0.099		
Parietal	83	4	0.048	−0.050 (−0.125; 0.023)	0.267
Occipital	101	10	0.099		

mined between the frontal and occipital regions (p=0.011), the temporal and parietal regions, (p=0.004), and the temporal and occipital regions (p=0.039). No statistically significant differences were found between the frontal and parietal regions (p=0.462) or between the parietal and occipital regions (p=0.267 (Table 3). Accordingly, the regions of greatest risk in patients aged over 65 were the temporal region followed by the occipital region. The risk in the occipital regions was similar to that in the parietal region but greater than that in the frontal regions. No difference was found between the parietal and frontal regions.

Examination of the relationship between head trauma-related scalp hematoma development and ICI showed that no ICI developed in any patient without hematoma associated with head trauma. Post-traumatic scalp hematoma developed in 199 of the 405 patients, and all the cases with ICI were in that group (Table 4). Scalp hematoma was located in the frontal region in 92 patients, in the temporal region in 16, in the parietal region in 41, and in the occipital region in 50. The difference in terms of the presence of hematoma between the regions was statistically significant, with hematoma being most common in the frontal region (p<0.001). Mean hematoma diameters in the scalp regions were 36±20 mm in the frontal region, 40±26 mm in the parietal region, 40±26 mm in the occipital region, and 50±33 mm in the temporal region. ROC analysis was performed to determine the ability of hematoma diameter to predict ICI. Since the main aim of the study was to reduce unnecessary CT of the brain, cutoff points with a 100% negative predictive value (NPV) were used at ROC analysis. Accordingly, a cutoff value of 29.5 mm in the frontal and parietal regions, 35 mm in the temporal region, and 48 mm in the occipital regions was found to exhibit 100% sensitivity and NPV (Table 4).

Discussion

The evaluation of patients with minor trauma presenting with head trauma is one of the most important areas of emergency medicine. The key point in these patients is the decision whether or not to perform CT of the brain. Brain CT is the gold standard test in head trauma and almost conclusively determines the presence or absence of intracranial hemorrhage or skull base fracture. However, care is required over CT of the brain since it involves radiation and because

Table 4. The ability of scalp hematoma to predict intracranial injury

Hematoma area	Area under ROC	Asymptotic 95% confidence interval		Cutoff (mm)	Sensitivity %	Specificity %	PPV %	NPV %
		Lower bound	Upper bound					
Frontal	0.831	0.740	0.922	29.5	100	70.5	9	100
Temporal	0.979	0.938	1.020	35	100	92	80	100
Parietal	0.898	0.767	1.000	29.5	100	69	14	100
Occipital	0.986	0.965	1.007	48	100	95	67	100

of the cost implications. Several scoring systems evaluating indications for CT of the brain in patients with minor head trauma have been developed[2-5]. However, to the best of our knowledge, the present study is the first to evaluate the value of scalp hematoma in the decision to perform CT of the brain in the over 65 population with minor head trauma. Three main findings emerged from this research. The first is that no ICI developed in any patients without post-traumatic scalp hematoma aged over 65 and with minor head trauma. The second is that the highest risk region in terms of ICI in head trauma in elderly population is the temporal region, followed by the occipital region, with the lowest and similar risks being observed in the parietal and frontal regions. The third principal finding of this study is that a hematoma diameter following head trauma in elderly population below 29.5 mm in the frontal and parietal regions, below 35 mm in the temporal region, and below 48 mm in the occipital region predicts the absence of ICI with 100% NPV.

In our study, both the presence of a dangerous trauma mechanism and the use of anticoagulants were found to be risky conditions for ICI. These findings were consistent with the results of the previous studies[1,4]. The previous studies, albeit few in number, have examined the relationship between head trauma and scalp hematoma in the adult population. Aghakhani et al.,[11] examined the association between scalp hematoma and ICI in cadavers in the adult population, and described the presence of scalp hematoma as a risk indicator for ICI. This finding was compatible with the over 65 population in the present study. Our review of the literature revealed no other studies with which to compare our findings in the adult population. However, several studies have investigated this subject in the pediatric population. Similarly to elderly population, the pediatric population is another special category in which standard CT brain indication scoring cannot be employed in minor head traumas. The previous studies examining the relationship between CT of the brain indications and scalp hematoma have therefore largely involved the pediatric population. Several studies have shown that the size and anatomical location of scalp hematoma are significant in terms of the risk of ICI in the pediatric population[12-14]. The common results of these studies of the pediatric population are that the presence and size of scalp hematoma increase the risk of ICI development, that temporal and parietal trauma represents the highest risk for ICI in the pediatric population, and that the frontal region entails the lowest risk[10,14]. In their study of a 10,659 member pediatric population, Dayan et al.,[12] also found that scalp hematoma diameter was associated with ICI and again reported that the temporal and parietal regions were the highest risk regions in terms of ICI. According to the Pediatric Emergency Care Applied Research Network prediction rules used in minor head trauma as pediatric patients, the presence of scalp hematoma is regarded as a risk for ICI, while its absence represents a low risk[15]. These findings in the pediatric population bear a close similarity to our own results in elderly population. We found that the presence of hematoma and a greater hematoma diameter represented a risk for ICI in elderly population, as in the pediatric population, that no ICI developed in any elderly patient without hematoma, and that the absence of hematoma indicated a low risk, similarly to the pediatric population. Our assessment of risk in the regions involved in head trauma also identified the temporal region as representing the highest risk in elderly patients, similarly to in pediatric patients, while the frontal region constituted the lowest risk. However, while the parietal region was found to present a higher risk similar to that of the temporal region in pediatric patients, in our elderly population, the parietal region represented a lower risk, similar to that of the frontal region. This may be attributable to anatomical causes. The majority of studies involving the pediatric population have also included babies and infants, and anatomical differences in this population, such as the fontanelles being unfused and the head/trunk ratio, may make the parietal bone a higher risk region.

The relationship between hematoma diameter and ICI has been investigated in previous pediatric studies, with a diameter less than 1 cm being found to represent the lowest risk, a diameter of 1–2 cm a moderate risk, and a diameter >3 cm a high risk[16]. The cutoff point for 100% NPV in the present study was 3 cm in the frontal and parietal regions, 3.5 cm in the temporal region, and 4.8 cm in the occipital region. A 3 cm threshold value appears to represent a high risk in both the pediatric and elderly populations. However, we encountered no previous study calculating separate cutoff values for each scalp region.

Limitations

The principal limitations of this study are its single-center nature and the relatively low number of patients. When traumas were divided in terms of scalp locations, the number of positive patients (with ICI) in each region was low. This also showed that our analysis results need to be tested in larger populations for greater reliability.

Whether the presence of multiple scalp hematomas is a risk factor for ICI could not be evaluated due to the insufficient number of these patients. This is one of the important limitations of this study.

Conclusion

The temporal region was found to exhibit the greatest risk in patients aged over 65 with minor head trauma, while the lowest risk was in the frontal and parietal regions. The development of trauma-related scalp hematoma was found to represent a greater risk than absence of such hematoma. The study findings showed hematoma <29.5 mm in the frontal and parietal regions, <48 mm in the occipital region, and <35 mm in the temporal region excluded ICI with 100% NPV.

This study shows that the site of head trauma, the presence or absence of hematoma, and the diameter of hematoma are useful for determining the risk of ICI in elderly population. Whether the findings are useful in the indication for CT of the brain in elderly population should be tested in further studies.

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