Original Article

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Role of High-resolution Computed Tomography in the Evaluation of Temporal Bone Fracture

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Abstract

Introduction: Skull base and temporal bone fractures are frequently associated with severe high-velocity head trauma. Even though most of these fractures are not life-threatening, they are often associated with severe morbidity which has got a major impact on the quality of life. Conventional computed tomography (CT) has got its own limitations and often missed finer details of the temporal bone fractures. Hence, it is imperative to include high-resolution CT (HRCT) in the armamentarium of the investigations for head injury.

Aim: This study aims to define the diagnostic value of the HRCT in temporal bone fractures and also to highlight the superiority of HRCT over conventional CT in defining the extent of the fracture.

Materials and Methods: This study involved patients with head injury who had been admitted to Government Rajaji Hospital, Madurai Medical College, irrespective of age/Glasgow coma scale score with symptoms/signs suspicious of temporal bone fracture. All patients were underwent both conventional and HRCT. The difference in the rate of detection of temporal bone fractures in both the techniques was compared and analyzed.

Results: Among the total of 60 enrolled patients, 20 patients were not having temporal bone fractures. Of the remaining 40 patients, conventional CT can pick up only 15 fractures. However, HRCT diagnosed temporal bone fractures in all 40 patients. We have found statistically significant difference in fracture detection rate between HRCT and conventional CT.

Conclusion: HRCT of temporal bone is more sensitive and specific than conventional CT in diagnosing temporal bone trauma. HRCT is highly efficient in assessing the extent of the fracture line in temporal bone trauma.

Key words: Head injury, High-resolution computed tomography, Temporal bone

INTRODUCTION

Head injury is one among the common killers in modern day road traffic accidents (RTA), and young adults are the most common victims.[1] Skull base and temporal bone fractures are frequently associated with severe high-velocity head trauma. Most common sensory organ injured is ear.[2] Because of the seriousness and immediate care needed for the associated major brain parenchymal injuries, these fractures are often overlooked.[3,4]

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Temporal bone is one among the complex bones in the human body. Apart from protecting the brain by bordering middle and posterior cranial fossae, it contains various important organs such as middle and inner ear cavity with its contents, 7th and 8th cranial nerves, internal carotid artery, and jugular vein.

Even though most of these fractures are not life-threatening, they are often associated with severe morbidity which has got a major impact on the quality of life and also requires prolonged rehabilitation.

Routine practice in head injury is to have a conventional computed tomography (CT) of the brain and bone window in axial sections and treat accordingly. This conventional CT has got its own limitations and often missed finer details of the temporal bone fractures. Hence, it is imperative to include high-resolution CT (HRCT)[5] in the armamentarium

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of the investigations for head injury. There is no clear consensus about to whom this HRCT is needed.

Aims and Objectives

The objective of this study is to define the diagnostic value of the HRCT in temporal bone fractures and to highlight the superiority of HRCT in defining the extent of the fracture.

MATERIALS AND METHODS

In this prospective study, we enrolled patients with head injury who had been admitted in head injury ward at Government Rajaji Hospital, Madurai Medical College, from February 2012 to February 2013 (Table 1). After obtaining informed written consent from the patient/patient's reliable attender, all patients are enrolled and studied as soon after admission to emergency department as possible.

Inclusion Criteria

All patients admitted with head injury, irrespective of age/Glasgow coma scale (GCS) score with symptoms/signs suspicious of temporal bone fracture such as:

- Ear bleeding
- Hearing loss
- Cerebrospinal fluid (CSF) otorrhea
- Facial nerve weakness.

As the aim of this study is to define the importance of HRCT, we have included all head injured patients not taking the age, mode of injury, and GCS into consideration.

Exclusion Criteria

- Those who had traumatic head injury that required emergency surgical intervention
- Images degraded by motion artifacts
- Those patients who were not willing to participate in this study.

Image Acquisition

All patients were subjected to:

- Conventional CT with bone window in axial section (10 mm axial sections with 9 s scan time)
- HRCT of temporal bones with axial and coronal reconstruction (1.5 mm sections with exposure factor of 120 kVp and 200-500 mAs).

Image Analysis

All images were analyzed to detect the presence of temporal bone fractures by an attending neuroradiologist and neurosurgeon, in which the former was blinded to the clinical condition of the patient.

Images were evaluated for:

- Whether fracture of temporal bone is present or not
- If present, the part of temporal bone affected (squama/petrous/mastoid/tympanic/styloid)
- In petrous fractures, the type of fracture (longitudinal/transverse/oblique)
- Extent of the fracture line into cochlea, semicircular canal, vestibule, ossicular chain, tegmen, carotid canal, foramen ovale, internal auditory canal, jugular foramen, sigmoid sinus.

Statistical Methods

Computer analysis of statistical data was done utilizing the "$N-1$" Chi-square-test.

RESULTS

Among the total of 60 enrolled patients, 20 patients were not having temporal bone fractures. That means, even those patients with clinical suspicion of temporal bone trauma, 33.3% of them may not have fractures in imaging studies. Of the remaining 40 patients, conventional CT can pick up only 15 fractures. However, HRCT diagnosed temporal bone fractures in all 40 patients. We have found statistically significant difference in fracture detection rate between HRCT and conventional CT. Statistical analysis by the "$N-1$' Chi-square-test revealed $\chi^2 = 9.83$ and $P = 0.0017$. By conventional criteria, this difference is considered to be statistically significant (Table 2).

Table 1: Clinical profile of patients in our study

Feature	Value	Range
Age	37.7 years	14-75 years
Sex		
Male	46	
Female	14	
GCS score	13	7-15
Symptoms		
Ear bleeding	45	
Hearing loss		
Conductive	16	
Sensorineural	5	
CSF otorrhea	10	
Facial nerve weakness	3	

GCS: Glasgow coma scale, CSF: Cerebro spinal fluid

Table 2: HRCT versus conventional CT

Conventional CT finding	HRCT (fracture positive)	HRCT (fracture negative)	Total
Conventional CT (fracture positive)	15	0	15
Conventional CT (fracture negative)	25**	20	45
Total	40	20	60

"$N-1$" Chi-squared test: χ^2=9.83, P=0.0017**, HRCT: High-resolution computed tomography, CT: Computed tomography

Among the total of 60 patients, 46 male and 14 female patients were randomly selected for the study. The incidence of fracture was not having any preponderance toward a particular gender.

There was no statistically significant relationship between GCS and the presence of fracture. Although there were more number of RTAs victims had fracture of temporal bone, it was only because of increased percentage of RTA victims included in this study. There was no statistically significant association between mode of injury and presence of fracture.

We have found significant proportion of patients with CSF otorrhea and facial nerve injury were having high chance of temporal bone fracture, even though the number is smaller. In our study, all 3 facial nerve injuries were associated with mastoid part of temporal bone fracture (Table 3).

The most common location of fracture in the temporal bone was petrous part, followed by squamous part. There was no case of styloid fracture in our study. The most common type of fracture was longitudinal which constituted 80% in our series. Longitudinal type of petrous bone fractures was frequently associated with conductive hearing loss, accounting for 62.5%. However, sensorineural deafness was commonly seen with transverse fractures, about 50%. Two patients with squamous fracture and one patient with mastoid fracture had conductive type of hearing loss.

One out of two patients with transverse and oblique fractures had facial nerve involvement. None of the longitudinal groups had facial nerve injury. We found all the 4 patients who sustained transverse and oblique fractures had CSF otorrhea. Only 37.5% of longitudinal group had otorrhea.

Table 4 is showing the value of HRCT in depicting the fracture line clearly and in showing the involvement of important adjacent structures also. Conventional CT in our study was not able to pick up any of these details.

Table 3: Symptomatology versus fracture incidence

Symptoms	Fracture incidence *N* (%)	Relative risk
Ear bleeding	26 (57.8)	0.75
Hearing loss		
Conductive	10 (62.5)	1.1
Sensorineural	2 (40)	
CSF otorrhea	8 (80)	1.56
Facial nerve involvement	3 (100)	1.5

HRCT: High-resolution computed tomography, CSF: Cerebro spinal fluid

Table 4: Finer details of fracture by HRCT

Structure	*N*
Cochlea	3
Semicircular canal	2
Vestibule	4
Ossicular chain	8
Tegmen	4
Carotid canal	None
Foramen ovale	None
Internal auditory canal	2
Jugular foramen	None
Sigmoid sinus	None

HRCT: High-resolution computed tomography

DISCUSSION

The symptoms of temporal bone trauma are unique in that most often the diagnosis depends heavily on symptoms. However, relied entirely on symptomatology can miss a considerable amount of significant temporal bone fractures.[6] According to a study by Waldron and Hurley,[7] in spite of full detailed clinical examination, 8 cases were missed, and 5 of them developed complications of temporal bone fractures. This was a significant number of false negativity. In our study, we were not analyzing in that aspect of symptomatology. Our analysis was entirely different. We have taken those patients who had symptoms highly suspicious of temporal bone fracture. Ear bleeding was the most common symptom in our study which had 57.8% yield of fracture positivity. Hearing loss had 62.5% and 40% positivity for conductive and sensorineural loss, respectively. However, traumatic facial nerve injury had 100% positivity rate, followed by CSF otorrhea which had 80% positivity. One limitation in this aspect is a smaller number of patients with these latter two symptoms.

Regarding the mode of injury, motor vehicle accidents are the most often implicated mode for temporal bone trauma (Patel *et al.*). In our study also, RTAs was the most common mode of trauma causing temporal bone injury, accounting for 75% of fracture cases, followed by accidental fall contributing 15% of cases. Gunshot injuries, in contrary to the international studies, were rarely observed in our population. Penetrating temporal bone injuries were commonly observed in assault cases. In our study, all 3 assault cases were associated with penetrating trauma to the temporal bone. However, the type and part of temporal bone fracture were not influenced by the mode of injury.

On gender difference, even though the incidence of temporal bone fracture was higher in male patients in this study, it was only because of increased number of male patients participated in the study when compare to female patients. In our study, male:female ratio was 4:1. Whether the gender difference in the thickness of skull has any impact on this gender difference of temporal bone fracture was not studied here.

Regarding the GCS score, those patients with moderate to severe head injury (moderate - GCS 9-13 [82.1%], severe - 3-8 [100%]) had high chance of temporal bone trauma. However, in this aspect of analysis, this difference was not statistically significant.

In imaging the temporal bone in trauma, plain X-ray was previously used. The study by Waldron and Hurley[7] showed a significant false negative rate in detecting temporal bone fractures with plain radiograph[8,9] and symptomatology alone. The role of HRCT in detecting temporal bone trauma is undoubtedly established by various studies. However, there is no clear consensus about to whom this modality is indicated because performing HRCT in all head injured patients is cumbersome in population like ours.

HRCT has got a role not only in diagnosis but also in accurately delineating the finer details of fracture line. The study conducted by Holland and Brant-Zawadzki showed that HRCT images are taken more efficiently and with minimal radiation, and reformation in multiple projections regardless of the original scanning plane. Delineation of more subtle fractures of the petrous bone and thorough evaluation of associated findings are possible with HRCT. And also, the three dimensional capability of HRCT offers a specific advantage over conventional CT.

HRCT is initially taken in axial section and then coronal, and sagittal reconstruction is carried out with specific software which allows maximum flexibility in detailing the course of fracture line. A valuable advantage is for those structures which are vertically oriented (descending part of facial canal). Furthermore, dynamic sequential scanning and low-milli ampere-second technique allows rapid imaging and minimizing the radiation exposure.

Contrary to high-resolution scanning, conventional CT (10 mm slices) is inefficient in diagnostic as well as for screening purposes. In our study, conventional CT diagnosed only 15 cases of temporal bone injury out of total 40 cases which were diagnosed by HRCT. However, this routine conventional tomography could be able to give clues such as opacification of mastoid air cells, intracranial air pockets, etc.

Analyzing the site of fractures in temporal bone, petrous part was the most frequently injured,[10] followed closely by squamous part. We found that petrous fractures accounted 50% and that of squamous was 32.5% in total number of 40 temporal bone fractures. Mastoid part was involved in 7.5% of cases and tympanic part in 2.5% (only one case). Among the petrous bone fractures, longitudinal type of fractures which runs along the long axis of petrous bone was the most common type, constituting 80% of the cases. Hearing loss[11,12] frequently seen in this type of fracture was conductive hearing loss which was 62.5% and rarely causing sensorineural hearing loss, constituting only 15%. Facial nerve injury was not seen in this type of fractures. CSF otorrhea was seen in 37.5% of longitudinal fractures.

Transverse fractures which run right angle to the petrous axis were seen in 10% and oblique type in 10% of cases. Sensorineural type of hearing loss was the most frequent type seen in these fractures, accounting for 50% of transverse fractures. Facial nerve involvement[13] observed in 50% of cases and CSF otorrhea also seen in 50% of these fractures. These results are paralleling the international studies. A similar sort of study was done by Holland and Brant-Zawadzki also showed results similar to our study.

Apart from categorizing the fracture types, HRCT has got a major role in precise and complete delineation of fracture line. For those patients who need surgical intervention for any of the complications of temporal bone injury, pre-operative HRCT is definitely needed to plan the surgical approach. In our study, HRCT showed ossicular chain disruption in 8 cases, tegmen involvement in 4 cases, vestibular injury in 4 cases, cochlear damage in 3 cases, and semicircular canal injury in 2 cases. However, none of these details about the extent of fracture line was seen in conventional CT.

The importance of early identification of these temporal bone injuries and their detailed description avoids some of the delayed complications of these injuries which may have a strong impact on the quality of life and sometimes may cause mortality also. Those complications are delayed facial nerve palsy, delayed CSF leak, and meningitis.

SUMMARY

This is a prospective study involving patients with head injury who had been admitted in Head injury ward at Government Rajaji Hospital, Madurai Medical College, from February 2012 to February 2013. All patients who had symptoms/signs suspicious of temporal bone fracture such as ear bleeding, hearing loss, CSF otorrhea, facial nerve weakness were included in this study. All patients were subjected to both conventional CT with bone window and HRCT of temporal bones with axial and coronal reconstruction. Among the total of 60 enrolled patients, 20 patients were not having temporal bone fractures. Of the remaining 40 patients, conventional CT can pick up only 15 fractures. However, HRCT diagnosed temporal bone fractures in all 40 patients which are a statistically significant difference.

HRCT of temporal bone is more sensitive and specific than conventional CT in diagnosing temporal bone trauma and also HRCT is highly efficient in assessing the extent of the fracture line in temporal bone trauma. Hence, it is the must to include HRCT in the evaluation of patients with head injury who are having risk factors for temporal bone fracture.

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