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Original article

Evaluation of Brain Injury Classifications Accuracy by Using CT scan and T2 - Star Weighted Image MRI in the Emergency Department

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Abstract

Background: While the diagnosis of traumatic brain injury (TBI) is a clinical decision, neuroimaging remains vital for guiding management on the basis of identification of intracranial pathologic conditions. CT is the mainstay of imaging of acute TBI for both initial triage and follow-up, as it is fast and accurate in detecting both primary and secondary injuries that require neurosurgical intervention, also has a limited resolution capacity in detecting non-hemorrhagic lesions and those lesions located in the posterior fossa. MRI is more sensitive for the detection of certain intracranial injuries (e.g., axonal injuries) and blood products 24-48 hours after injury, but it has limitations (e.g., speed, accessibility, sensitivity to motion, and cost). The evidence primarily supports the use of MRI when CT findings are normal and there are persistent unexplained neurologic findings or at sub-acute and chronic periods. Radiologists should understand the role and optimal imaging modality to a conventional MRI protocol with minimum sequences that reduces study time in order to be able to complete examination fast with patient. The use of examination CT and a combination of MRI protocols consisting of T1, T2, FALIR and T2* in emergency department to help with the good diagnosis of brain trauma classification treatment planning and assessing response to treatment. ***Objective:*** The role of helical CT scan and MRI T2 star weighted image to classification brain injury. ***Method:*** This project is based on cross-sectional design. The population of this study were100 patients the population of this study were patients with brain trauma that have been indicated for CT and MRI test in emergency department period of sampling which was during September 2023 to February 2024. Epidemiological data were collected at admission: age, sex, TBI mechanism, presence of m TBI, moderate and severe extra-cranial injury, post-resuscitation level of consciousness expressed by GCS and its motor subscale, and pupil examination. Findings from the admission CT scan were recorded following the Traumatic Coma Data Bank classification and MRI had been done through 72h week and 2week depending on stability of patients. questionnaire was designed and copied by the researcher. Examination had done on CT scan (Philips Multiva System 64 slice) in a supine position using a standard brain protocol, as part of the initial clinical assessment, according to the Scandinavian Guidelines for Head Injury Management. MRI examinations was performed using MRI 1. 5 T scanner (Philips MULTIVA systems) using a phase array head coil at the radiology department. The data had encoded and then entered into the statistical program (SSPS version 26). ***Results:*** A total 100 were patients with brain trauma that have been indicated for CT and MRI investigated in emergency department radiographically. The age of each study samples was normally distributed and ranged from 6 to 60, 7 to 55, and 10 to 60 years with a mean of 34. 6±17 for mild group, 30. 05±13. 7 for moderate group and 10 to 60 for sever group respectively after the inclusion and exclusion criteria, without significant differences between them (P-value= 0. 454) which reflecting the matching purpose of samples collection. All the 100 participants who completed, CT identified radiographic TBI in were true positive diagnostic accuracy (60%) while missed diagnostic were 40case. In MRI were true positive diagnostic accuracy (92%) while missed in 8 cases with the most common injuries being skull fracture, concision, intracranial hemorrhage, subdural hematoma, and subarachnoid hemorrhage, diffuse axonal injury, trauma axonal injury. Using CT as the criterion standard in mild TBI, through 24h the sensitivity (0. 7%) and Specificity (29. 6%). MRI 1 through 72h after TBI had the sensitivity (86. 7%) and Specificity (100%). MRI 2 through week after TBI had the sensitivity (6. 7%) and Specificity (43. 5%). MRI 3 through 2 weeks after TBI had the sensitivity (25. 1%) and Specificity (64. 7%). Using CT as the criterion standard in moderate TBI, after brain injury through 24h the sensitivity (54. 5%) and Specificity (33. 4%). MRI1 were sensitivity (0. 9%) and Specificity (24. 1%). MRI 2 were sensitivity (87. 3%) and Specificity (97. 8%). MRI 3 were sensitivity (0. 5%) and Specificity (33. 4%). Using CT as the criterion standard in severe TBI, after brain injury through 24h the sensitivity (100%) and Specificity (57%). MRI 1 were sensitivity (0. 8%) and Specificity (75. 2%). MRI 2 were sensitivity (0. 6%) and Specificity (30%). MRI 3 were sensitivity (100%) and Specificity (100%). ***Conclusion:*** MRI is a reasonable alternative to CT to identify radiographically evident TBI in clinically stable patients. MRI is a very sensitive technique for diagnosing DAI and ATI in moderate and severe TBI. For proper diagnosis, we recommend performing a conventional MRI in the sub-acute phase (within the first 4 weeks of the trauma) that includes at least T1, T2, FLAIR and gradient echo sequences in the different slice planes that reduces study time in order to be able to complete examination fast as soon as an MRI in patients with TBI.

Keywords: ***Traumatic brain injury. Head trauma. MRI. CT. Diffuse axonal injury. Prognosis.***

1. Introduction

Traumatic brain injury (TBI) is a major cause of death, disability, and economic burden worldwide (Alexia Samiotis, et al.,2023). TBI is defined as any aggression by external forces that can lead to anatomical lesions or functional impairment in cranial or brain regions (Gravesteijn, et al,2022). The pathophysiology of TBI is complex, and the underlying molecular and cellular mechanisms remain elusive. In this scenario, TBI-associated structural and functional alterations are classified as primary or secondary lesions (Lucas A. S. M, et al., 2021). Primary lesions are caused by direct mechanical forces to the skull during the initial impact and are often associated with contusions, hematomas, subarachnoid hemorrhage, and diffuse axonal injury. The extent of primary lesions depends on the origin and magnitude of the impact and the duration and location of the applied force (Gaetz M, 2004). Secondary TBI lesions are the consequence of primary lesions, in which cerebral metabolism and cerebral blood flow are affected (Ragan DK, et al., 2013). Resulting in biochemical, metabolic, cellular, and molecular changes, such as neuroinflammation, oxidative stress, excite toxicity, and edema. These events may ultimately lead to neurodegeneration and cerebral atrophy. These changes can persist for an exceptionally long time after injury, affecting the quality of life of the patients (Bramlett HM, et al., 2015). When considering TBI in adults and children, it is possible to highlight differences in their etiology, histopathology, and management. Even without apparent external bleeding, blood loss in children can result in devastating hemorrhagic events, which makes a faster and more accurate diagnosis necessary to achieve a better prognosis (Araki T, et al., 20 17). There are many obstacles to the initial assessment of TBI in children, especially in situations where the patient exhibits nonspecific symptoms and there are no signs or evidence of trauma, making the diagnosis essentially based on the caretaker's report (Jenny C et al 1999). Misleading a TBI diagnosis can obscure many child abuse situations (Lucas A. S. M, et al., 2021), abusive head trauma (AHT) is responsible for most child abuse related deaths (Lopes NR2013). Potentially life-threatening conditions, such as subdural and epidural hemorrhage (Mondello. S, et al 2018), can occur due to both accidental head trauma and AHT in children and adults. Especially in children, subdural hemorrhages are unusual consequences of mild TBI events (Bechtel K, et al., 2004). But can be found in almost 90% of cases of shaken baby syndrome (Lips U, et al.,2010). Among detected intracranial lesions, subdural hemorrhage is more common in AHT (90%), while epidural hemorrhage is more common in accidental trauma (Choudhary AK, et al 2018). Therefore, it is important to evaluate the pediatric population in a more specific analysis. The cognitive deficits of moderate and severe TBI in children include memory and executive function impairment and worse school readiness skills (Taylor HG, et al,2008). When taking into account pedagogical support, post-TBI students require special educational services. As reported in follow-up studies, the need for school assistance accounted for up to 45% of moderate and severe TBI cases (Rivara FP, etal.,2012) and 50% of severe TBI cases (Prasad MR, et al.,2017). Regarding the future impact on academics, young children who experience TBI are 18 times more likely to show poorer academic performance than healthy children than adult (Prasad MR, et al.,20). In the long term, brain trauma could also initiate or accelerate the development of several neurodegenerative diseases, such as Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis (Daneshvar DH, et al.,2011).

1.1 Classification of TBI

Glasgow Coma Scale TBI is a clinical diagnosis traditionally classified using the Glasgow Coma Scale (GCS). GCS scores 13-15 are mild brain injuries, 9-12 are moderate, and 3-8 are severe. There is a strong correlation between GCS score and morbidity and/or mortality at the severe end of the spectrum but limited correlation at the mild end of the spectrum. The GCS has been a long-standing clinical tool used to quickly categorize TBI as mild, moderate, or severe solely on the basis of physical examination findings without the need to use specialized tools. GCS score is determined by summing the scores from three categories: best eye response (score 1-4), best verbal response (score 1-5), and best motor response (score 1-6), yielding scores of 3-8 (severe), 9-12 (moderate), and 13-15 (mild) (Teasdale G, et al.,2014). The value of this method has been its ease of use combined with the strong correlation to morbidity and mortality at the severe end of the TBI spectrum. The GCS still remains a primary tool both clinically and in research for the classification of TBI. Unfortunately, correlation with morbidity on the mild end of the spectrum is poor. A perfect score of 15 does not signify absence of a TBI, nor does it exclude the possible development of post concussive syndrome. Despite the gross limitations for patients with mild TBI, a recent review of 811 143 patients from the National Trauma Data Bank showed that a GCS score less than or equal to 13 can discriminate the need for trauma center care (Brown JB, et al.,2014). GCS scores have been used to discriminate in-hospital mortality, receipt of neurosurgical interventions, severe brain injury, and emergency intubation (Chou R, et al.,2017). For mild TBI, duration of loss of consciousness and posttraumatic amnesia have a much stronger correlation with outcome and worse Glasgow Outcome Scale scores at 6-12 months (Sussman ES, et al.,2018). There are different classification systems for TBIs, based on severity, path anatomic type, outcome, and prognosis (Rehabil Res Dev 2009). Generally, TBIs were classified as mild, moderate, or severe by using the Glasgow Coma Scale (GCS). An important parameter of the severity of TBI is post- or peri-traumatic amnesia. Post-traumatic amnesia (PTA) of 1-24 h indicates a moderately severe TBI; however, more recent classifications of moderate TBI require post-traumatic amnesia extending beyond 24 h (Sherer, M, et al, 2011) and (Greenwald, B. D, et al., 2012). A widely acceptable TBI classification system is the Mayo System which divided TBIs as possible, probable-moderate, and definite moderate-severe (Greenwald, B. D, et al., 2012). A TBI is classified as probable mild if there is loss of consciousness below 30 min, post-traumatic amnesia for less than 24 h, and there is a depressed, basilar, or linear skull fracture, but with intact dura matter. A TBI is classified as possible if the patient develops blurred vision, confusion, headache, or nausea, and as definite moderate-severe if there is loss of consciousness lasting 30 min or more, post-traumatic amnesia of 24 h or more, or worst full Glasgow Coma Scale score below 13, or if there is death due to this TBI. The Mayo Classification System also requires that all other causes of impaired consciousness should be excluded. If there is additional evidence of brain hematoma, hemorrhage, contusions, or ruptured dura mater, the TBI is classified as moderate-severe (Malec, J. F, et al. 2007). Adams et al. (2000), after reviewing the neuropath logical findings of 434 brains of patients who died of TBI in Glasgow, established three stages of DAI following a centripetal model of lesions as follows: DAI I, lesions located in the subcortical white matter; DAI II, lesions located in the corpus callosum; and DAI III, lesions located in the dorsal portion of the brainstem. Before the advent of cranial MRI there were no satisfactory methods for anatomically classifying lesions present in patients suffering from severe head injury in the living subject. Cranial CT also has a limited resolution capacity in detecting non-hemorrhagic lesions and those lesions located in the posterior fossa. Because of abovementioned problems we like to propose a new approach for classifying TBIs and what will be needed to build a new and better classification. In our study, advanced magnetic resonance imaging sequences were excellent diagnostic instruments, that used to establish a conventional MRI protocol with minimum sequences that reduces study time in order to be able to complete an MRI on these patients in the TBI, and for classification TBI beside CT routine examination of brain trauma in emergency department, according to Adams et al, in all TBI classification and TAI lesions were classified according to Gentry and Firsching classifications. We illustrated the use of examination

CT and a combination of MRI protocols consisting of T1, T2, FALIR and T2* in emergency department to help with the good diagnosis of brain trauma, treatment planning and assessing response to treatment.

2. Research Methods

Material and methods

This cross-sectional study that was conducted at hospital's belong to Middle Euphrates cities of Iraq emergency department in the period of sampling which was during September 2023 to January 2024. A total of 100 patients were done studied under helical CT scan, the time of examination CT after brain trauma immediately to all patients and repeated it monitoring within 48hours in acute TBI. Then MRI examinations including routine MRI (T1, T2, FLAIR) and T2* weighted, were done after 72hours (for mild), one week (moderate) and two weak follow up by neurologist in sever TBI after the patient stable and can transports from ICU OR HDU to MRI room examination. The patient was conducted on CT scan (Philips Multiva System 64slice) in a supine position using a standard brain protocol, as part of the initial clinical assessment, according to the Scandinavian Guidelines for Head Injury Management. CT readings were first obtained from the radiology report. The intracranial traumatic findings on CT were classified into:(1) contusion, (2) epidural hematoma (EDH), (3) traumatic subarachnoid hemorrhage (tSAH), and (4) subdural hematoma (SDH) Intravenous contrast administration was not recommended due to potential masking and mimicking of hemorrhage. After that the patient was examined by Conventional MR sequences: MRI examinations were conducted on 1. 5Tesla MRI (Philips Multiva System) in a supine position using a standard 6 channel head coil The MRIs from all three time points were read and reported by radiologist and neurologist. The intracranial traumatic MRI findings were categorized into: (1) TAI, (2) contusion, (3) EDH, (4) SDH, and (5) tSAH.

Patient exam position

The patient was conducted on CT scan (Philips Multiva System 64slice) in a supine position using a standard brain protocol, as part of the initial clinical assessment, according to the Scandinavian Guidelines for Head Injury Management. CT readings were first obtained from the radiology report. A CT scan was typically performed in emergency department and took 10 minutes. To ensure safety, patients removed jewelry and metal objects. They lied down on a narrow table, either facing up or down. The scanner rotates the head, creating three-dimensional images from individual slices. These images are displayed on a monitor and stored for later viewing and printing. CT scans are particularly useful for evaluating injuries and are minimally invasive and quick. Once the CT scan was done, the images were being sent to a radiologist to get diagnosis. A radiologist is a doctor who specializes in diagnosing and treating conditions using imaging techniques. CT scans patient positioning was supine with head first with arms beside the trunk. After that the patient was examined by Conventional MR sequences: MRI examinations were conducted on 1. 5Tesla MRI (Philips Multiva System) in a supine position using a standard 6 channel head coil. Brain MRIs were done on the exam room sofa, with the patient in supine, the arms were on the sides of the trunk, the head placed within the head coil and the ears plugged to reduce the noise as the machine made thumping, knocking, and humming sound. The head balanced in such a way that the interpapillary line was paralleled to the couch the patient's head fixed in the head vacuum cushion and the motion artifacts avoided. In the longitudinal alignment, a red laser light appears is different from the horizontal alignment light.

Conventional MRI sequences

Conventional MRIs protocol T1 weighted image comprised slice thickness 5mmslice gap 0. 0 TR4000 Parameter short TE 25 flip angle 90, matrix size 320x320 and TR T2WI long TE 200 and TR7000 flip angle 130 T2 FLAIR, the scan parameter repetition time TR 9000and echo time TE 130, matrix size 320x320, FOV210-230 and T1WI SE (slice thickness 5mm slice gap 0. 0- 1mm, matrix size 320x320 acquired. all slices orientation axial plane are insufficient in clarity of anatomical region of trauma

Data collection

Epidemiological data were collected at admission: age, sex, TBI mechanism, presence of mTBI, moderate and severe extra-cranial injury, post-resuscitation level of consciousness expressed by GCS and its motor subscale, and pupil examination. Findings from the admission CT scan were recorded following the Traumatic Coma Data Bank classification (TCDB). Individual lesions identified on CT such as cerebral contusions, subarachnoid hemorrhage, intraventricular hemorrhage, corpus callosum, brainstem or deep grey matter nuclei lesions and extra-axial collections (epidural- or subdural) were also recorded. Data from subsequent CTs were also recorded. Cranial MRI was evaluated by two independent neuroradiologists who ignored the result of the initial CT or the clinical situation of the patient. The presence of contusions and lesions suggestive of DAI were recorded, as well as their localization and their hemorrhagic or non-hemorrhagic origin, combining for this purpose the information coming from different MR sequences. MRI findings were classified according to a scale that follows a centripetal gradation of the severity of the injury, i. e. the Adams scale for lesions related to DAI. When the grades assigned by the neuroradiologists differed, a final grade was established by consensus. Patients were evaluated 72 hours, week and 2 week after injury by means of the extended Glasgow Outcome Scale (eGOSE) applied using a structured interview, the Barthel index (BI) and the Mini Mental State Examination (MMSE) by Folstein

Data analysis

Data were analyzed and reported only for patients who complete the trial statistical analysis of data, and performed use in order to evaluate the level of agreement of sensitivity, specificity, Positive and negative predictive value and overall accuracy are necessary for all methods in evaluating brain tumors. After collecting the data, Descriptive statistics like Mean, percentage difference, and significant tests were evaluated. The mean and standard deviations of the average. An unpaired two-tailed Student's t-test were used. The data had encoded and then entered into the statistical program (SSPS version 26).

3. Result

3.1 Baseline demographic characteristics of study's sample

A total 100 samples were investigated in this study. The cause of trauma for 56 patients was car, motorbike or bike accidents and the rest were falls and fighting injuries. The age of each study samples was normally distributed and ranged from 6 to 60, 7 to 55, and 10 to 60 years with a mean of 34. 6±17 for mild group, 30. 05±13. 7 for moderate group and 10 to 60 for sever group respectively without significant differences between them (P-value= 0. 454) which reflecting the matching purpose of samples collection, as shown in Table 1

Table 1: Baseline demographic characteristics of the study's sample between patient's age (Mean± SD)

	Mild (15)	Moderate (55)	Severe (30)	P-Value
Mean± SD	34. 6±17	30. 05±13. 7	29. 13±13. 37	0. 454
Range (min-max)	15 (6-60)	55 (7-55)	30 (10-60)	

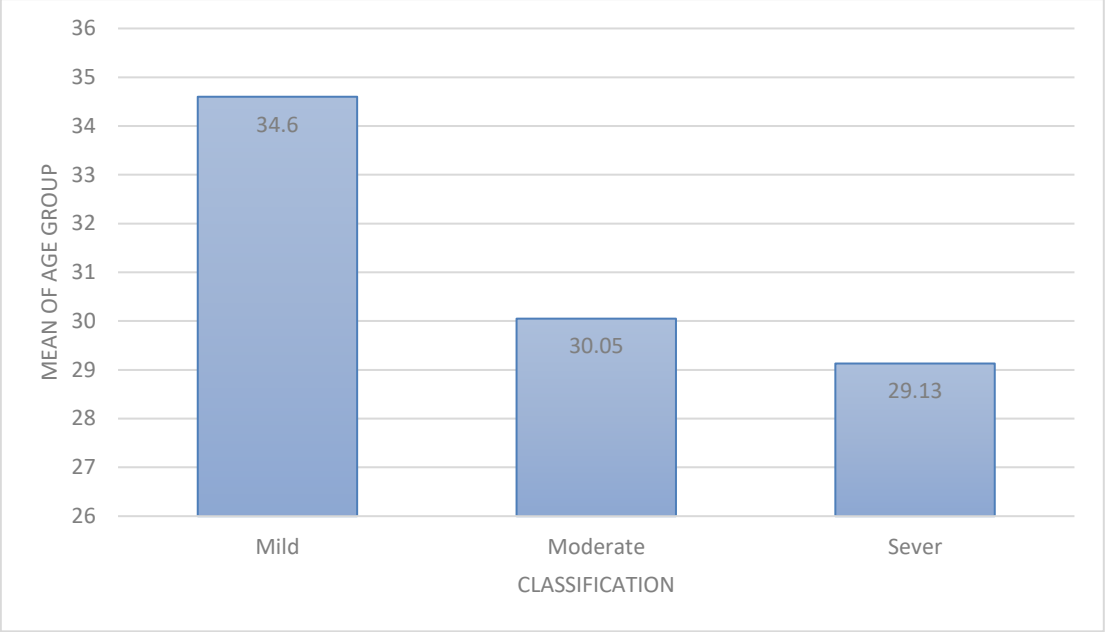

Figure 1: Mean values of study groups between Mild, Moderate, and Severe groups

Table 2, shows the mean values of study groups. Where, the mild, moderate and severe groups of male participants are 34. 36±17. 91, 31. 94±13. 97 and 32. 1±14. 52 respectively. While the mild, moderate and severe groups of participants are 35. 25±17. 07, 35. 25±17. 07 and 23. 2±12. 25 respectively. Furthermore, the determined p-values (0. 889 and 0. 257) indicate that there is no significance between both male and female groups.

Table 2: Baseline demographic characteristics of the study's sample between patient's age (Mean± SD) according to gender

	Mild (Mean± SD)	Moderate (Mean± SD)	Sever (Mean± SD)	P-Value
Male	34. 36±17. 91	31. 94±13. 97	32. 1±14. 52	0. 889
Female	35. 25±17. 07	26. 16±12. 62	23. 2±12. 25	0. 257

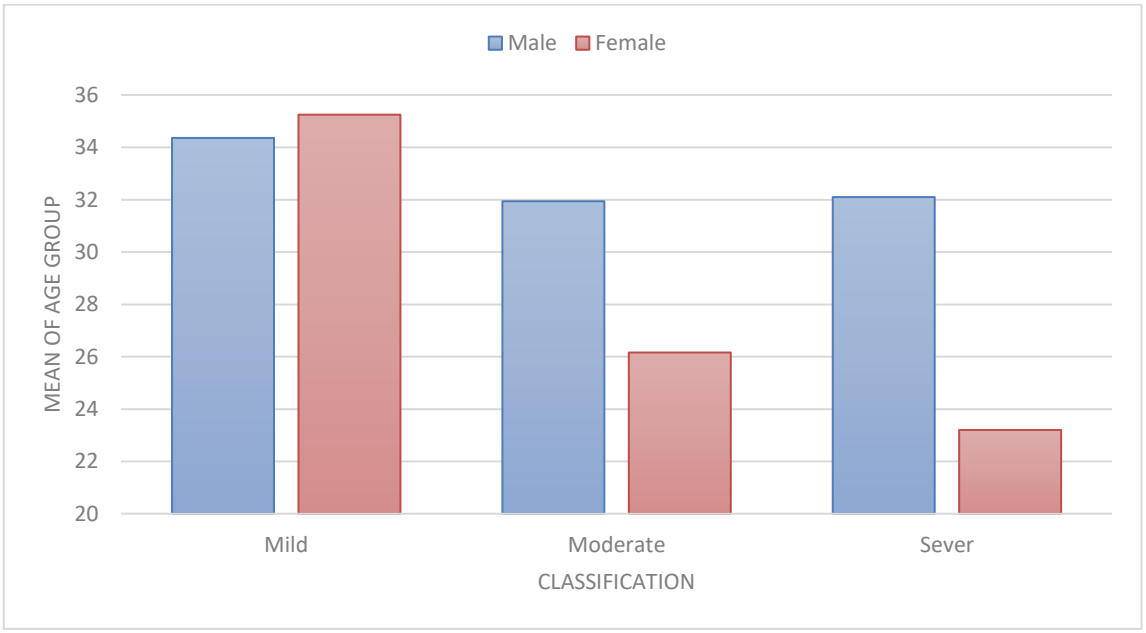

Figure 2: Mean values of study groups between Mild, Moderate, and Sever groups according to gender.

3.2: Statistical Analysis in Methods

The collected data was entered, double checked and analysed using IBM SPSS software version 26. Descriptive statistics that were qualitatively summarized the characteristics of the collected data were used in this study. Additionally, Independent Sample T-test and ANOVA test were used to determine the significance among study's groups. Furthermore, the utilized p-value that indicates the differences among study's groups, was suggested to be less than 0. 05 in this study.

3.3: Accuracy

Interpreter reliability for radiologists determining the presence of radiographic traumatic injury was good. All the 100 participants who completed, CT identified radiographic TBI in were true positive diagnostic accuracy (60%) while missed diagnostic were 40case. In MRI were true positive diagnostic accuracy (92%) while missed in 8 cases,with the most common injuries being skull fracture, concision, intracranial hemorrhage, subdural hematoma, and subarachnoid hemorrhage, diffuse axonal injury, trauma axonal injury as show in table 3.

Table 3: Diagnostic accuracy of CT and MRI scanners, True Positive refers to patients that are correctly diagnosis, while False Positive refers to patients that are incorrectly diagnosis

Medical Imaging	True Positive	False Positive	Diagnostic Accuracy
CT	60 (100)	40 (100)	60%
MRI	92 (100)	8 (100)	92%

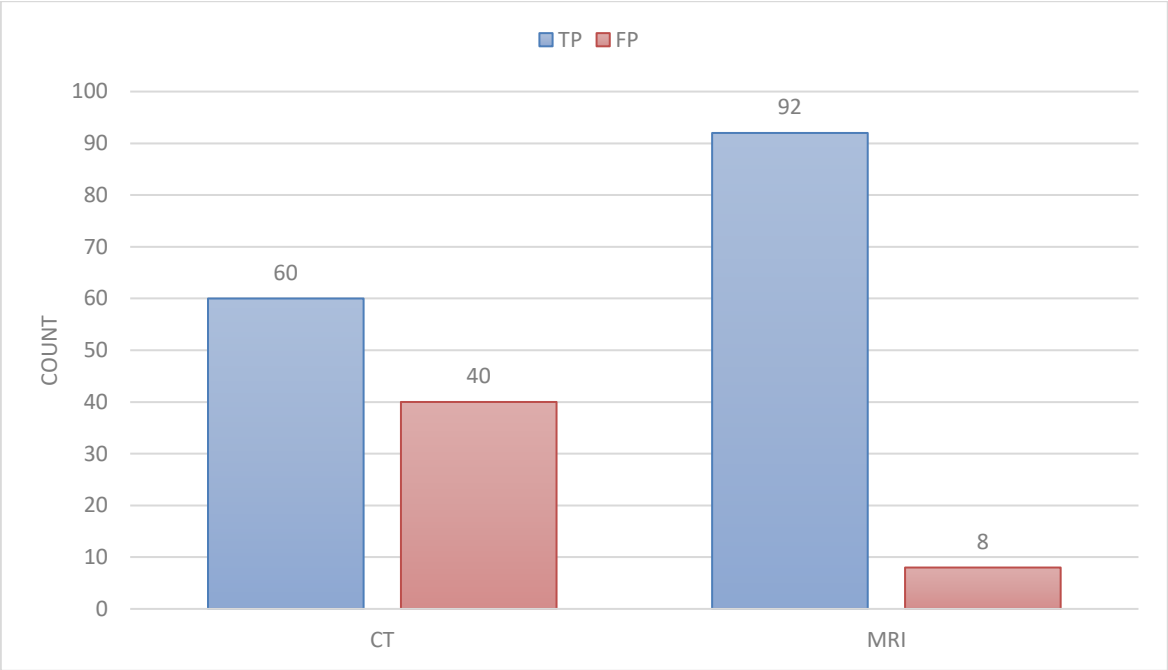

Figure 3: Bar chart shows the total number of patients that are diagnosed by CT and MRI scan.

Table 4: Diagnostic accuracy of haemorrhagic patients by CT and MRI scanners illustrated that 5 cases hemorrhagic for which radiographic TBI was missed by CT scan,5 cases had isolated, linear, non-depressed skull fractures, and 2 had isolated subarachnoid hemorrhage was missed by MRI.

Table 4: Diagnostic accuracy of haemorrhagic patients by CT and MRI scanners, True Positive refers to patients that are correctly diagnosis, while False Positive refers to patients that are incorrectly diagnosis.

Medical Imaging	True Positive	False Positive	Diagnostic Accuracy
CT	60 (65)	5 (65)	92. 3%
MRI	58 (65)	7 (65)	89. 2%

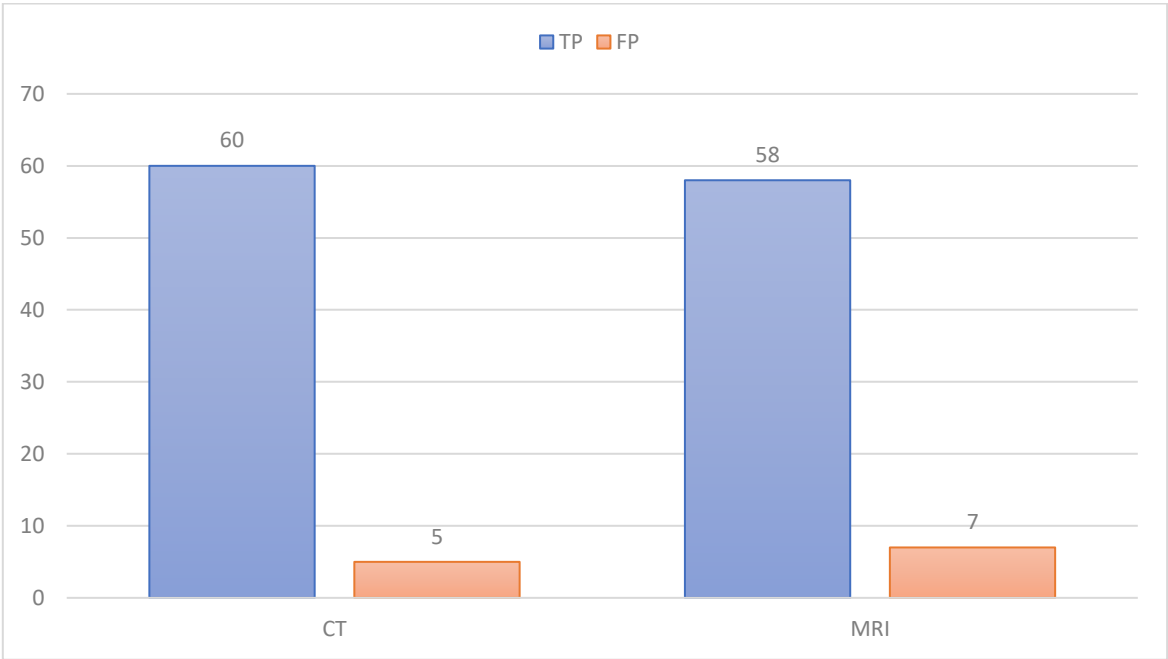

Figure 4: Bar chart shows the total number of haemorrhagic patients that are diagnosed by CT and MRI scan.

Ultimately, 5 cases in which TBI was identified by MRI severe TBI and not by CT were determined as moderate to represent real injuries identified by MRI and missed by CT. Injuries missed by CT included subdural hematomas (n = 1), parenchymal contusions (n = 1), and 1 case subarachnoid hemorrhage (1 child had both subdural hematoma and contusion). 2 children had DAI left thalamic and basal ganglia.

MRI decreased the perceived likelihood of abuse in some cases when CT was unable to distinguish enlarged subarachnoid spaces from subdural.

Hematomas, In all these cases, MRI was failed to definitively exclude subdural hematoma. In 1 case, CT was interpreted as indeterminate for subarachnoid hemorrhage, and MRI was unable to definitively identify or exclude TBI. MRI decreased the perceived likelihood of abuse in some cases when CT was unable to distinguish enlarged subarachnoid spaces from subdural hematomas. On the MRI sequences used, the most likely to identify TBI were GRE T2*, FLAIR and T2 single-shot turbo spin echo, which identified signs of TBI in 93 participants, respectively. The sequences least likely to identify injury.

Table 5, shows 35 cases non haemorrhagic classified in two groups of 15 cases, mild and 20 cases, moderate according to Glasgow Coma Scale score. mTBI is defined by a Glasgow Coma Scale score between 13 and 15 at 30 minutes post-injury, and one or more of the following symptoms: <30 min loss of consciousness; < 24 hours' post-traumatic amnesia (PTA); impaired mental state at time of accident (confusion, cortical confusion, disorientation negative in CT and positive by MRI.

20 cases were with NHLs, 19 cases were definitively diagnosed by MRI and 1 case was failed. But they were negative in CT scan. Injuries were located most commonly in the selenium of the corpus callosum and occur frequently in the thalamus and the mesial temporal lobe. Because most NHS occur concomitantly with hemorrhagic lesions, it was difficult to determine their effects on prognosis. Since most NHLs resolve completely, they are probably less significant to prognosis than hemorrhagic lesions.

Table 5: Diagnostic accuracy of non-haemorrhagic patients by CT and MRI scanners, True Positive refers to patients that are correctly diagnosis, while False Positive refers to patients that are incorrectly diagnosis.

Medical Imaging	True Positive	False Positive	Diagnostic Accuracy
CT	0 (35)	35 (35)	0 %
MRI	34 (35)	1 (35)	97. 1 %

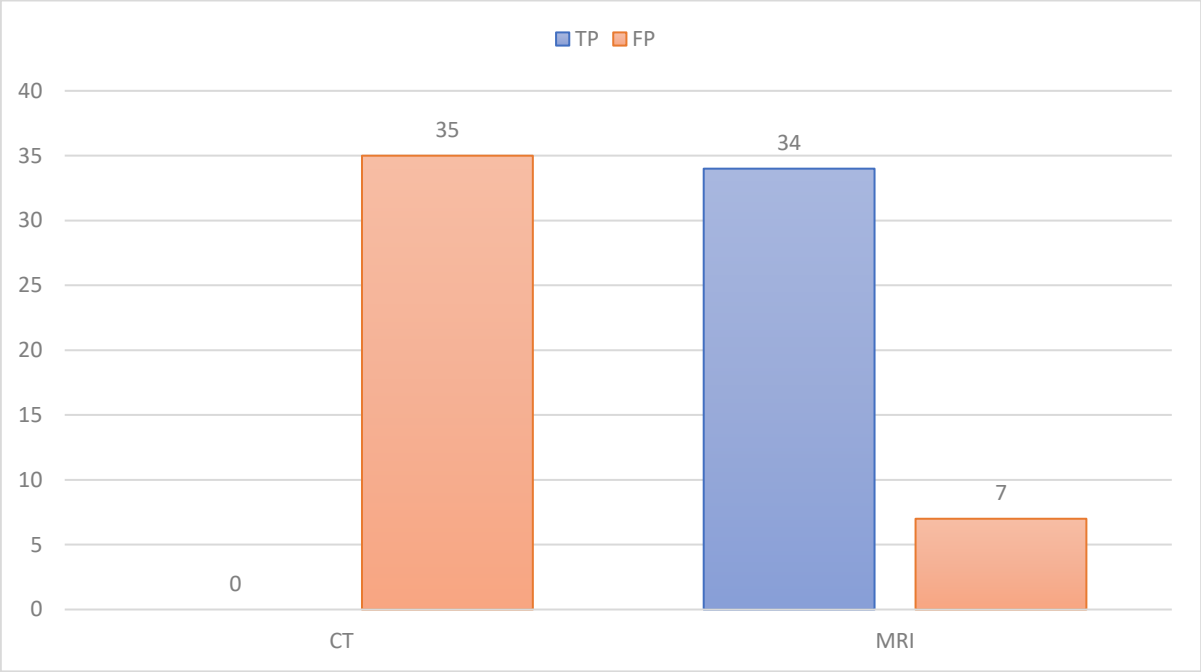

Figure 5: Bar chart shows the total number of non-haemorrhagic patients that are diagnosed by CT and MRI scan.

Using CT as the criterion standard, after brain injury through 24h the sensitivity (0. 7%) and Specificity (29. 6%).

MRI1 through 72h after TBI had the sensitivity (86. 7%) and Specificity (100%)

MRI2 through week after TBI had the sensitivity (6. 7%) and Specificity (43. 5%)

MRI3 through 2 week after TBI had the sensitivity (25. 1%) and Specificity (64. 7%) follow-up by MRI in mild TBI.

Table 6: Area under cure of medical imaging techniques in diagnosing mild brain injuries

Medical imaging	AUC	Standard-Error	Sensitivity	Specificity	95%- CI	Cut-off	P-value
CT	0. 147	0. 038	0. 7%	29. 6%	0. 221-. 073	0. 5	0. 001
MRI1	0. 933	0. 052	86. 7%	100%	1. 035-0. 831	0. 5	0. 056
MRI2	0. 250	0. 057	6. 7%	43. 5%	0. 36-0. 14	0. 5	0. 001
MRI3	0. 324	0. 061	25. 1%	64. 7%	0. 44-0. 204	0. 5	0. 004

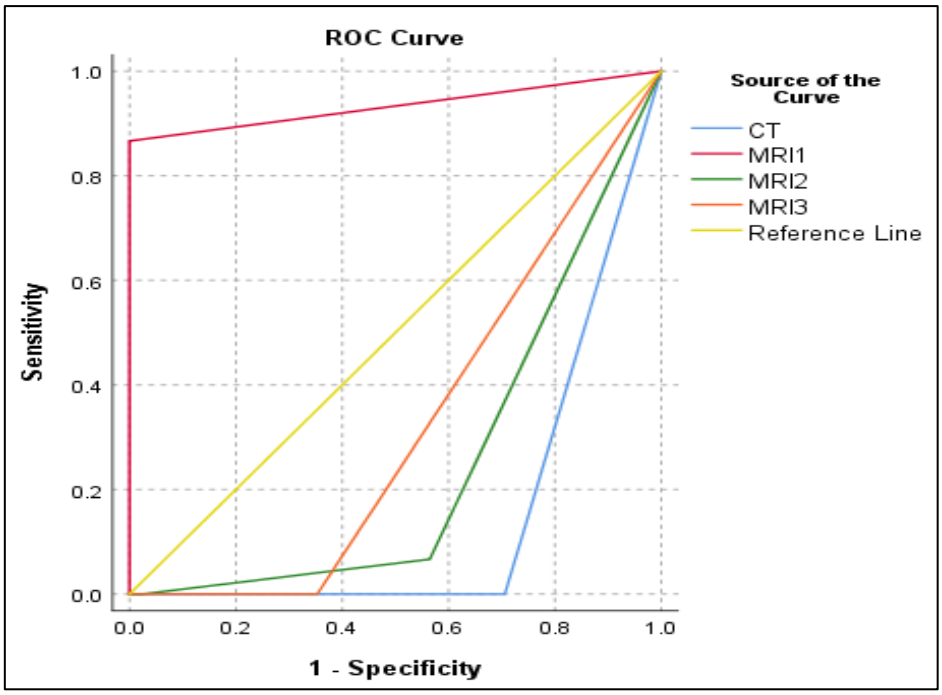

Figure 6: ROC curve of medical imaging techniques for diagnosing mild brain injuries in study group.

Using CT as the criterion standard, after brain injury through 24h the sensitivity (54. 5%) and Specificity (33. 4%).
MRI1 through 72h after TBI had the sensitivity (0. 9%) and Specificity (24. 1%)
MRI2 through week after TBI had the sensitivity (87. 3%) and Specificity (97. 8%)
MRI3 through 2 week after TBI had the sensitivity (0. 5%) and Specificity (33. 4%) follow-up by MRI in moderate TBI

Table 7: Area under cure of medical imaging techniques in diagnosing moderate brain injuries.

Medical imaging	AUC	Standard-Error	Sensitivity	Specificity	95%- CI	Cut-off	P-value
CT	0. 439	0. 058	54. 5%	33. 4%	0. 553-. 0326	0. 5	0. 011
MRI1	0. 356	0. 057	0. 9%	24. 1%	0. 467-0. 244	0. 5	0. 008
MRI2	0. 926	0. 03	87. 3%	97. 8%	0. 868-0. 983	0. 5	0. 294
MRI3	0. 167	0. 045	0. 5%	33. 4%	0. 255-0. 078	0. 5	0. 004

Using CT as the criterion standard, after brain injury through 24h the sensitivity (54. 5%) and Specificity (33. 4%).
MRI1 through 72h after TBI had the sensitivity (0. 9%) and Specificity (24. 1%)
MRI2 through week after TBI had the sensitivity (87. 3%) and Specificity (97. 8%)
MRI3 through 2 week after TBI had the sensitivity (0. 5%) and Specificity (33. 4%) follow-up by MRI in moderate TBI.

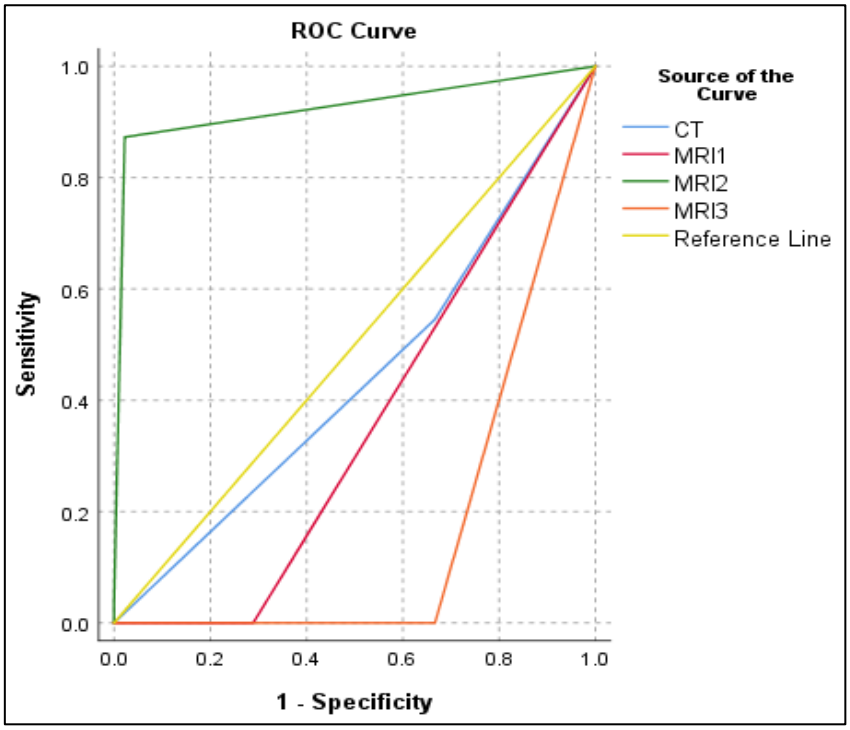

Figure 7: ROC curve of medical imaging techniques for diagnosing moderate brain injuries in study group.

Using CT as the criterion standard, after brain injury through 24h the sensitivity (100%) and Specificity (57%).
MRI1 through 72h after TBI had the sensitivity (0. 8%) and Specificity (75. 2%)
MRI2 through week after TBI had the sensitivity (0. 6%) and Specificity (30%)
MRI3 through 2 week after TBI had the sensitivity (100%) and Specificity (100%) follow-up by MRI in severe TBI.

Table 8: Area under cure of medical imaging techniques in diagnosing sever brain injuries.

Medical imaging	AUC	Standard-Error	Sensitivity	Specificity	95%- CI	Cut-off	P-value
CT	0. 786	0. 044	100%	57%	0. 872-. 07	0. 5	0. 12
MRI1	0. 407	0. 058	0. 8%	75. 2%	0. 521-0. 293	0. 5	0. 008
MRI2	0. 15	0. 037	0. 6%	30%	0. 223-0. 077	0. 5	0. 001
MRI3	1	0. 001	100%	100%	1-1	0. 5	0. 32

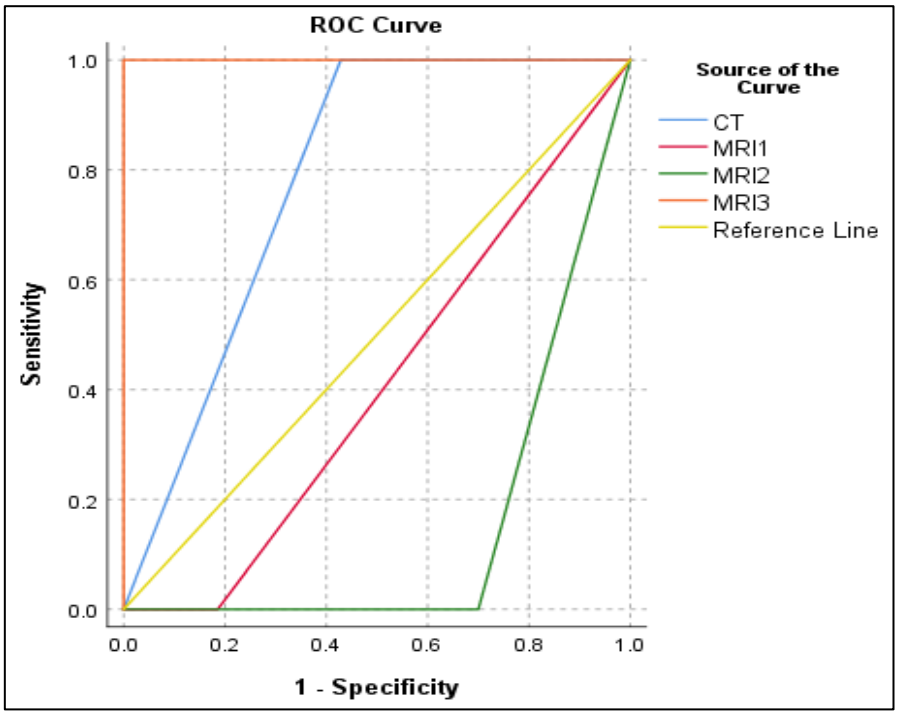

Figure 8: ROC curve of medical imaging techniques for diagnosing sever brain injuries in study group.

4. Case presentation

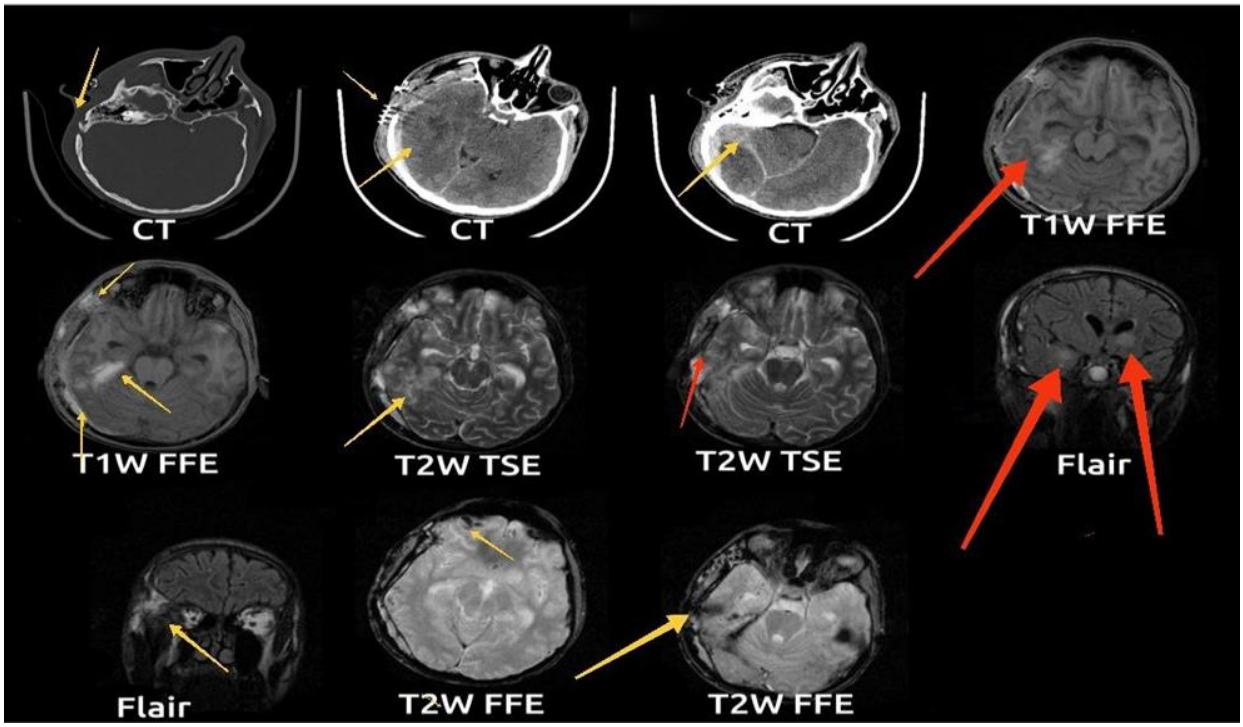

Figure 9: a-Male with 17 years old, motor vehicle accident, plain axial images of CT both soft tissue and bone window shows a right fronto parietal acute subdural hematoma with overlying right frontal minimally depressed fractures and surgical clips. b: MRI: evidence of right fronto parietal acute subdural hematoma seen, concomitant right temporal and left frontal contusion seen in addition to left thalamic focus of DIA.

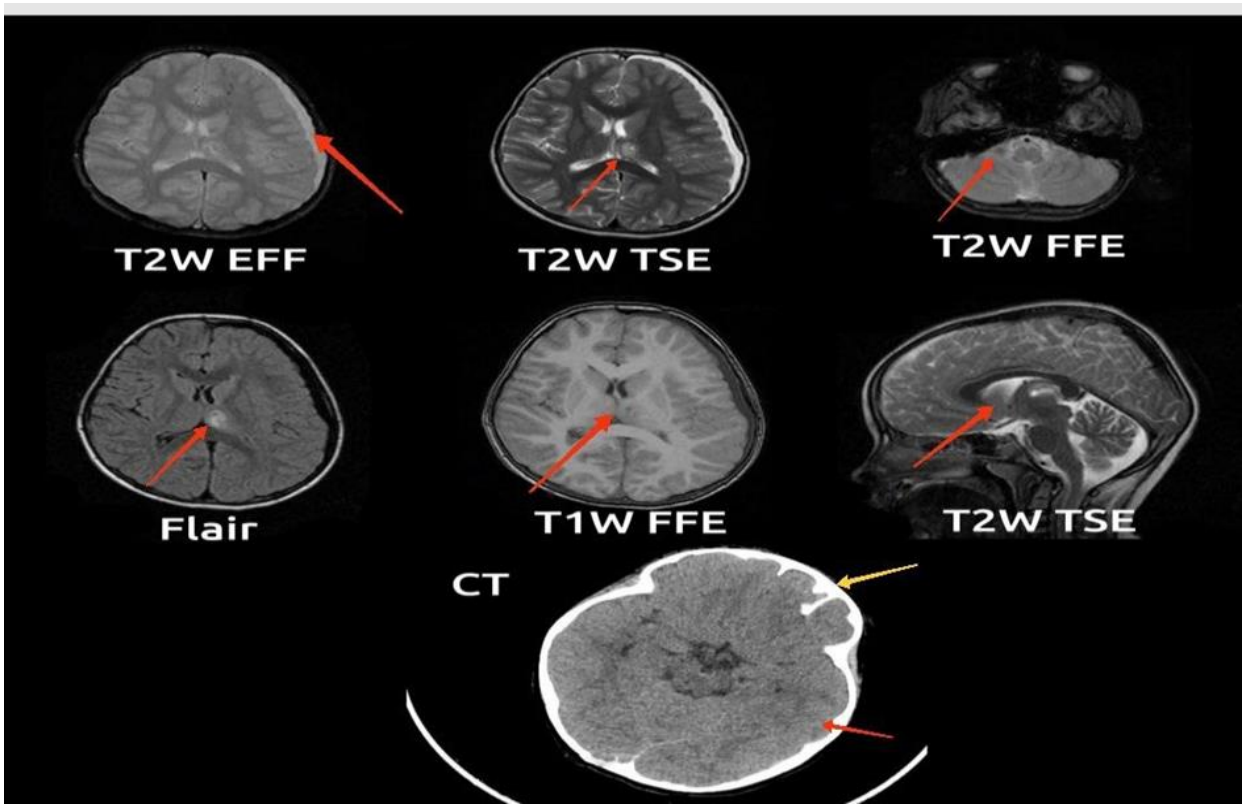

Figure 10: Child with 7 years, motor vehicle accident, plain axial images of CT soft tissue shows hemorrhage left acute SDH frontoparietal and seen in frontal lobe. MRI shows scatter foci of hemorrhage seen in left thalamic DAI, basal ganglia and left frontal lobe, that missed by CT, and acute SDH in left frontoparietal lobe.

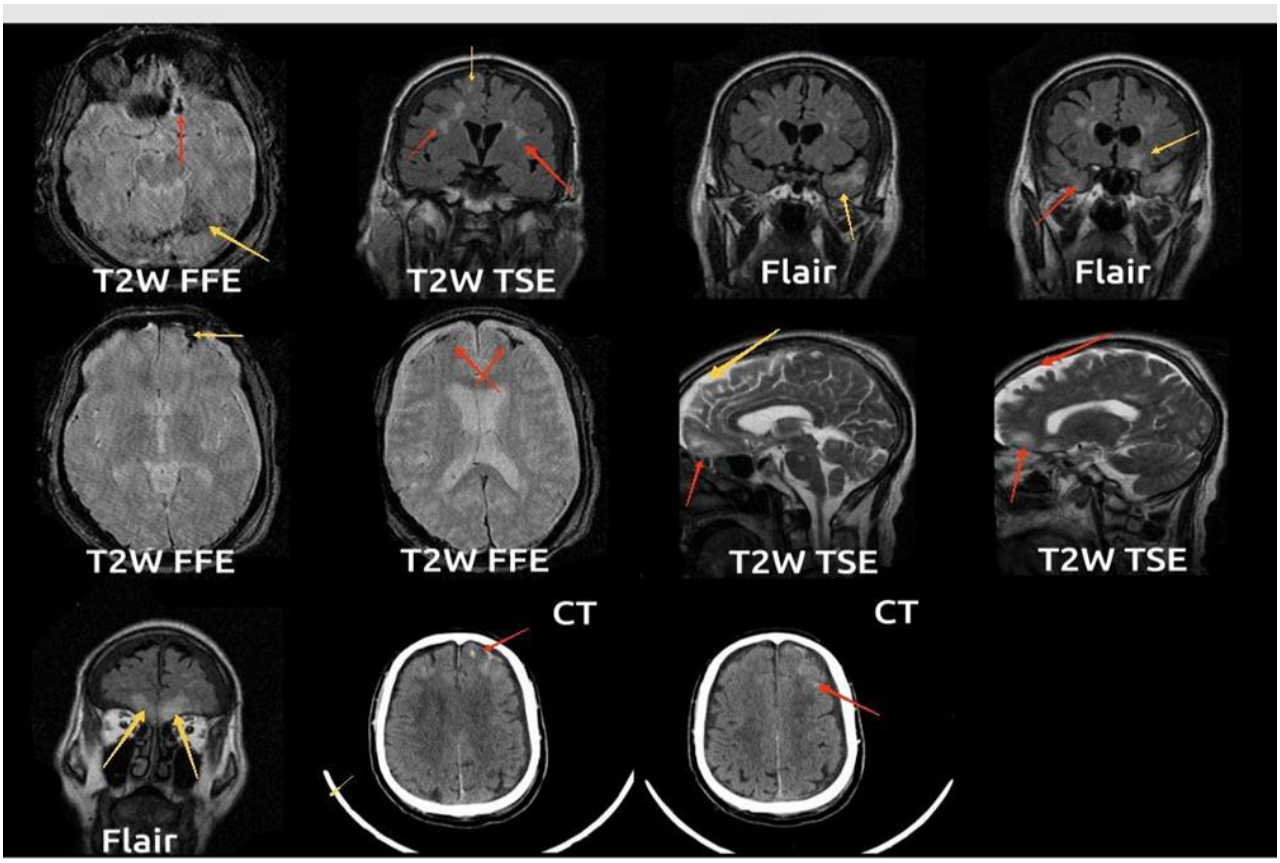

Figure 11: Male with 55 years, motor vehicle accident, plain axial images of CT soft tissue shows SDH hemorrhage in bilateral frontal hemorrhagic. MRI illustrated bilateral frontal SDH hemorrhage with contusion and right post horn of lateral ventricle

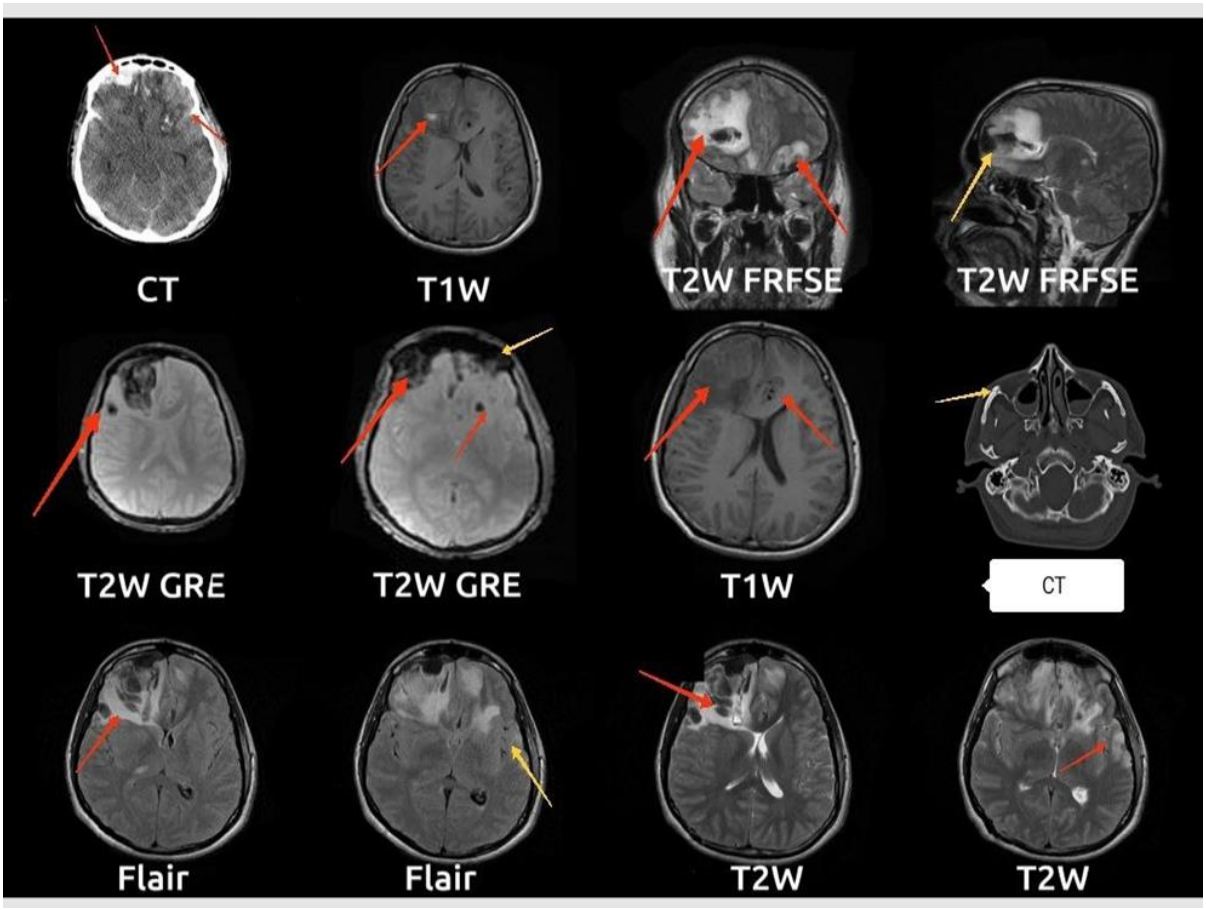

Figure 12: Male with 25 years, with direct blunt force. Plain axial images of CT both soft tissue and bone window shows bilateral frontal hemorrhage contusion and depressed fracture in RT. zeugmatic bon. MRI shows bilateral frontal heterogeneous hemorrhage contusion (high signal) in T1and T2. T2* image appeared with Susceptibility artifact (low signal) more on right side surrounding cytotoxic edema (hyper density) (petical hemorrhage).

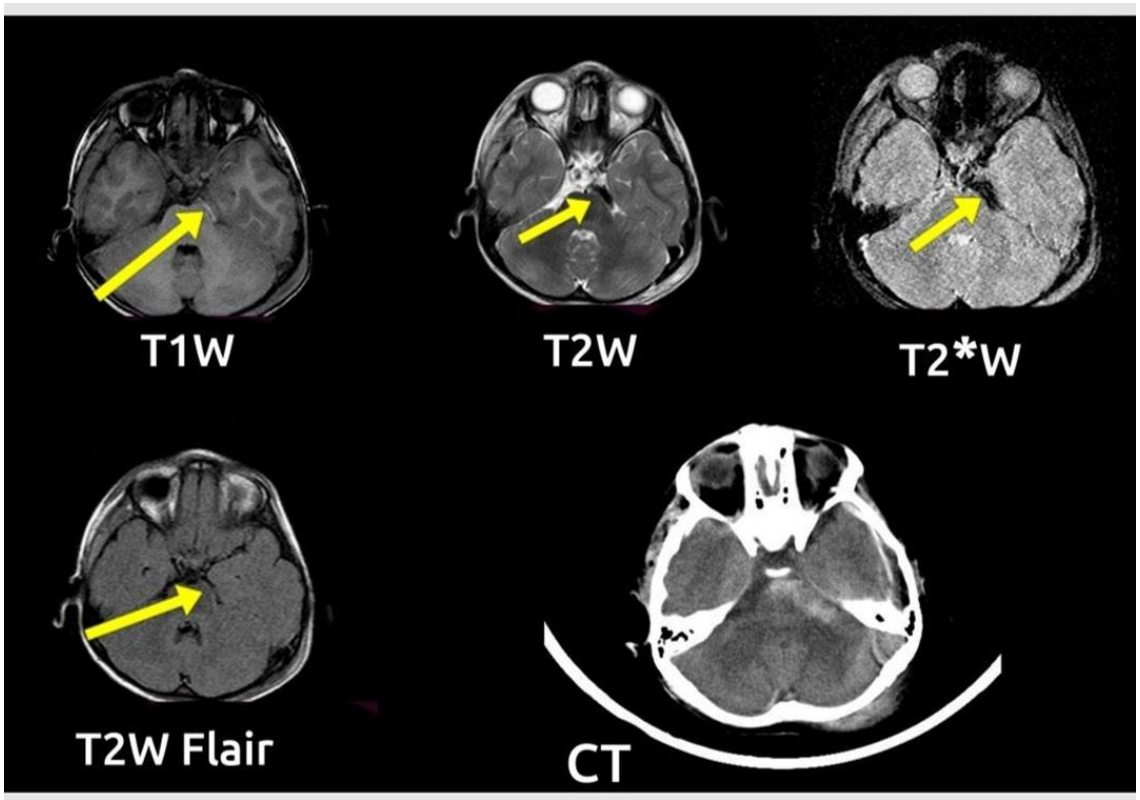

Figure 12: Child with 6 years, motor vehicle accident, Plain axial images of CT soft tissue shows SAH in basal cistern. MRI shows SAH in left ambient cistern.

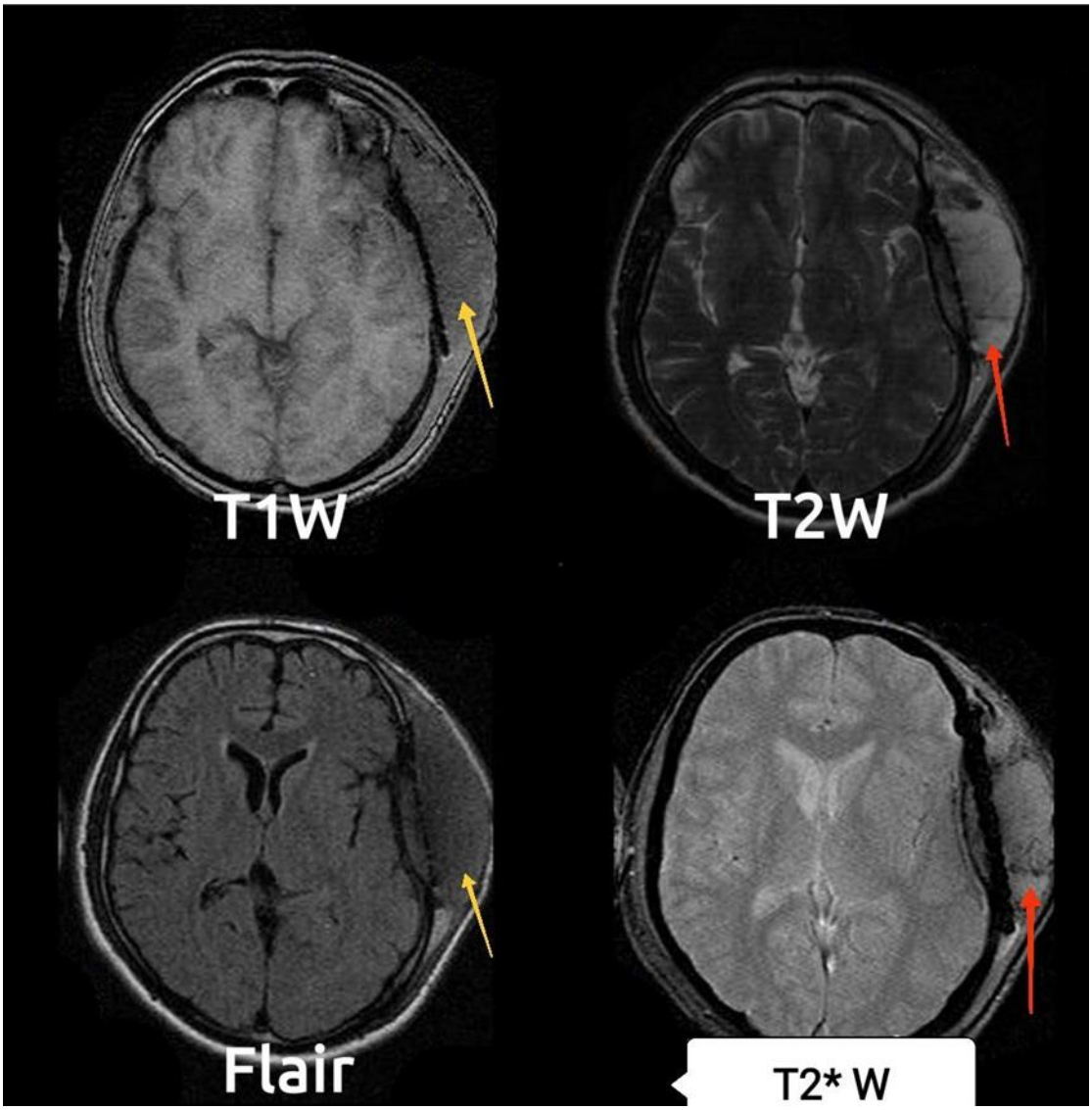

Figure 13: male with 20 years old, with falls accident, MRI shows late sub-acute left sublegal hematoma Crescent shape left frontotemporal side, that T1 FALIER were (iso to high), T2 and T2* were high signal.

5. Discussion

A total 100 samples were investigated in this study. The cause of trauma for 56 patients was car, motorbike or bike accidents and the rest were falls and fighting injuries. The age of each study samples was normally distributed and ranged from 6 to 60. The collected data was entered, double checked and analysed using IBM SPSS software version 26. Descriptive statistics that were qualitatively summarized the characteristics of the collected data were used in this study. Additionally, Independent Sample T-test and ANOVA test were used to determine the significance among study's groups. Furthermore, the utilized p-value that indicates the differences among study's groups, was suggested to be less than 0. 05 in this study.

The studies of Alfonso L. & Ana. R et al., was similar to our samples study illustrated that diagnostic accuracy CT were in all (76%) cases since the majority of relevant CT scan changes developed within 24houres. In all patients cranial CT was performed during the first 24 h after the trauma, followed by control CT, in order to detect the development of new lesions or changes in the pre-existing ones. CT findings were classified according to the classification of Marshall et al. While in MRI finding were Cortical 39 (81%) Basal 7 (15%) Tentorial 2 (4%), whilst in our result, CT identified radiographic TBI in were true positive diagnostic accuracy (60%) while missed diagnostic were 40case. This could be due to the fact that IVH is clearly associated with the presence of lesions related to DAI in the corpus callosum. (i. e. grade II DAI). In MRI were true positive diagnostic accuracy (92%) while missed in 8 cases.

Marta C., Ana C. L. at el., MRI is a very sensitive technique for diagnosing DAI in severe TBI. For proper diagnosis, we recommend performing a conventional MRI in the sub-acute phase (within the first 4 weeks of the trauma) that includes at least T1, T2, FLAIR and gradient echo sequences in the different slice planes.

Lagares A, Ramos A, et al., illustrated in their survey that the prognostic capability of MRI is similar in patients with DAI to that in the whole series. It would be useful to establish the risk of an individual patient presenting with DAI in relation to different clinical variables in order to determine which patients would benefit from being studied with MRI. It seems clear that the mechanism of trauma, the level of consciousness and the presence of intra ventricular hemorrhage are predictive factors of the presence of DAI-related lesions in MRI. This fact is also observed in our short series. MRI might be able to detect in which patients this score is due to a traumatic lesion especially in non-hemorrhagic lesions sensitivity 87. 3% and Specificity 97. 8%.

Yet, in the majority of studies MRI was performed at a later stage of the evolution of head injury and on the other hand in the majority of cases MRI sequences that are very sensitive to hemorrhagic DAI were not performed, such as gradient echo T2. Aguas J, Begue R. et al. This fact explains the low frequency of hemorrhagic DAI in the majority of studies and the association of non-hemorrhagic DAI with a good prognosis. Firsching et al. have been shown the use of MRI as a prognostic tool in the acute trauma

scenario and have added a new classification of findings with this technique. However, their results have not been replicated by other authors. From the point of view of the use of cranial MRI as a prognostic tool through month, in our series, the study of the regression analysis models and ROC curves demonstrate that MRI is superior to CT.

Our results suggested that fast MRI and following up instead CT is a reasonable alternative to CT with the potential to eliminate ionizing radiation exposure for thousands of children each year. The ability to complete imaging in ~6 minutes, without the need for anesthesia or sedation, suggests that fast MRI is appropriate even in acute settings, where patient throughput is a priority that gave us good diagnose when CT missed small bleeding and DAI in children. While Daniel M. Lindberg, MD, used Fast MRI sequences included 3T axial and sagittal T2 single-shot turbo spin echo, axial T1, axial fluid-attenuated inversion recovery, axial T2*, and axial diffusion-weighted imaging, viewed the availability of a low-risk imaging modality sensitive to changes in the brain parenchyma could advance brain injury research by allowing serial imaging for young children with mild, moderate and severe TBI. This could improve understanding of the physiologic processes underlying "secondary brain injury," where in tissue damage continues after the initial trauma. Although the sensitivity of fast MRI did not meet our prespecified threshold, accuracy may be decreased with 1. 5T scanners, we feel that the benefit of avoiding radiation exposure outweighs the concern for missed injury. No dose of radiation is completely safe, and median radiation exposure from head CT for children,6,10 years old is ~2. 6 mSV, equivalent to several months of background radiation. Brenner DJ, et al., Miglioretti DL, Johnson E, Williams A.,et al. Numerous research articles have been published on new MRI sequences, such as susceptibility-weighted imaging (SWI), diffusion-tensor MRI or tractography, to improve DAI diagnosis and its potential link to TBI prognosis, K. G. Moen et al., Nevertheless, these sequences are more complex than conventional sequences and result in increased time and costs in such clinically unstable critical patients.

The GRE and T2 sequences were the most likely to identify radiographic TBI. It could be more important in MRI center of emergency department, with higher rates of ischemia or cytotoxic edema, which often develops in the sub-acute phase of injury. These data stand in distinction to 2 studies concluding that MRI was insensitive for TBI. Kralik SF, et al., 2017. Ryan ME, et al., 2016. We identified 3 potential reasons for the difference. First, our MRI protocol included GRE sequences, which are sensitive for blood products. Young et al, who also used GRE sequences, found comparable sensitivity for CT and fast MRI for all injuries except skull fractures. Second, our study was performed at emergency department hospital with technologists who was experienced in performing unseated examinations in young and children patients. Finally, One previous study of fast MRI feasibility suggested that fast MRI resulted in longer imaging delays and increased length of stay. Given the short imaging time, we feel that these parameters are likely to be related to scanner availability and transport times. Because all participants underwent clinical CT before enrollment, we cannot directly test whether MRI increased ED length of stay. Software enhancements can improve MRI speed and feasibility even further. Decreased imaging time improves clinical accuracy and may improve image quality by decreasing opportunities for motion. These data are subject to important limitation.

Imaging duration was significantly longer (~8minutes) for fast MRI than for CT, and this did not include the time needed for MRI screening, transport, positioning, substitution of MRI-compatible equipment, and immobilization, each of which can affect MRI availability and the time a patient is away from medical supervision. We feel that all these delays will be most significant for patients with severe TBI, or polytrauma, who are more likely to require emergent interventions or complex medical equipment. There is a risk that a feasible, low-risk imaging alternative may inappropriately increase imaging use. Even without the risks of radiation, avoidable imaging still results in unnecessary cost and may identify worrisome but clinically irrelevant incidental findings. We recommend using the PECARN rule, coupled in some cases with a reasonable period of observation, to identify children at low risk of clinically significant brain injury, for whom any imaging (CT or MRI) can safely be avoided, Kuppermann N, et al., and Nigrovic LE, et al.

Subjectively, radiologists felt that identification of skull fractures became easier over time with experience comparing CT with fast MRI. We recommend that fast MRI implementation begin with children who require repeat imaging for TBI identified by CT to provide a training period in which traumatic injuries can be compared on the 2 modalities. Image quality varied between scans, especially because more than half of CT scans were performed at various outside institutions, and only 28% of these had three-dimensional reformatting for skull films. This could have artificially increased the measured accuracy of MRI if CT motion produced false-negative CT scan results. Imaging time and accuracy will be affected by willingness to repeat MRI sequences affected by motion.

We excluded patients with clinically unstable injuries to ensure patient safety and informed consent. The large proportion of participants with significant delays due to transfer from other institutions further biased toward clinical stability. Therefore, our results cannot be generalized to clinically unstable injuries. Longer imaging time and the need for other CT imaging are also relative contraindications to using MRI in unstable patients, although clinically unstable injuries, especially those with mass effect, are more likely to be radio graphically apparent. Finally, it is possible that imaging findings changed in the interval between CT and MRI. Although our interval was relatively short, it is possible that some findings became more or less apparent if pathologic blood was redistributed between imaging studies.

The major limitation of our study is that it has been performed in a selected series of patients. The mortality in this group of patients is extremely low compared with that of general series of severe and moderate head injury patients so that generalizations of our results have to be taken with reservations. However, we have tried to perform MRI as soon as possible during the evolution of our patients, as well as recording other clinical and radiological data related to prognosis in these patients. This work is the largest series to our knowledge comparing the information provided by traditional prognostic factors and that from conventional MRI.

6. Conclusion

MRI is a reasonable alternative to CT to identify radiographically evident TBI in clinically stable patients. MRI is a very sensitive technique for diagnosing DAI in moderate and severe TBI. For proper diagnosis, we recommend performing a conventional MRI in the sub-acute phase (within the first 4 weeks of the trauma) that includes at least T1, T2, FLAIR and gradient echo sequences in the different slice planes that reduces study time in order to be able to complete an MRI in patients with TBI.

Conflict Of Interest

There is no conflict of interest.

Funding

Not Applicable

Data Availability

Data would be available upon reasonable request by corresponding author.

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