Risk Factors For Positive CT In Head Injured Patients

With Admission GCS 15

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CERTIFICATE

This is to certify that this dissertation titled **"Risk factors for positive CT in head injured patients with admission GCS 15"** is an original bonafide work conducted by **Dr.S.Senthil babu** at Madurai Medical College & GRH, Madurai under my guidance and supervision.

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CONTENTS

INTRODUCTION

Head injury remains one of the most common reasons for seeking medical attention after injury. Admissions due to head injuries constitute a third of all trauma admissions. Mild head injury constitutes nearly about 70% to 85% of patients with head injuries[3,8,11,24,27,40].

The term mild, or minor head injury is defined as a subset of closed head injury ranging from simple scalp lacerations or contusions without brain involvement to those incurring a loss of consciousness. Mild Traumatic Brain Injury Committee of Head Injury Interdisciplinary Special Interest Group of the ***American Congress of Rehabilitation Medicine*** [1993] defined mild traumatic brain injury as follows:

A patient with mild traumatic brain injury is a person who has had a traumatically induced physiological disruption of brain function as manifested by at least one of the following:

I. any period of loss of consciousness.
II. any loss of memory for the events immediately before or after the accident.
III. any alteration in mental state at the time of the accident [e.g., feeling dazed, disoriented, or confused]
IV. focal neurological deficit(s) that may or may not be transient but where the severity of the injury does not exceed the following:
    a. loss of consciousness of approximately 30 minutes or less.
    b. after 30 minutes, an initial Glasgow coma scale [GCS] of 13-15; and post-traumatic amnesia [PTA] not greater than 24 hours.

Servadei et al [34] had classified mild head injury as

a. ***Low risk mild head injury*** - are those with GCS score of 15 and without a history of loss of consciousness, amnesia, vomiting or diffuse headache.

b. ***Medium risk mild head injury*** – are those who have GCS 15 and one or more of the following symptoms of loss of consciousness, amnesia, vomiting or diffuse headache.

c. ***High risk mild head injury*** – are those with an admission GCS of 14 or 15 with a skull fracture and /or neurological deficits.

New Italian Guideline[45] have graded mild head injury in four groups.

a. ***Group 0*** – patients with GCS 15 who do not have clinical features such as loss of consciousness (LOC), post traumatic amnesia [PTA] headache or vomiting. No *risk factors* such as co-agulopathies, alcoholism, drug abuse, epilepsy, previous neurological treatment or disabled elderly patients should be present.

b. ***Group 1*** – included patients with GCS 15. The patients presented one or more clinical features (LOC, PTA, headache, vomiting). No *risk factors* mentioned above should be present.

c. ***Group 2*** – included patients with GCS 14 with or without clinical features (LOC, PTA, headache, vomiting) and with or without *risk factors*.

d. ***Group O1-R*** – included patients with GCS 15 with or without clinical features (LOC, PTA, headache, vomiting) but with one or more of the *risk factors*.

Mild head injury constitutes nearly 70% to 85% of patients with head injuries [3,8,16,24,27,38,40].

They require only minimal medical attention. However, a small number will deteriorate, develop neurological sequelae[5,10,33,46] and/or require neurosurgical intervention owing to intracranial complications.

Computed tomography (CT) scanning of the head is an excellent imaging modality to identify acute intracranial injury and to identify those patients requiring neurosurgical intervention[4,7]. Increased CT scan availability and sensitivity has led to increased utilization. Use of this imaging modality may offer a cost effective and safe substitute for hospital admission, observation and discharge.

It's a challenge to a clinician to determine which patients with head injury are at risk for intracranial injury and who may benefit from head CT scanning. There is a general agreement that the patients with penetrating skull injury, depressed skull fracture, altered level of consciousness or new focal abnormalities on physical exam should undergo head CT scanning. It is less clear which patients presenting with normal neurological examinations are at risk of intracranial injury.

A certain percentage of patients with seemingly "mild" head injury who present with no or minimal disturbance in consciousness subsequently deteriorate. Incidence of this phenomenon, often referred to as "talk and deteriorate" have been reported to between 1.0% to 3.0% of those initially diagnosed as having mild head injury[13].

Moreover, the management of mild head injuries is controversial in all its aspects. This is due to difference of populations and resources available in addition to different medicolegal aspects in dealing with such cases.

The incidence of abnormal CT findings in mild head injuries varies in various reports ranging from 5% to 28%[14,16-17,19,21,23,37-41,44] of which 0.76% to 8.57% required surgical interventions[2,5,19,37]. There are reports of incidences of positive CT findings ranging from 14% to 83% in pediatric population[18,22,26,29,30,36,47] of which 1.6% to 56% required surgery[18,29].

The consequences of positive CT scan in patients with mild head injury are varied

1. Management may be altered
2. Hospital stay is prolonged
3. Medicolegal aspects
    a. Positive CT scan converts a simple injury into a grievous one
    b. Discharging a patient without subjecting to CT scanning and found to have CT scan positive subsequently may result in risk of litigation especially in this consumer era.

Various predictors of positive CT scans in mild head injured patients including the demographic data, historical data, physical examination data and radiological data were extensively reported and analysed and various guidelines were proposed by several authors to aid the clinician to select patients for subjecting to CT scan in mild head injuries[1,3,4,7,9,11,13,18,19,21,23,24,26,27,29,30,35,37-41,47].

REVIEW OF THE LITERATURE

Of all brain injured hospitalized patients, those with mild head injury predominate, constituting 70-85% of the group.

Controversy surrounds the appropriate diagnostic algorithm for trauma patients with head injury, with GCS score of 15. Because these patients are so common, they constitute a significant economic, public health and medico legal dilemma. Most physicians rely on clinical criteria such as GCS score, loss of consciousness, mode of injury, changes in mental status to predict the probability of intracranial lesion[1,3,4,7,11,18,19,21,23,24,26,27,30,35-41]. However some studies have demonstrated that normal neurological examination does not reliably rule out intracranial lesions[28].

CT scanning is a sensitive imaging modality that reliably detects intracranial abnormalities. This had led some authors to recommend liberal use of CT scanning in patients with a GCS score 15 or a history of significant mechanism of injury[2-4,8,11,13,16,21-24,26,27,29,35-39,44,47].

Despite more than two decades of debate and study, the optimal evaluation of patients with MHI remains controversial. Computed tomography has become the mainstay in the diagnostic work up of the trauma patients, with mild head injury. Previous recommendations have taken one of four approaches. Most authors recommend CT of the head for every patient with blunt head trauma and a history of loss of consciousness or amnesia despite a normal mental status on admission [8,16,17,35,37,38]. Other authors prefer to observe these patients because the yield of abnormal CT results is low. A third group recommends CT for only selected patients in an attempt to reduce the number of negative studies. A final group recommends a combination of CT and observation[8,16,17].

However, it is a challenge to a clinician to determine which patients with mild head injury are at risk for intracranial injury and who may benefit from the head CT scanning. There is a general agreement that the patients with penetrating skull injury, depressed skull fracture, altered level of consciousness (reduced GCS score) or new focal abnormalities should undergo head CT scanning. It is less clear which patients presenting with normal neurological examinations are at risk of intracranial injury.

Despite the controversies, all the authors agree that there is a definite incidence of intracranial injury, as interpreted as positive CT scan in MHI patients and also certain percentage of them required surgical intervention and many of them have proposed various clinical and radiological predictors of intracranial injury in mild head injury patients.

Many studies have exclusively dealt with mild head injured pediatric patients because of the anatomical and physiological differences in the brain of pediatric population when compared with adult population viz., the large subdural spaces, disproportionately large head, incompletely myelinated brain and open sutures and fontanels make pediatric population highly susceptible to vascular and parenchymal injury from motion of the brain during rapid acceleration and deceleration of the head[7].

Haydel et al (2000)[11] in the 1st phase of a prospective study of 520 consecutive patients who had minor head injury (patients with GCS 15 normal neurological examination with loss of consciousness) noted that 6.9% had positive scans. Using recursive partitioning they derived a set of seven factors which identified all patients who had positive CT brain they were headache, vomiting, an age over 60 years, drug or alcohol, intoxication, deficits in short term memory. Physical evidence of trauma above clavicle and seizure. In the second phase of 909 patients 6.3% had positive scans, the sensitivity of the seven findings combined was 100% (95% confidence interval, 95-100%). All patients with positive CT scans had at least one of the finding. They concluded that for the evaluation of patients with minor head injury, the use of CT can be safely limited to those who have certain clinical findings.

Lee et al (1995)[15] in their prospective study included a series of 1812 consecutive mild head injured adult patients (patients of age more than 16years with GCS 15 with one or more of the following – a blow to the head, loss of consciousness, or post-traumatic amnesia of the less than 30 minutes in duration), 1.5% deteriorated after head injury, 1.3% required surgical intervention, 3% deteriorated due to non-surgical causes (post-traumatic seizure, syndrome of inappropriate secretion of anti diuretic hormone). 57% of deterioration occurred during the first 24 hours after injury. Age over 60, presence of drowsiness, focal motor weakness, post-traumatic headache and vomiting has increased risk of deterioration.

Vilke et al (2000)[44] in their prospective study enrolled non penetrating head trauma patients of age more than 14years with GCS score of 15 and with history of loss of consciousness. Of the 58 patients included in the study 5% had positive CT findings, only one patient underwent neurosurgical intervention. They concluded that significant brain injury and need for CT scanning cannot be excluded in patients with minor head injury despite a GCS score of 15 and normal complete neurological examination on presentation.

Nagy et al (1999)[24], in their prospective study of 1170 patients who had GCS score of 15 with loss of consciousness, detected 3.3% abnormal CT findings. In their study 1.8% had changes in therapy as a direct result of their CT results, including 4 operative procedures. No patient with a negative CT results deteriorated during the subsequent observation period. They concluded that CT was a useful test in patients with mild head injury, because it may lead to a change in therapy in a small but significant number of patients and subsequent hospital observation adds nothing to the CT results and is not necessary in patients with isolated minimal head injury.

Ibanez et al (2004)[12] in a prospective study enrolled 1101 patients analysed the risk factor in mild head injury (GCS 14, 15 with or without LOC. Age >14). The incidence of intracranial lesions was 7.5% and 1% underwent neurosurgical intervention. The head injury related mortality rate in this series was 0.4%. A Glasgow coma scale score of 14, loss of consciousness, vomiting, headache, signs of basilar skull fracture, neurological deficit, co-agulopathies, hydrocephalus treated with shunt insertion, associated extra cranial lesions, and patient age greater than 65 years were identified as independent risk factors but failed to achieve 100% sensitivity in the detection of all patients with CT scans positive for intracranial lesions within specificity limits. They concluded that clinical variables are insufficient to predict all cases of intracranial lesions following mild head injury.

Dunning et al (2004)[6] performed a meta analysis of the literature to assess the significance of factors for prediction of intracranial haemorrhage. The literature was searched using MEDLINE, EMBASE and thirty five papers containing 83,636 patients were included in the meta analysis. Relative risk ratios were calculated for 23 clinical correlates form the history, mechanism of injury and the examination. The results of meta analysis showed. Eight factors in clinical history (severe headache, nausea, vomiting, loss of consciousness, amnesia, post traumatic seizure, pensionable age, male gender), two factors from mode of injury (pedestrians, fall), six variables in clinical examination and investigations (skull fracture, GCS<15, focal neurological deficit, base of skull fracture, other significant trauma, evidence of alcohol intake) were found to significantly increase the risk of intracranial injury.

Thiruppathy et al[43] in a prospective study included consecutively admitted 381 patients with mild head injury (defined as patients with GCS 13-15). Thirty eight percent of the patients had positive findings on CT brain. Seven percent of patients required surgical intervention. six percent showed neurological deterioration. There was one death in this series. Admission GCS score, focal neurological deficits and fractures detected by skull radiography were found to be statistically significant predictors of positive findings on CT.

Viola et al[45] included a consecutive series of 4536 adult minor head injury patients who were graded in to four groups according to guidelines worked out by Italian Society of Neurosurgery. Group O had one positive CT brain, Group I had 10% positive CT scan, Group II had 62% abnormal CT brain, Group O-1R had 25% abnormal CT scan. No patients were operated in Group O, 0.33% were operated in Group I, 12.5% were operated in Group 2, 2.1% operated on Group O-1R.

PEDIATRIC HEAD INJURY

Wang et al (2000)[47] in a population based multi-center, prospective study of pediatric trauma patients with mild alterations in consciousness (GCS 13-14), reported an incidence of 27.4% abnormal CT scans and 3.7% required surgical intervention in a selected group of patients and concluded that great majority of this patients will not require operative intervention, but the implications of missing these hemorrhages can be severe for this sub group of head injured patients. Because clinical criteria and cranial X-rays are poor predictors of intracranial hemorrhage, it was recommended that all children with a GCS score as 13 and 14 routinely undergo screening via computer tomography.

Simon et al (2001)[36], in their retrospective study of selected pediatric population noted an incidence of 14% as positive CT scan and 0.70% of the study group underwent surgical intervention and concluded that a normal neurologic exam and maintenance of consciousness does not preclude significant rates of intracranial injury in pediatric trauma patients. Contrary to convention, neither LOC nor mild altered mentation was a sensitive indicator to select patients for CT scanning. Skull fractures and superficial craniofacial injuries were similarly unreliable. Identification of these patients was important for the occasional case requiring intervention and for the tracking of complications. A liberal policy of CT scanning was warranted for pediatric patients with a high-risk mechanism of injury despite maintenance of normal neurologic status in the field and at hospital screening.

Schutzman et al (2001)[30], proposed various guidelines for evaluation and management of children younger than 2 years old with apparently minor head trauma but concluded that the effect of the proposed guidelines on clinical outcomes and resource utilization should be evaluated.

Schunk et al (1996)[29], in their retrospective analysis of the utility of head computed tomographic scanning in pediatric patients with normal neurologic examination in the emergency department, reported an incidence <5% and need for neurosurgical intervention in 1% of the cases and concluded that commonly used clinical variables viz., sleepiness, vomiting, headache, LOC, irritability, amnesia and seizures, were not associated with intracranial injuries in these children.

Aikten et al (1998)[1], in their survey of current management practices of pediatricians, emergency physicians and family physicians of minor pediatric head trauma concluded that most physicians chose clinic or home observation for initial management, and clinical management was more varied when patients had sustained either loss of consciousness or seizures and suggested further study of the appropriate management of head trauma in children needed to guide physicians in their case.

Rattan et al (2001)[26], in their prospective, selective study of pediatric head injured patients, concluded that while a significant association was found between the duration of consciousness and GCS, but no significant association of either of these variable with CT scan findings was noted.

Murshid (1998)[23], in his retrospective review of selective cases concluded that the indications for CT scan were, an abnormal GCS, presence of neurological deficit, signs of suspicion of basal or depressed fracture and persistent or progressive head ache or vomiting and recommended that infants with minor head injuries should be followed up atleast once after 2-3 months for possible growing fractures.

Moran et al (1993)[21], reported an incidence of 8.3% positive scan in their prospective, selective population and concluded that LOC and skull fracture are independent predictors of positive cerebral CT scans and recommended immediate CT scan in all minor head injury patients with LOC or a suspected skull fracture, to optimize the outcome of those needing surgical intervention and those patients without LOC and GCS score of 13-15 do not require CT scanning unless otherwise clinically indicated.

Inamasu et al (2000)[13] in their retrospective study, reported an incidence of 0.5% deterioration of mild head injured patients and concluded that, although routine use of CT scans in patients with mild head injury has been controversial, CT scans should be taken if patients have experienced transient LOC to prevent or reduce the occurrence of deterioration in the emergency department.

Borzuck (1994)[2] in his retrospective descriptive study reported an incidence of 8.2% of abnormal CT scan and 0.76% neurosurgical intervention and concluded that abnormalities on

CT scans in patients with mild head trauma are fairly common, although the need for neurosurgical intervention was rare. Clinical decision rules can be used to identify these patients with more serious intracranial pathology and recommended such strategies should be validated prospectively in various emergency department settings. He also defined that, loss of consciousness (LOC) was a difficult variable to quantify because, qualified witness was usually not available. Instead, LOC was coded as questionable LOC, brief LOC of several seconds, or LOC of a minute or more.

Mikhail et al (1992)[19], in their prospective study of 35 selected patients reported, 22.86% incidence of intracranial injury and 8.57% required surgery. One patient died following surgery and concluded that intracranial injury does exist in patients suffering from minor head trauma with a GCS score of 13 or above and further, age over 40 years and complaint of headache were associated with an increased risk of intracranial injury.

Stein et al (1993)[39] in their retrospective study reported an incidence of 18.4% intracranial lesions and 5.5% requirement of surgery and recommended that any patient, who had suffered a loss of consciousness or amnesia following head injury have an urgent cranial CT scan.

Stiell et al[40], in their article on Canadian CT head rule study for patients with head injury for phase I (derivation), enumerated the methodologic standards for derivation as clinical decision rules as follows:-

1. The outcome or diagnosis to be predicted must be clearly defined and assessment should be made in a blinded fashion.
2. The clinical findings to be used as predictors must be clearly defined and standardized and their assessment must be done without knowledge of outcome.

3. The reliability or reproducibility of the predictor findings must be demonstrated.
4. The subjects in the study should be selected without bias and should represent a wide spectrum of characteristics to increase generalizability.
5. The mathematical techniques for deriving the rules must be identified.
6. Decision rules should be clinically sensible: have a clear purpose, be relevant, demonstrate content validity, be concise and be easy to use in the intended clinical application.
7. The accuracy of the decision rule in classifying patients with (sensitivity) and without (specificity) the targeted outcome should be demonstrated.

And the patients were assessed in a standardized manner with different variables from history, neurologic examination and general examination or diagnostic tests.

And in their subsequent article on methodology for phase II (validation and economic analysis)[41], recommended that CT head scan is only required for patients with minor head injury with any of the following findings:

High – risk (for neurological interventions)

a. GCS score <15 at 2 hours after injury.
b. Suspected open or depressed skull fracture.
c. Any sign of basal skull fracture (haemotympanum, “racoon” eyes, CSF otorrhea/rhinorrhea, battle’s sign).
d. Vomiting ≥ 2 episodes
e. Age ≥ 65 years.

Medium risk (for brain injury on CT scan)

1. Retrograde amnesia ≥ 30 minutes.
2. Dangerous mechanism (pedestrian struck by motor vehicle, occupant ejection from motor vehicle, fall from elevation ≥ 3 feet or 5 stairs).

Because history, physical examination and demographic data are unreliable in predicting those patients with intracranial pathology, some additional radiological study is needed to make the diagnosis of positive CT scan. Plain skull X-rays have been advocated as useful to triage patients for further investigation or admission[25,31,32].

ROLE OF XRAY

Servadei et al (1997,1998)[31,32] in their prospective CT study in a series of 98 patients found significantly more intracranial lesions in those with a fracture[19] than those without[3] and 6 patients underwent operations and concluded that head injured patients with a skull fracture should undergo CT scanning to enable early detection of an intracranial haematoma.

Feurman et al (1998)[8], in their retrospective, review, recommended that a head CT scan be obtained on all patients with Glasgow coma scale score of <15, abnormal mental status, or hemispheric neurological deficits. If no operative lesion is found on the CT scan, the patient should be admitted for observation because there is still a risk of deterioration. Those with a GCS score of 15, a normal mental status and no hemispheric neurological deficit may be discharged, to be observed at home by a competent observer despite basilar or calvarial skull fracture, loss of consciousness or cranial nerve deficit. No benefit was gained from skull radiography in any group.

Rosenorn et al (1991)[28], concluded that the incidence of intracranial complications in patients without and with skull X-ray, with or without fracture does not differ significantly and in these circumstances, they do not find any justification for routine skull X-ray after mild head trauma. Furthermore, it has been found that approximately 25% of all acute skull X-ray films were of unsatisfactory quality.

Mandra et al (2000)[18], in their retrospective review of selective pediatric population identified intracranial pathology on CT examination in 83% of their selective population and 56% requirements of neurosurgical procedures. They concluded that skull X-ray examination was not sufficient to rule out intracranial haematoma and recommended CT scanning and admission to hospital for 24-hrs observation for all children with minor head injury, because of the risk of delayed haematoma.

VALUE OF NORMAL CT

The value of computerized tomographic scans in patients with mild head injuries, irrespective of whether the CT scan is positive or negative for intracranial injury is discussed by many others.

Stein et al (1992)[38] in their retrospective review of 1538 patients reported that in 17.2% of patients abnormalities were seen on initial CT scan and 3.77% required surgery. In patients with a GCS score of 13, 40% had abnormalities on the CT scan and 10% required surgery. None of the 1334 patients with normal CT scans on admission showed subsequent deterioration and none needed surgery. These figures suggested that history and physical examination alone are not adequate to assess head injury or severity of risk patients with normal CT scans should be considered for observation at home, allowing hospital personnel to devote full attention to the more seriously injured patients.

Livingston et al in their prospective, consecutive study (2000)[17], and retrospective analysis (1991)[16], concluded that patients with a cranial CT scan, obtained on a helical CT scanner that shows no intracerebral injury and who do not have other body system injuries or a persistence of any neurologic finding can be safely discharged from the emergency department without a period of either inpatient or outpatient observation.

Shackford et al (1992)[35] in their retrospective study derived the following implications from their retrospective data.

1. A CT scan is recommended for all patients with a MHI because one in five will have an acute lesion detectable by the scan.
2. A CT scan should be mandatory for a patient with a MHI and a GCS score of 13, since one in three will have an acute lesion and one in ten will require craniotomy.
3. Patients with a MHI and abnormal results on neurological examination should be admitted since one in five will require some form of treatment.
4. Patients with a MHI and positive findings on CT scan should be admitted because one in four will require treatment.
5. Patients with a MHI who have abnormal results in neurological examination and positive findings on CT scan should be admitted to an ICU, since two of five will require treatment and one in four will require either ICP monitoring or craniotomy.
6. Patients with a MHI who have normal results on neurological examination and negative findings on a CT scan have very small risk of requiring treatment (one in 50) and no risk of requiring craniotomy.
7. Admission to hospital does not guarantee skilled neurologic observation.
8. Patients with a MHI who have normal results on neurological examination and negative

findings on a CT scan can be discharged from the emergency room, provided there is a mechanism for follow up.

They concluded that, their retrospective study provided sufficient data to justify a prospective, randomized study of the clinical utility and cost of CT scanning and selective discharge of patients with isolated minor head injury.

AIMS OF THE STUDY

1. To define the incidence of positive CT brain in head injured patients with GCS score 15.

2. To identify the risk factors / predictors of positive CT brain in head injured patients with admission GCS score 15.

3. To evaluate necessary neurosurgical intervention.

4. To analyse the outcome of head injury patients with GCS score 15.

PATIENTS AND METHODS

Hospital set up

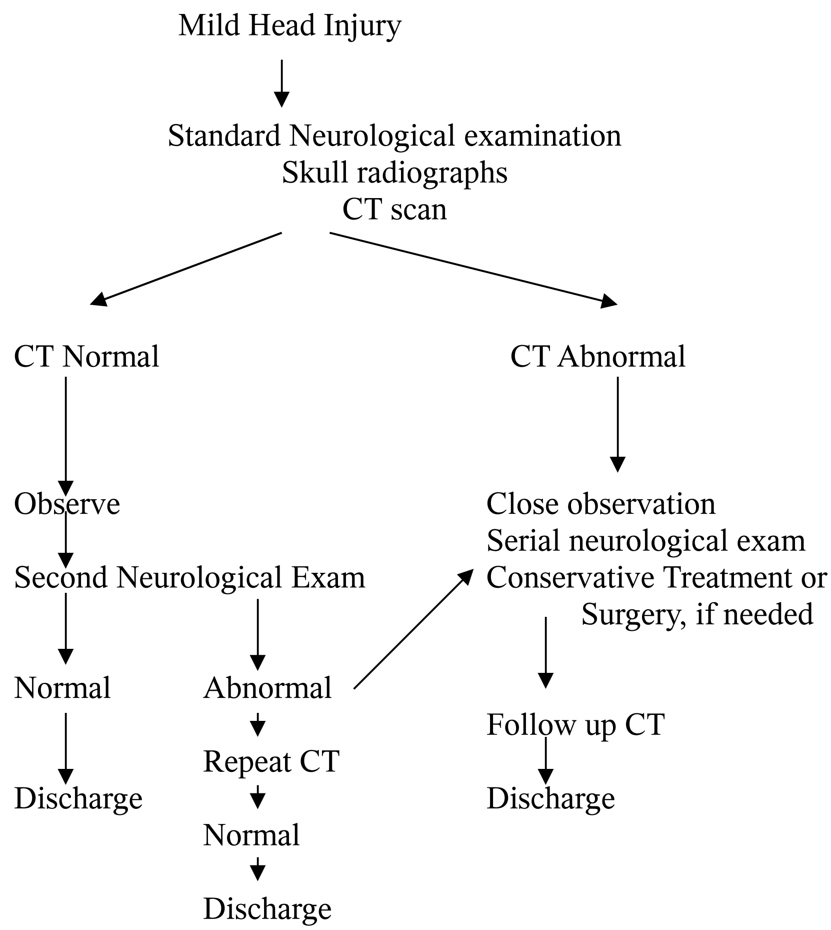
Our hospital Government Rajaji Hospital is a tertiary referral hospital for south Tamilnadu. Admission include both referral cases and direct admissions from our casualty. In our head injury ward all isolated head injury cases as well as polytrauma cases with predominant head injury are admitted through the casualty by the casualty medical officer directly. All cases are entered in the accident register and were treated as medico legal cases.

Admission to the head injury ward is entirely at the discretion of Casualty Medical Officer.

All cases were examined by the duty neurosurgery residents and by the duty neurosurgeon who are on stay duty round the clock. Poly trauma will be dealt by respective specialists on call.

Management protocol

The following is the management protocol we follow for mild head injury patients:



Study pattern

Ours is a prospective study which enrolled consecutively admitted patients in our head injury ward. All patients were subjected to CT scanning without any historical or clinical selection criteria. Our study included patients in all age group.

Exclusion criteria

1. Patients who were admitted in head injury ward 24 hours after the occurrence of injury.
2. Patients referred with CT brain from outside our institution.
3. Patients with Glascow coma scale less than 15

Reasons for this exclusion criteria were

Patients who were admitted after 24hrs of the occurrence of injury are referred for the persistent symptoms or neurological illness they had and most of them had positive CT brain. Patients who were referred with CT brain done at outside institution frequently had positive CT, as both these factors will artificially inflate the total number of positive CT scans and vitiate our study.

Inclusion criteria

All patients with GCS score of 15 irrespective of age, mode of injury who were admitted in our head injury unit.

Criteria for CT scan

All patients were subjected to CT brain without any selection criteria.

Operational definitions

Positive CT scan	One that demonstrated any of the following[35] a. Extradural haematoma b. Subdural haematoma c. Subarachnoid haemorrhage d. Intracerebral haematoma e. Intraventricular haemorrhage f. Pneumocephalus g. Contusion h. Linear or depressed fractures i. Basilar fracture
Negative CT scan	If there is no acute injury to the cranium and for brain[35].

History of loss of consciousness (LOC)	Patient who were amnestic of the trauma event, gave a history of LOC or had a witnessed LOC were considered to have a positive LOC[21].
Scalp injury	Defined as trauma above the clavicle and includes the lesions such as abrasions and even small lacerations[2] and signs of facial or skull fracture[11].
Focal neurological deficit (FND)	Defined as unequal or asymmetrically reactive pupils, nystagmus, other abnormal eye movements, focal extremity weakness or Babinski's reflex, any cranial nerve involvement[2].
Seizure	Suspected or witnessed seizure after the traumatic event[11].
Associated polytrauma	Thoracic, abdominal, spinal cord injury or facial / limb fracture[12].
X-ray skull finding	Linear or depressed fracture visualized in Xray skull.
Vomiting	Any emesis after the traumatic event[11].

The Interpretation of a CT scan as Positive or Negative scan was defined as follows[35]

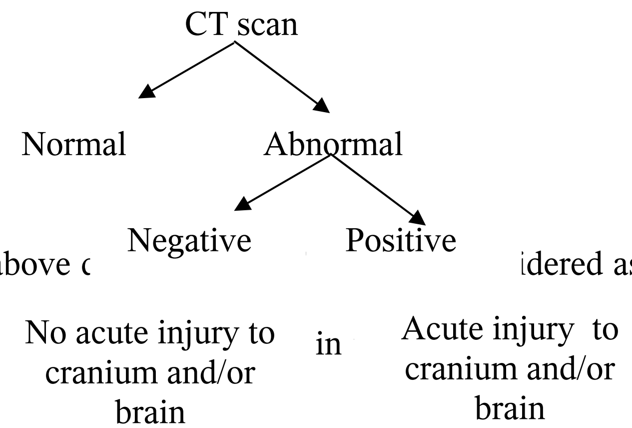
Abnormal scan

One that showed any acute or chronic pathologic state or abnormality (an old infarct, extra cranial soft tissue swelling, a facial fracture).

Positive scan

One that demonstrated an acute pathologic state in the skull or brain (a basilar or linear skull fracture, cerebral contusion etc).

skull fractures only.



From the above c idered as a positive scan as that one that demonstrated an in asilar or linear skull fracture, cerebral contusio

A CT scan was interpreted as negative scan if there was no acute injury to the cranium and /or brain.

The following factors were studied and analysed descriptively and statistically, whether they could prove as positive predictive factors / risk factors:

I. ***Demographic data***

   a. Age

   b. Sex

   c. Mode of injury

II. ***Historical data***

   a. Loss of consciousness

   b. Post traumatic seizure

   c. Ear/nose/ oral bleed

   d. Vomiting

III. Physical examination data

a. Scalp injury

b. Associated polytrauma

c. Focal neurological deficit

IV. Radiological data

a. Skull X-rays

Following were the intervention and outcome profiles studied and analysed

a. Surgical interventions.

b. Length of hospital stay.

c. Late complications.

d. Deterioration.

e. Discharge GCS score.

f. Residual neurological deficit.

g. Systemic vegetative symptoms.

h. Death.

Statistical analysis

Numerical data were analysed using simple statistical methods like *percentages, mean and range*.

When the numerical data was involved in comparing between the two groups of patients *Chi square test* was used to identify the significant risk factors. These significant risk factors were further subjected for comparison by using multivariate statistical analysis methods:

i. Logistic regression analysis

ii. Recursive partitioning analysis

In addition both significant and insignificant factors were analysed for the following:

a. *Sensitivity (positivity in disease).*

b. *Specificity (negativity in health).*

c. *Predictive value of positive CT.*

d. *Predictive value of negative CT.*

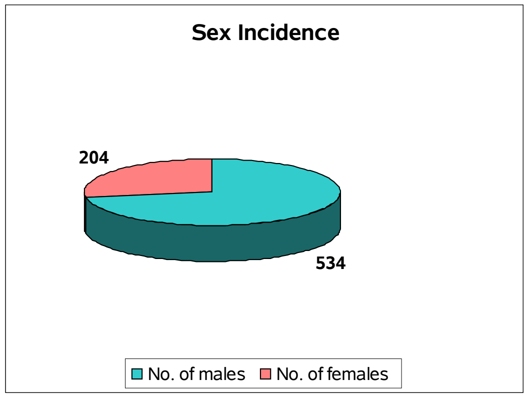
e. *Likelihood ratio of having disease for a positive CT result.*

RESULTS

Demographic profile

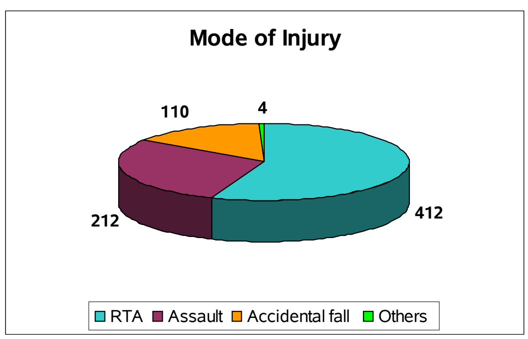
The following were the constituents of our study population.

Sex incidence



No. of males	534 (72.4%)
No. of females	204 (27.6%)

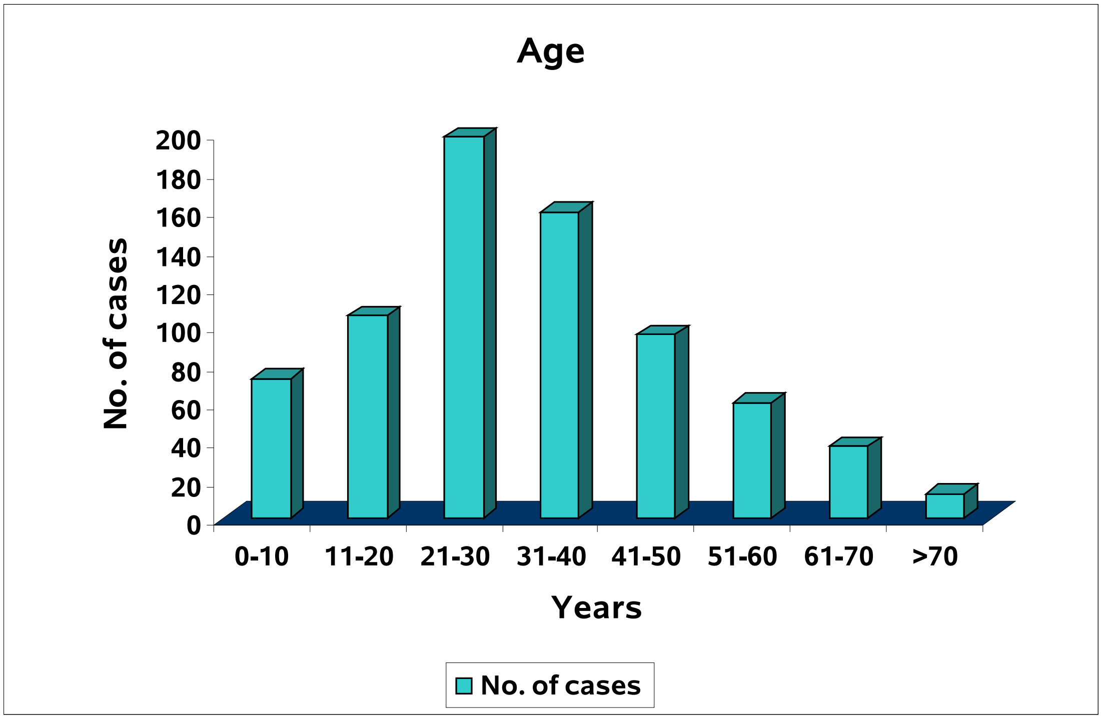
Mode of injury



RTA	412(55.8%)
Assault	212(28.7%)
Accidental fall	110(15%)
Others	4(0.005%)

Age

The patient group involved in the study group ranged from 4 months to 80 yrs. Average age is 33.5 years.

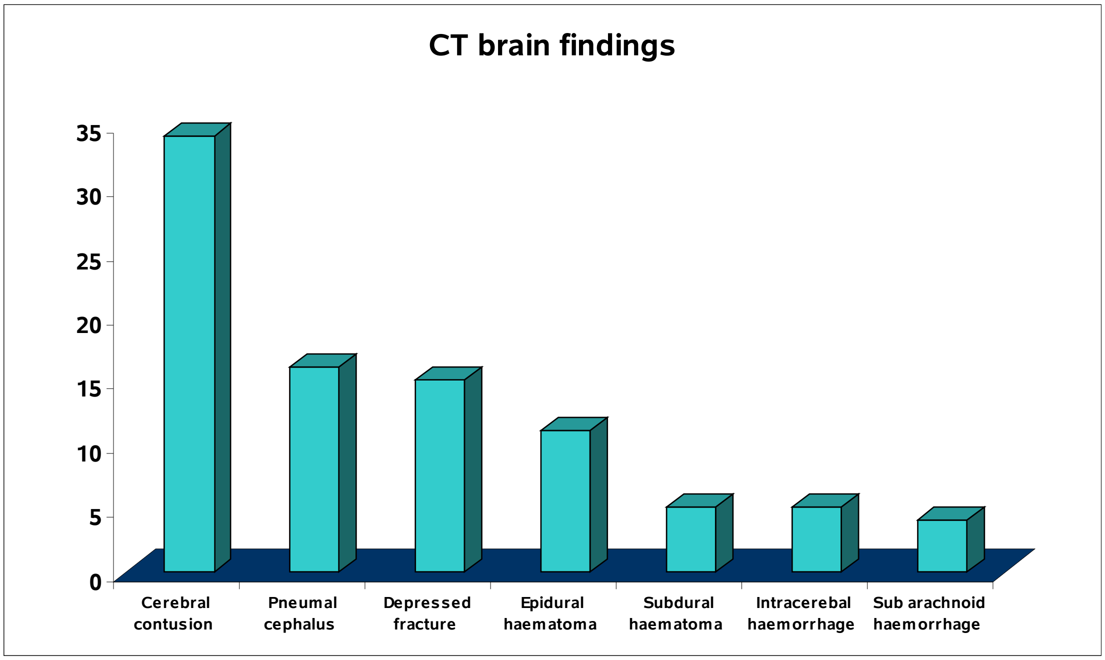


Age	No. of cases
0-10	72 (10%)
11-20	105 (14%)
21-30	198 (27%)
31-40	159 (21%)
41-50	95 (13%)
51-60	60 (8%)
61-70	37 (5%)
>70	12 (2%)

CT scan findings

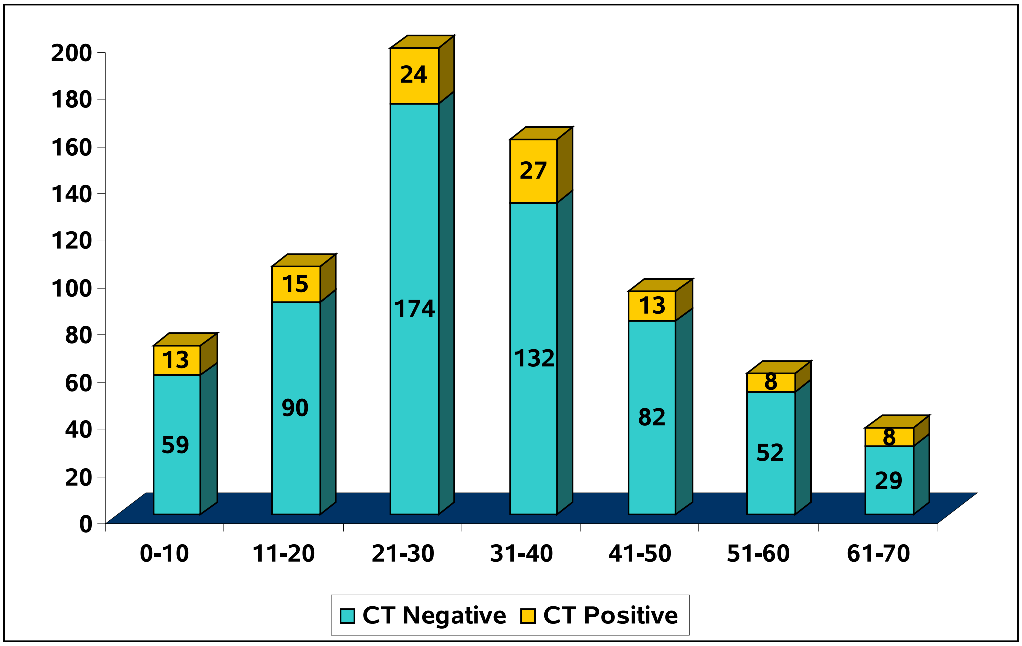
Out of 738 patients 110 (15%) had positive CT brain.

The various positive CT findings in 110 patients were enumerated in descending order of frequency as follows:



CT brain findings	**No. of cases**	**n=738**
Cerebral contusion	34	4.6%
Pneumalcephalus	16	2.17%
Depressed fracture	15	2.03%
Epidural haematoma	11	1.49%
Subdural haematoma	5	0.68%
Intracerebal haematoma	5	0.68%
Subarachnoid haemorrhage	4	0.54%

Age as a predictive factor for positive CT scan

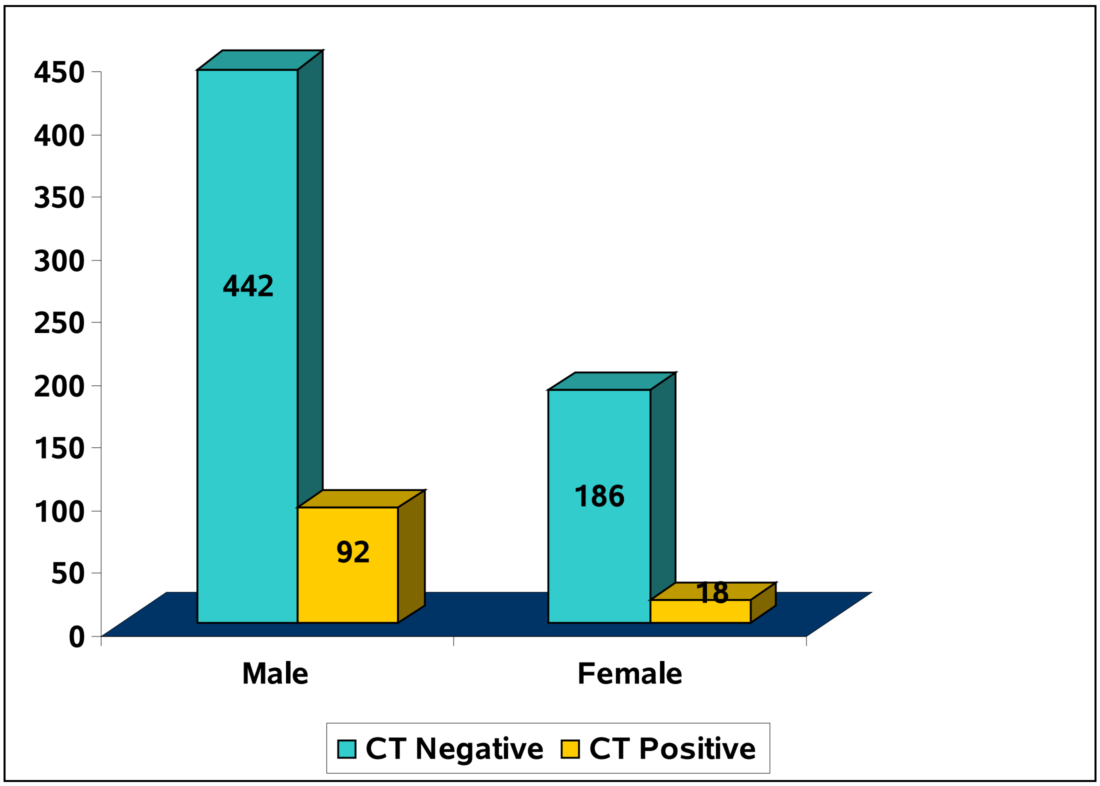


Age	No. of cases n=738	CT positive cases n=110
0-10	72 (10%)	13 (12%)
11-20	105 (14%)	15 (14%)
21-30	198 (27%)	24 (22%)
31-40	159 (21%)	27 (24%)
41-50	95 (13%)	13 (12%)
51-60	60 (8%)	8 (7%)
61-70	37 (5%)	8 (7%)
>70	12 (2%)	2 (2%)

When different ages were analysed using chi square test as a predictor of positive CT scan in head injured patients with GCS 15 it was found to be ***statistically not significant*** (X^2 = 3.979; df = 7; p = 0.782193014)

Age ≤24 and ≥60 years were separately analysed using chi square test. But they were found to be ***statistically not significant*** (X_2 (≤2) = 1.084; df =1; p=0.297804723, X_2 (≥ 60) = 0.3 ; df=1; p=0.583882423).

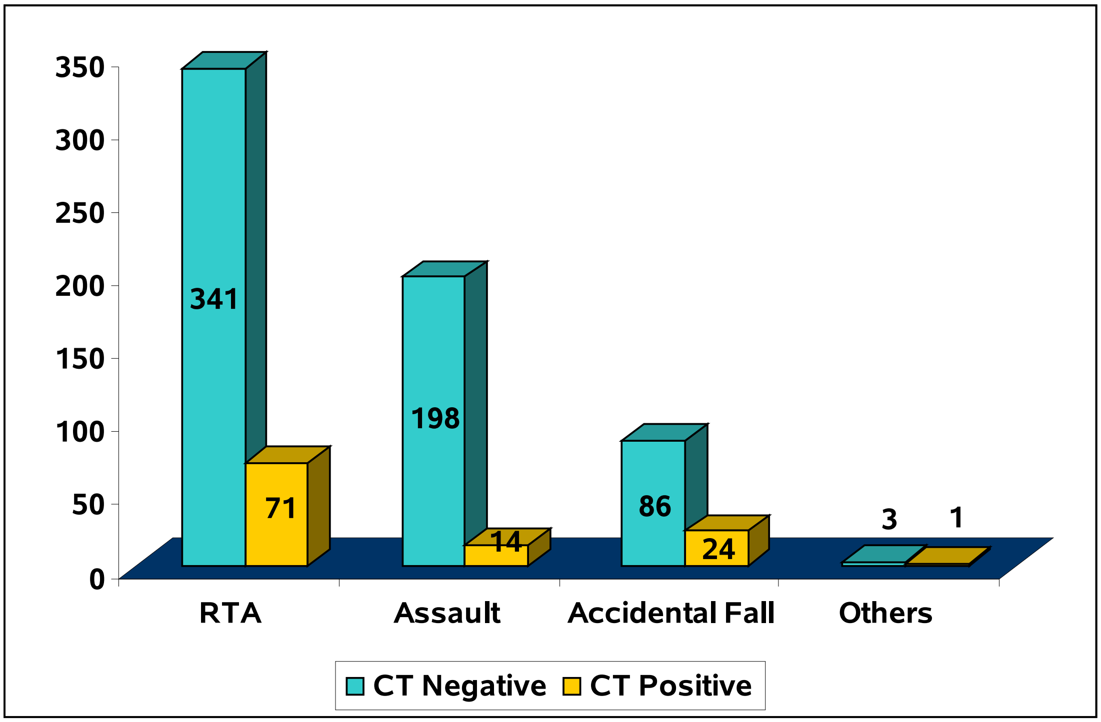
Sex as a predictive factor for positive CT scan



Total no. of male patients	534
Total no. of positive CT in male patients	92
Total no. of female patients	204
Total no. of positive CT in female patients	18

Sex was analysed using chi square test. Taking sex as a predictive factor for positive CT scan in head injured patients with GCS 15 was found to be ***statistically significant*** (X^2=8.22; df=1; p=0.00414312). Male patients were more prone to have positive CT brain than female patients (because males constituted largest number in the study group).

Mode of injury as a predictive factor for positive CT scan



Road Traffic Accident

Total no. cases.	412 (55.8%)
Total no. of cases with positive CT brain.	71 (64.5%)

RTA was analysed as a predictive factor in predicting positive CT brain in head injured patients with GCS 15. Using chi square test RTA was found to be ***statistically significant*** (x^2=4.0, df=1; p=0.04550027).

Assault

Total no. cases.	212 (28.7%)
Total no. of cases with positive CT brain	14 (12.7%)

Assault was analysed as a predictor of positive CT brain in head injured patients with GCS 15 using chi square test. Assault was found to be ***statistically significant*** (x^2=16.2; df=1; p=5.69941E-05).

Accidental Fall

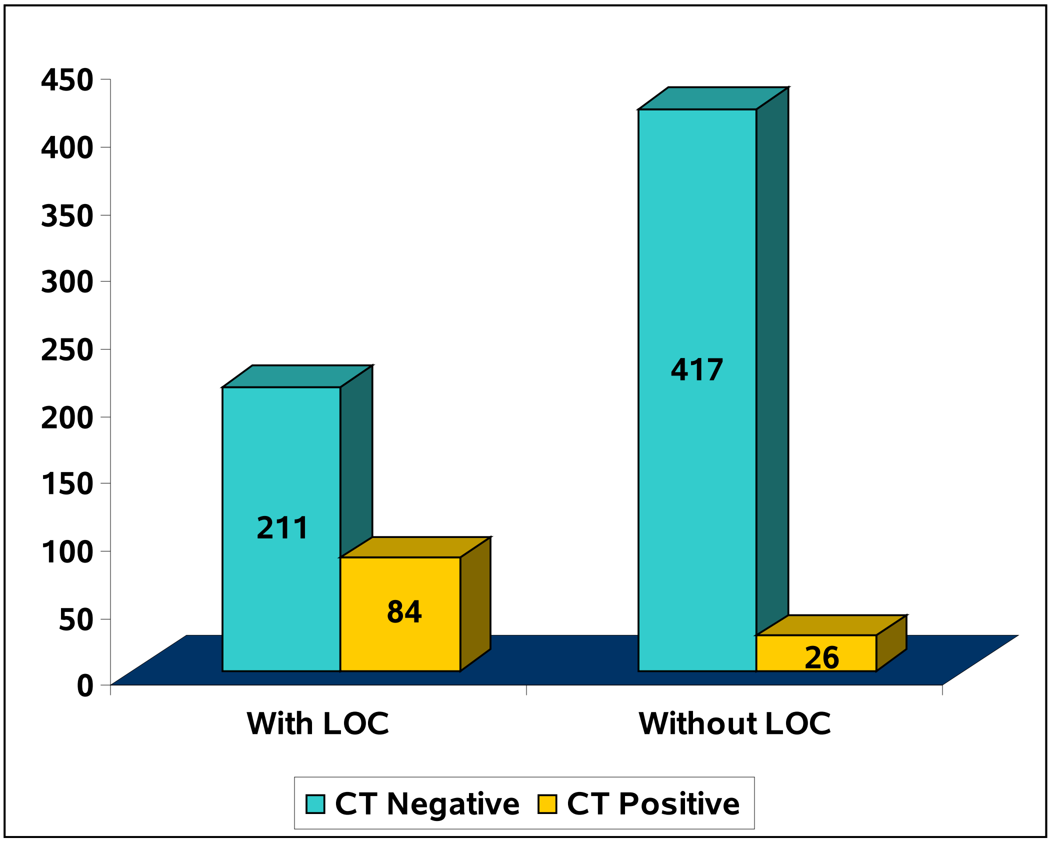
Total no. cases.	110 (15%)
Total no. of cases with positive CT brain	24 (22%)

Accidental fall was analysed as a predictor of positive CT brain in head injured patients with GCS 15 using chi square test. Accidental fall was found to be ***statistically significant*** (x^2=4.8; df=1; p=0.028459739).

History of loss of consciousness as a predictive factor for positive CT scan

Definition of positive loss of consciousness (LOC)

Patient who were amnestic of the trauma event, gave a history of LOC or had a witnessed LOC were considered to have a positive LOC.

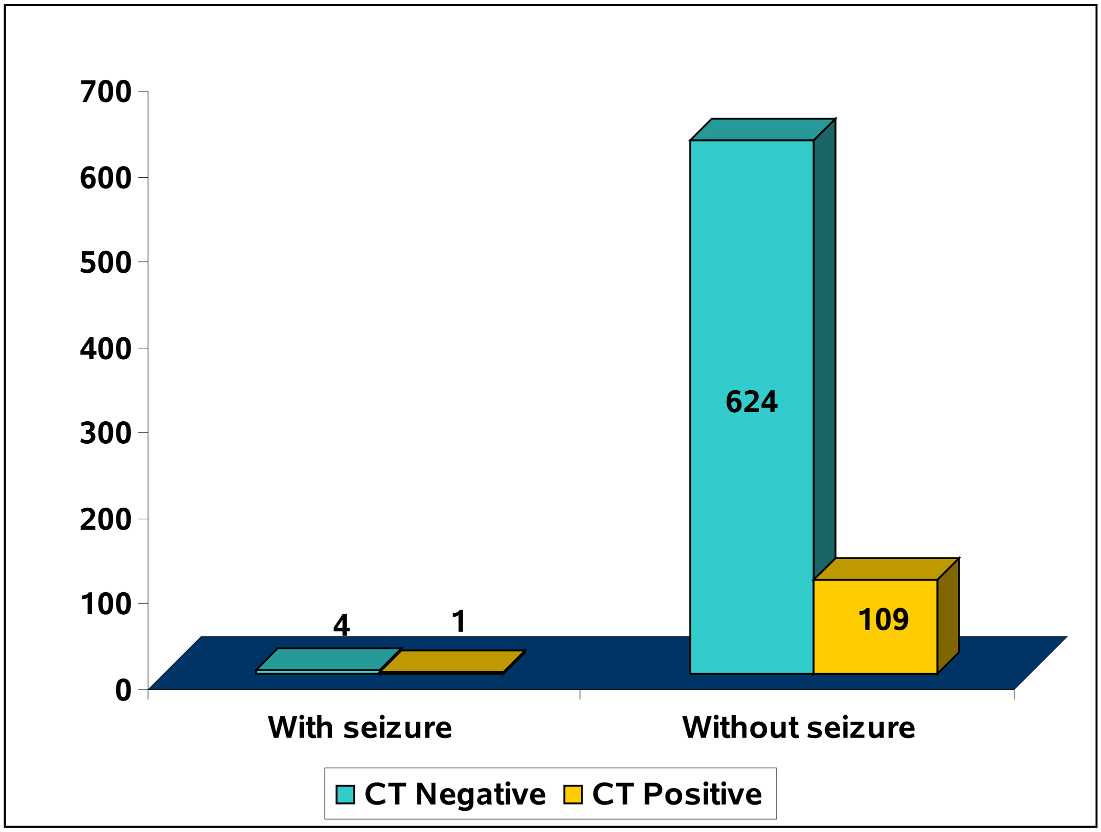


Total no. cases with LOC.	295(40%)
Total no. of cases with positive CT brain	84(76%)

When analysed using chi square test, history of loss of consciousness as predictive factor for positive CT scan in head injured patients with GCS15 was found to be ***statistically significant*** X^2=71.21; df=1; p=3.21156E-17).

History of loss of consciousness is a predictive factor for positive CT scan in head injured patients with GCS 15.

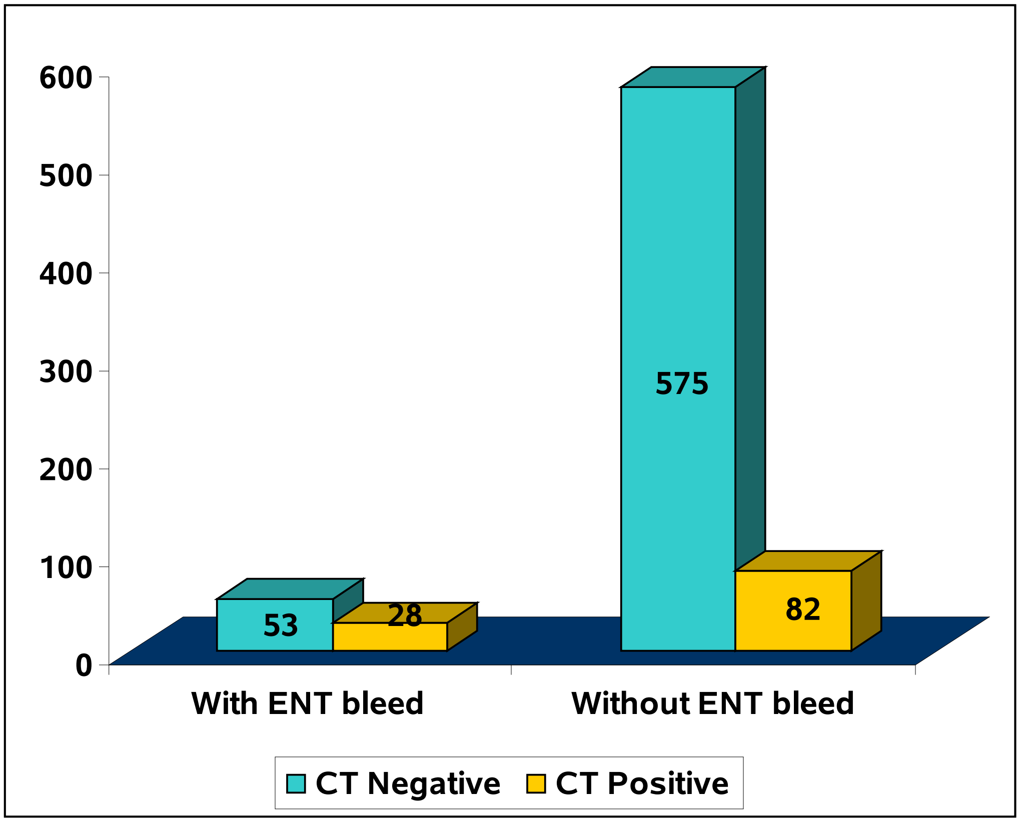
History of post traumatic seizure as a predictor of positive CT scan



Total no. cases with seizure	5 (0.7%)
Total no. of cases with positive CT brain	1(0.9%)

Post traumatic seizure was analysed using chi square test for its significance. But it was ***not found statistically significant*** (x^2=0.0953; df=1; p=0.757544433).

History of ENT bleed as predictor of positive CT scan

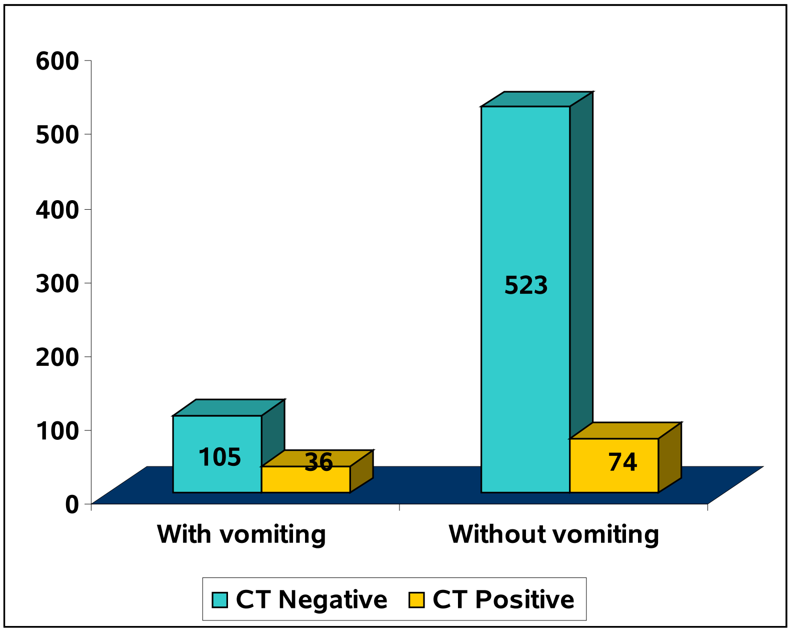


Total no. of cases with ENT bleed	81 (11%)
Total no. of cases with positive CT brain	28 (25.5%)

When analysed using chi square test, ENT bleeding as a predictive factor for predicting positive CT scan in head injured patients was found to be ***statistically significant*** (X^2=28.11; df=1; p=1.14612E-07).

History of ENT bleed is a predictor for positive CT scan in head injured patients with GCS-15.

History of vomiting as predictor of positive CT scan



Total no. of cases with vomiting	141 (19%)
Total no. of cases with positive CT brain	36 (33%)

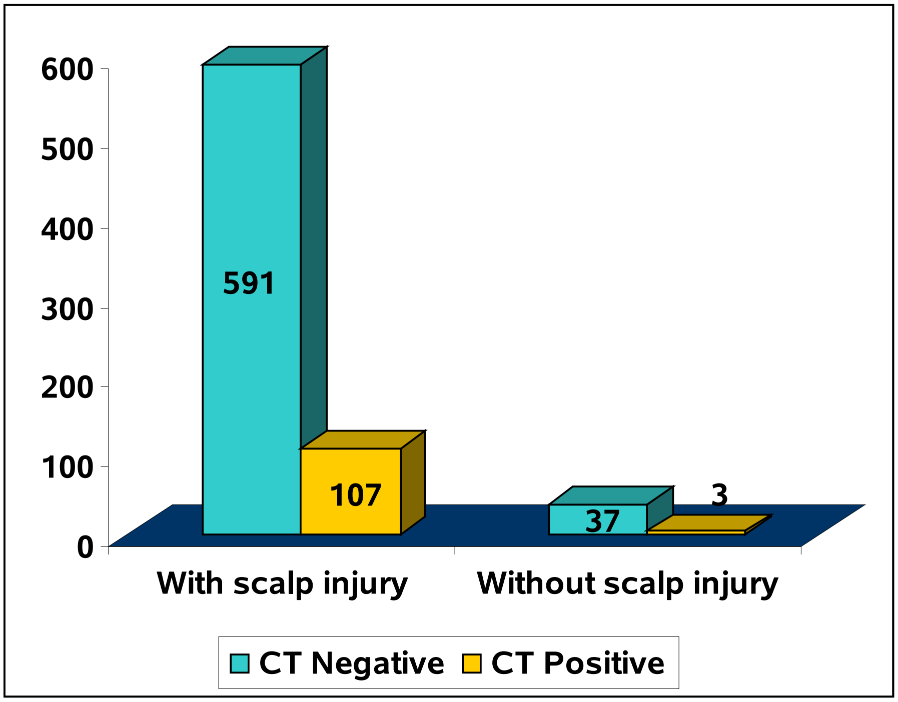
When analysed using chi square test, vomiting as a predictive factor for positive CT scan in head injured patients was found to be ***statistically significant*** (X^2=15.56; df=1; p=7.99278E-05). History of vomiting is a predictor for positive CT scan in head injured patients with GCS-15.

Patients with history of one episode of vomiting and with history of more than three episodes of vomiting were analysed by chi square test. It was found that history of more than three episodes of vomiting was more significant than history of one episode of vomiting.

Scalp injury as a predictor of positive CT scan

Definition of scalp injury

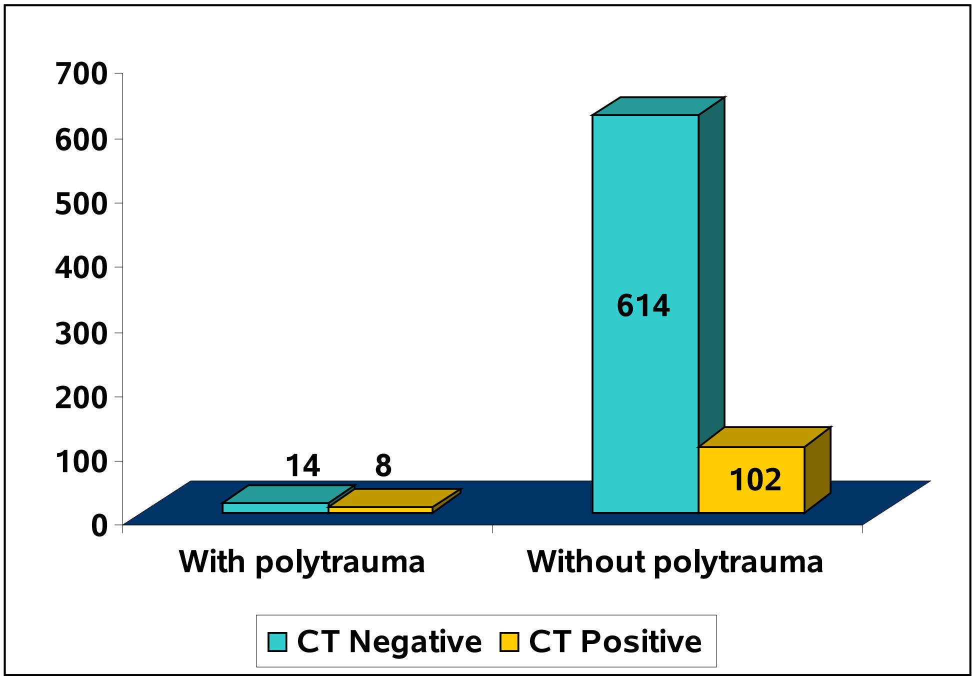
Defined as trauma above the eye brows and includes the lesions such as abrasions and small lacerations[2].



Total no. of cases with scalp injury	698 (95%)
Total no. of cases with positive CT brain	107 (97%)

Scalp injury as a predictive factor for positive CT scan in head injured patients with GCS-15 was analysed using chi square test. It was found to be ***statistically not significant*** (X^2=1.87; df=1; p=0.171475146).

Associated polytrauma as a predictor of positive CT scan



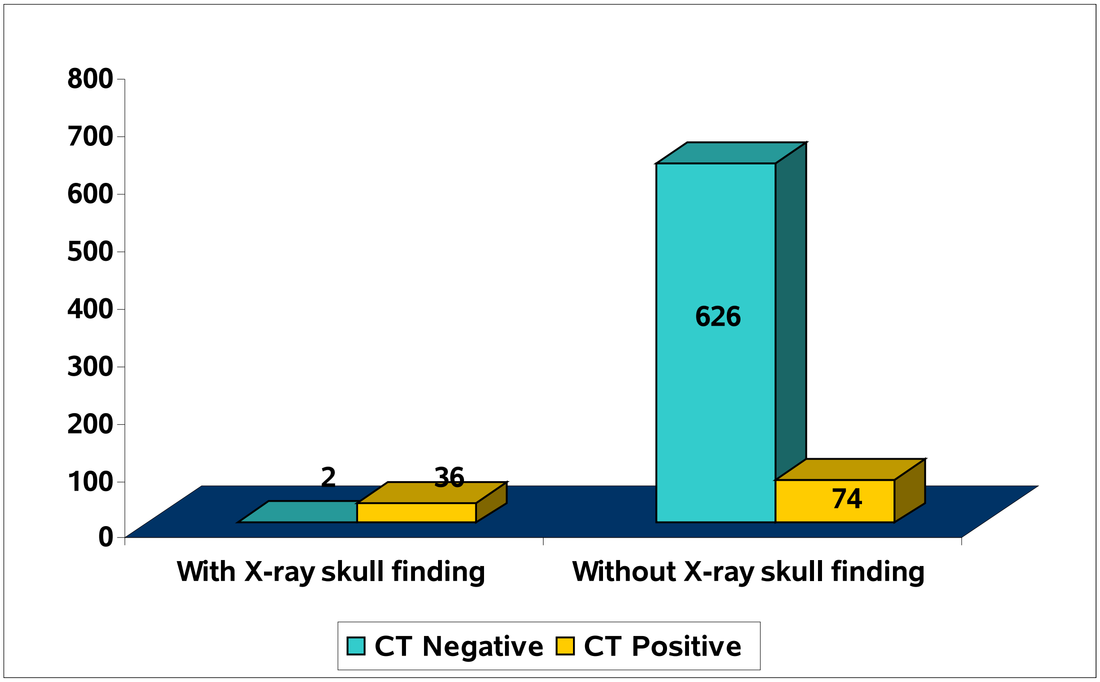
Total no. of cases with poly trauma	22 (3%)
Total no. of cases with positive CT brain	8 (7%)

When analysed using chi square test, poly trauma as a predictive factor for positive CT scan in head injured patients with GCS 15 was found to be ***statistically significant*** (X^2=8.12; df=1; p=0.004377956).

Associated polytrauma is a predictor for positive CT scan in head injured patients with admission GCS 15.

X ray skull findings as a predictor of positive CT scan

All patients in the study group were subjected to routine skull x-ray antero posterior and lateral projections.

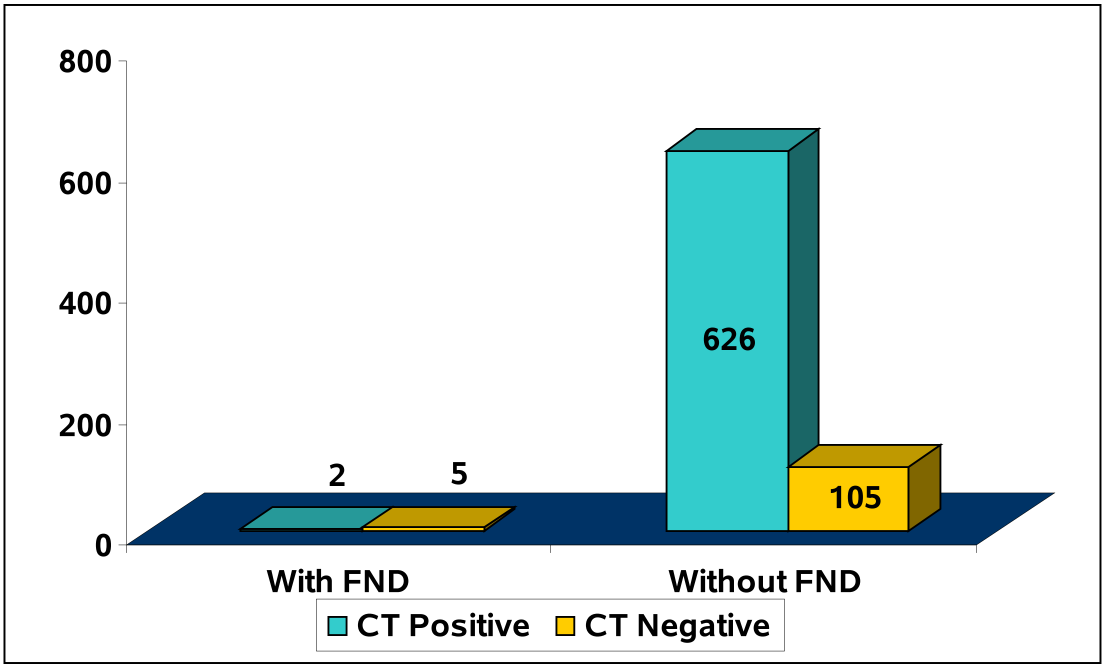


Total no. cases with xray skull finding	38 (5%)
Total no. of cases with positive CT brain	36 (33%)

X ray skull finding was analysed using chi square test as predictive factor and was found to be ***statistically significant*** (x^2=199.83; df=1;p=2.27473E-45).

X ray skull finding is a predictive factor for positive CT scan in head injured patients with GCS15.

Focal neurological deficit as a predictor of positive CT scan



Total no. cases with focal neurological deficit	7 (0.9%)
Total no. of cases with positive CT brain	5 (4.5%)

When analysed using chi square test, focal neurological deficit as a predictive factor for position CT scan in head injured patients with GCS 15 was found to be ***statistically significant*** (X^2=18.85; df=1; p=1.41411E-05).

Focal neurological deficit on initial examination is a predictive factor for positive CT scan in head injured patients with GCS 15.

The factors which were found to be statistically significant as follows in descending order:

1. X ray skull (p=2.27473E-45)
2. Loss of consciousness (p=3.21156E-17)
3. ENT bleed (p=1.14612E-07)
4. Focal Neurological deficit (p=1.141411E-05)
5. Vomiting (p=7.99278E-05)
6. Mode of injury (p=0.000495276)
7. Sex(Male) (p=0.00414312)
8. Associated polytrauma (p=0.004377956)

The predictive factors which were statistically significant were then analysed by multivariate statistical analysis i.e., *logistic regression analysis and recursive partitioning analysis.*

The above eight positive predictive factors were analysed by ***logistic regression analysis.***

The final result of this multivariate statistical analysis is given in the below Table:

Significant predictive factors	Co-efficient	Chi square	df	Significance	Odds ratio	95.0% CI for Exp.	
						Lower	Upper
X ray skull finding	5.267	199.83	1	0.0000	193.87	41.401	907.842
LOC	1.595	71.21	1	0.0000	4.928	2.545	9.544
ENT bleed	0.442	28.11	1	0.0000	1.556	1.092	2.218
FND	3.742	18.85	1	0.0000	42.203	6.217	286.480
Vomiting	0.328	16.2	1	0.0000	1.388	1.090	1.768
Mode of injury	-0.069	17.75	3	0.0004	0.933	0.652	1.334
Sex(Male)	-0.560	8.22	1	0.0041	0.571	0.298	1.096
Associated poly trauma	1.204	8.12	1	0.0043	3.335	1.037	10.718

After analysing the statistically significant factors by logistic regression analysis the factors were classified as very high, high risk, medium risk and low risk factors based on odd ratio and co-efficient.

Factors with odds ratio more than 10 and Co-efficient more than 2 were grouped as *very high risk factors*. Factors with odds ratio 2 to 10 and Co-efficient 1 to 2 were grouped as *high risk factors*. Factors with odds ratio 1 to 2 and Co-efficient 0 to1 were grouped as *medium risk factors*. Factors with odds ratio 0 to 1 and Co-efficient less than 0 were grouped as *low risk factors*.

a. **Very high risk factors**

i. X ray skull finding

Odds ratio = 193.81

CI lower = 41.40; upper = 907.84

Co-efficient = 5.26

ii. Focal neurological deficit

Odds ratio = 42.203

CI lower = 6.217; upper =286.48

Co-efficient = 3.74

b. **High risk factors**

i. Loss of consciousness

Odds ratio = 4.93

CI lower = 2.55; upper = 9.54

Co-efficient = 1.595

ii. Associated polytrauma

Odds ratio = 3.34

CI lower = 1.04; upper = 10.72

Co-efficient = 1.204

c. **Medium risk factors**

i. ENT bleed

Odds ratio = 1.56

CI lower = 1.09; upper = 2.22

Co-efficient = 0.44

ii. Vomiting

Odds ratio = 1.39

CI lower = 1.09; upper = 1.77

Co-efficient = 0.328

d. Low risk factor

i. Mode of injury (dangerous mechanism of injury)

Odds ratio = 0.933

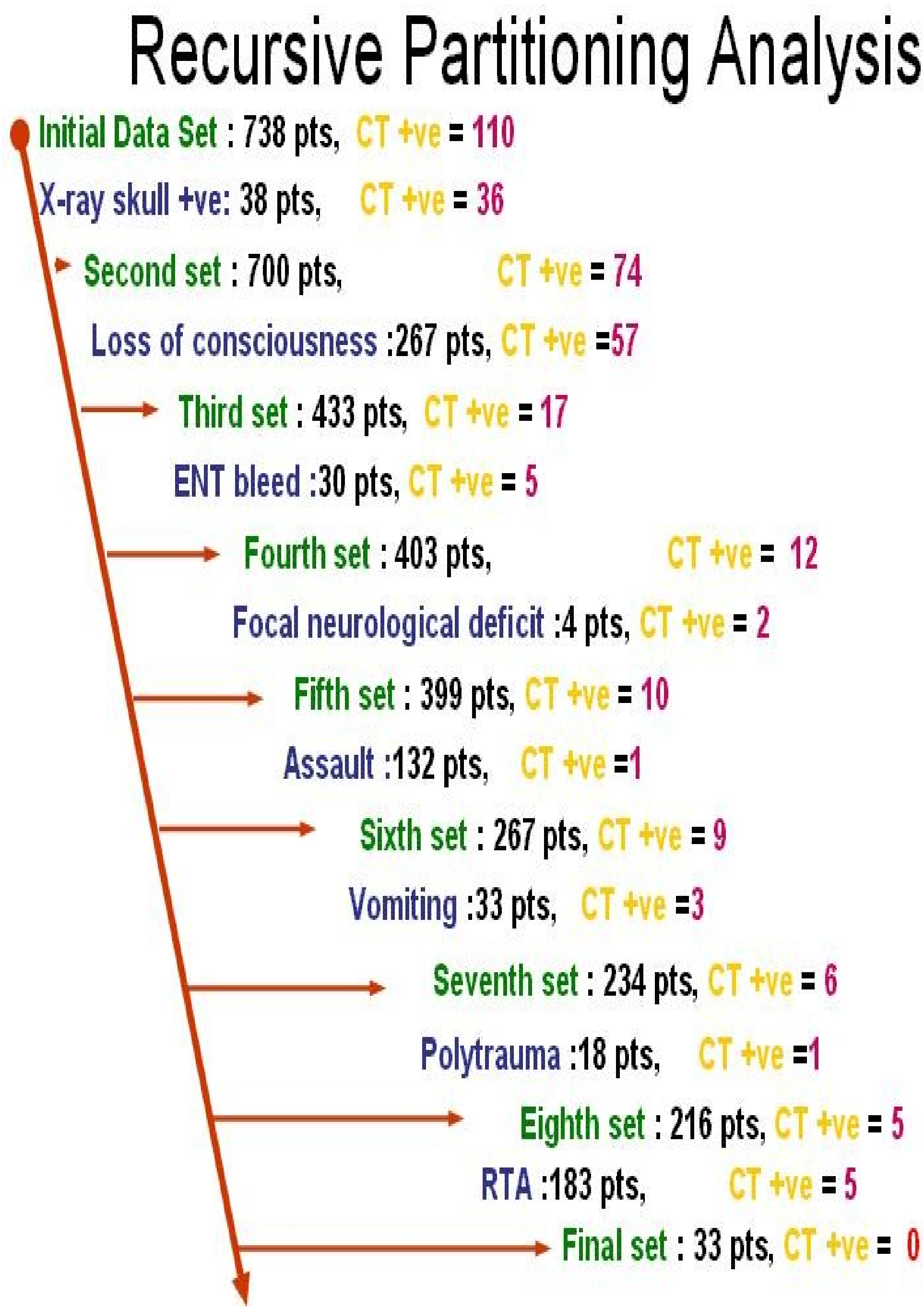
CI lower = 0.652; upper = 1.33

Co-efficient = -0.069

Recursive partitioning analysis is another multivariate statistical analysis used in this study. Recursive partitioning analysis yielded a set of eight statistically significant positive predictive factors that identified all patients with positive CT scans.

Starting with initial set of data on 738 patients, 110 of whom had positive CT scans, we repeatedly removed the data on patients who had the finding with the highest p value (by chi square analysis), for the comparison between patients with positive scans and those with negative scans, until there was a set with no positive scans.

Results of recursive partitioning analysis:



The significant and non significant predictors of positive CT brain were analysed for following separately:

a. Sensitivity
b. Specificity
c. Predictive value of positive CT
d. Predictive value of negative CT
e. Likelihood ratio of having disease for a positive CT result.

Predictive factors	**Sensitivity**	**Specificity**	**Predictive value of positive CT**	**Predictive value of Negative CT**	**Likelihood ratio**
X-ray skull finding	95%	89%	33%	99.7%	1.07
Loss of consciousness	28.5%	94%	76.4%	66%	0.3
Focal neurological deficit	71%	86%	4.5%	99.7%	0.83
Associated polytrauma	36%	86%	7%	98%	0.42
ENT bleed	34.6%	87.5%	25.5%	91.6%	0.4
Vomiting	25.5%	87.6%	32.7%	83.3%	0.3
Road traffic accident	17.2%	89%	64.5%	46.2%	0.2
Assault	6.6%	81.7%	12.7%	68.5%	0.09
Accidental fall	21.8%	86.3%	21.8%	86.3%	0.27
Seizure	20%	85%	0.9%	99.4%	0.2
Scalp injury	15%	92.5%	97%	5.9%	0.16
Sex	17.2%	91.2%	83.6%	29.6%	0.19

Sensitivity, specificity, predictive value of positive and negative CT, likelihood ratio of each factors predicting positive CT brain which was analysed earlier were grouped further as follows:

a. Sensitivity:

The sensitivity of various factors predicting positive CT brain were analysed and given in the descending order below.

i. X ray skull finding (95%)

ii. Focal neurological deficit (71%)

iii. Associated polytrauma (36%)

iv. ENT bleed (34.6%)

v. Loss of consciousness (28.5%)

vi. Vomiting (25.5%)

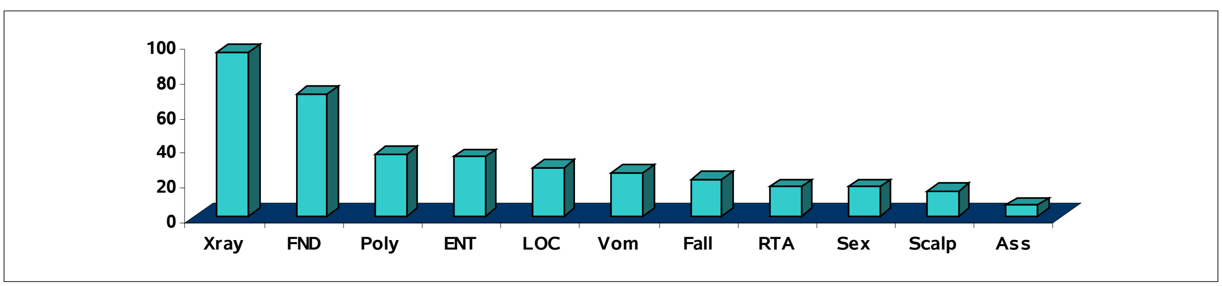
vii. Accidental fall (21.8%)

viii. Road traffic accident (17.2%)

ix. Sex (Male) (17.2%)

x. Scalp injury (15%)

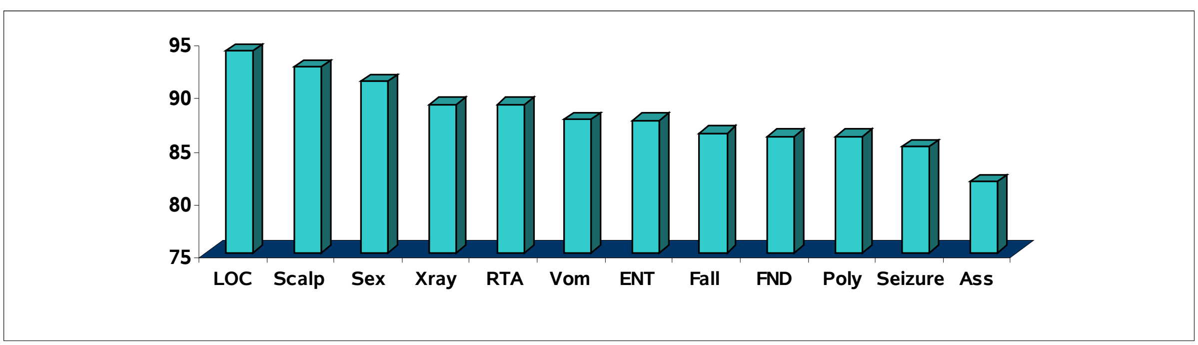
xi. Assault (6.6%)



b. Specificity:

The specificity of various risk factors were analysed and given below in descending order.

i. Loss of consciousness (94%)
ii. Scalp injury (92.5%)
iii. Sex (Male) (91.2%)
iv. X ray skull (89%)
v. Road traffic accident (89%)
vi. Vomiting (87.6%)
vii. ENT bleed (87.5%)
viii. Accidental fall (86.3%)
ix. Focal neurological deficit (86%)
x. Associated polytrauma (86%)
xi. Seizure (85%)
xii. Assault (81.7%)



c. Predictive value of positive CT:

Predictive value of various factors predicting positive CT brain were analysed and given below in descending order.

i. Scalp injury (97%)

ii. Sex (Male) (83.6%)

iii. Loss of consciousness (76.4%)

iv. Road traffic accident (64.5%)

v. X ray skull finding (33%)

vi. Vomiting (32.7%)

vii. ENT bleed (25.5%)

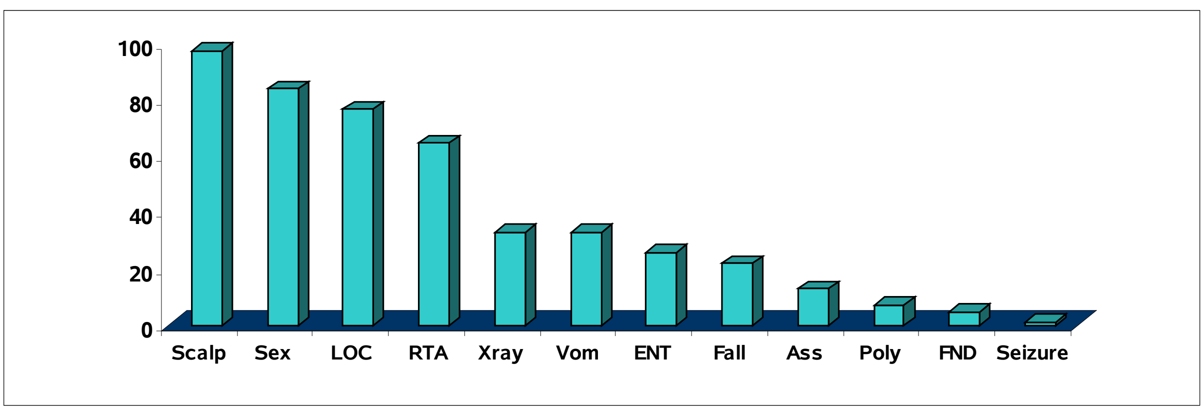
viii. Accidental fall (21.8%)

ix. Assault (12.7%)

x. Associated polytrauma (7%)

xi. Focal neurological deficit (4.5%)

xii. Seizure (0.9%)



d. Predictive value of Negative CT

Predictive value of various factors predicting negative CT scan were analysed and given below in descending order.

i. X ray skull finding (99.7%)

ii. Focal neurological deficit (99.7%)

iii. Seizure (99.4%)

iv. Associated polytrauma (98%)

v. ENT bleed (91.6%)

vi. Accidental fall (86.3%)

vii. Vomiting (83.3%)

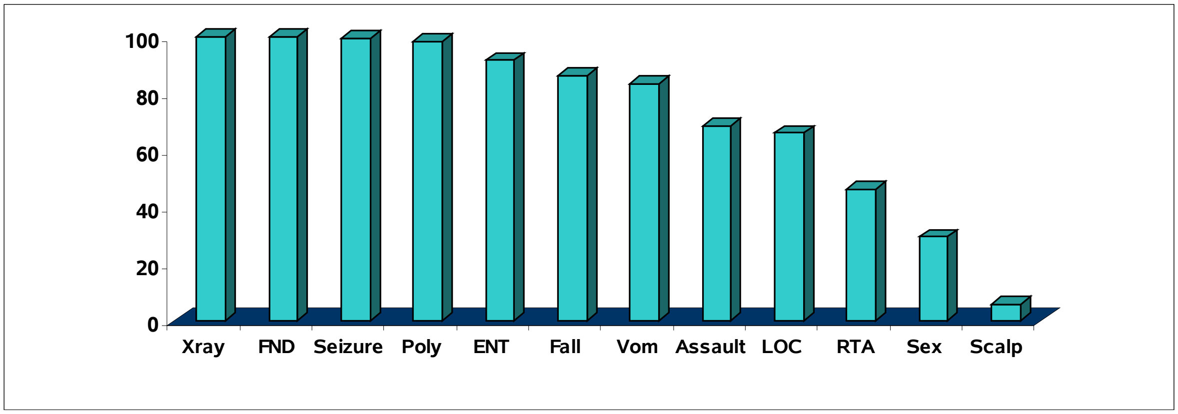
viii. Assault (68.5%)

ix. Loss of consciousness (66%)

x. Road traffic accident (46.2%)

xi. Sex (Male) (29.6%)

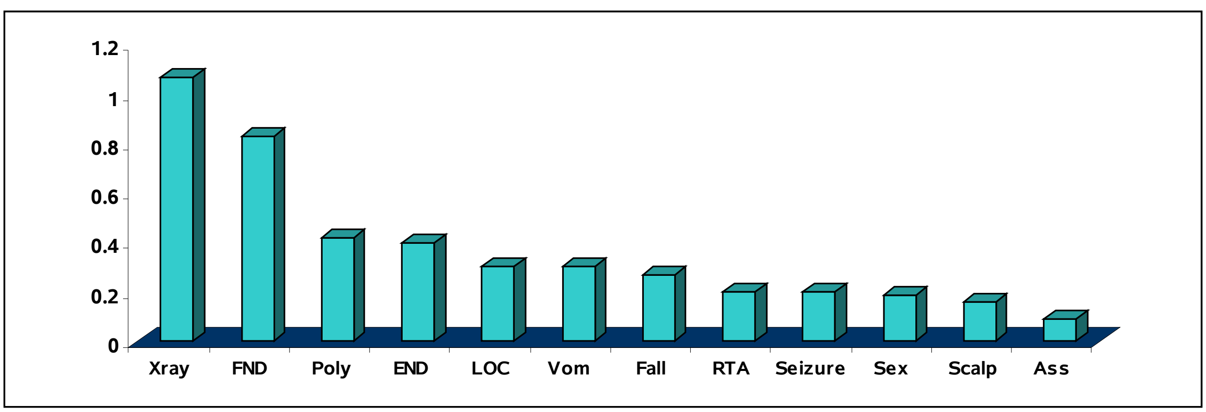
xii. Scalp injury (5.9%)



e. Likelihood ratio of having risk factors for a positive CT

Likelihood ratio of having various risk factors predicting a positive CT were analysed and given below in descending order.

i. X ray skull finding (1.07)
ii. Focal neurological deficit (0.83)
iii. Associated polytrauma (0.42)
iv. ENT bleed (0.4)
v. Loss of consciousness (0.3)
vi. Vomiting (0.3)
vii. Accidental fall (0.27)
viii. Road traffic accident (0.2)
ix. Seizure (0.2)
x. Sex (Male) (0.19)
xi. Scalp injury (0.16)
xii. Assault (0.09)



Surgical intervention

Total no. of cases surgically intervened	***13***
No. of compound depressed fractures operated	10
No. of extra dural haematoma operated	2
No. of intracerebral haematoma operated	1

Hospital stay

Average duration of hospital stay of patients in the study group as a whole	*3.3 days*
Average duration of hospital stay of patients with negative CT scan	2.8 days
Average duration of hospital stay of patients with positive CT scans	5.99 days

The duration of hospital stay for patients with positive CT scan is significantly prolonged i.e., it is double that of duration of hospital stay for patients with negative CT scans.

DISCUSSION

Of all head injured hospitalised patients, those with mild head injury predominate, constituting 80 to 85 percent of the group. The incidence is higher in males, our study also confirm the same with an incidence of 72.4%. The male : female ratio in our study is 2.5:1. In most of the studies Road Traffic Accident was the most common mode of injury. In our study also road traffic accident constituted 55.8% followed by assault (28.7%) accidental fall (15%).

Prior to the advent of modern diagnostic neuroimaging, mild head injury was believed to be reversible or transient without persistent sequelae. This was partly due to the lack of detectable objective neurological deficits and unremarkable imaging studies. Because the mild nature of the injury precluded postmortem evaluations, pathological diagnosis was performed only in rare cases in which mortality was attributable to co-morbid disease.

Despite more than two decades of debate and study, the optimal evaluation of patients with MHI remains controversial. Computed tomography has become the mainstay in the diagnostic workup of the trauma patient.The workup of the patient with head injury is no exception. Previous recommendations have taken one of four approaches. Most authors recommend CT of the head for every patient with blunt head trauma and a history of loss of consciousness or amnesia despite a normal mental status on admission[8,16,17,35,37,38]. Other authors prefer to observe these patients because the yield of abnormal CT results is low. A third group recommends CT in only selected patients in an attempt to reduce the number of negative studies. A final group recommends a combination of CT and observation[8,16,17]. Our approach was to subject, all the patients with GCS score of 15, admitted in our head injury ward to CT scan brain irrespective of age, sex and mode of injury or neurological status.

Most physicians rely on clinical criteria such as GCS score, loss of consciousness, mode of injury, or changes in mental status to predict the probability of intracranial lesion[1,3,4,7,11,13,18,19,21,23,24,26,27,29,30,35-41]. However, some studies have demonstrated that normal neurological examination does not reliably rule out intracranial lesions[29].

This has led some authors to recommend liberal use of CT scanning in patients with a GCS score less than 15 or a history of a significant mechanism of injury[2-4,8,11,16,21-24,26,27,29,30,35-39,44,47].

We under took this study to further define and to analyse the indication for CT scanning in head injured patients with GCS 15.

Most of the previous studies have analysed CT scanning in a retrospective manner, for a selected sample of population, with their own subjective criteria.

Haydel et al (2000)[11] in the 1st phase of a prospective study of 520 consecutive patients who had minor head injury (*patients with GCS 15, normal neurological examination but with history of loss of consciousness*) noted that 6.9% had positive scans. But in our study we included all patients with GCS score 15 *with or without loss of consciousness*. Fifteen percent of our study group had positive CT brain. Using recursive partitioning they derived a set of seven factors which identified all patients who had positive CT brain they were headache, vomiting, an age over 60 years, drug or alcohol, intoxication, deficits in short term memory, Physical evidence of trauma above clavicle and seizure, of these factors only three clinical findings(deficits in short term memory, drug or alcohol intoxication, and physical evidence of trauma above clavicles) were statistically significant in predicting positive CT brain. The recursive partitioning yielded a set of eight factors in our study they were Xray skull finding, history of loss of consciousness, ENT bleed, focal neurological deficit, assault, vomiting, associated polytrauma, road traffic accident, all of these factors were statistically significant.

Lee et al (1995)[15] in their prospective study that included a series of 1812 mild head injured adult patients (patients of age more than 16years with GCS 15 with one or more of the following – a blow to the head, loss of consciousness, or post-traumatic amnesia of the less than 30 minutes in duration). In their study, 1.5% deteriorated after head injury, 1.3% required surgical intervention. Age over 60, presence of drowsiness, focal motor weakness, post-traumatic headache and vomiting has increased risk of deterioration in their study. Fifty seven percent of deterioration occurred during the first 24 hours after injury. In our study head injury patients with GCS score of 15 of all age groups with or without loss of consciousness were included and 1.75% of our study population required surgical intervention.

Vilke et al (2000)[44] in their prospective study enrolled non penetrating head trauma patients of age more than 14years with history of loss of consciousness. Of the 58 patients included in the study 5% had positive CT findings, only one patient underwent neurosurgical intervention. In our study head injury patients with GCS score of 15 of all age groups with or without loss of consciousness were included. Fifteen percent of our study group had positive CT brain and 1.75% required surgical intervention. They concluded that significant brain injury and need for CT scanning cannot be excluded in patients with minor head injury despite a GCS score of 15 and normal complete neurological examination on presentation.

Nagy et al (1999)[24], in their prospective study of 1170 patients who had GCS score of 15 with loss of consciousness, detected 3.3% abnormal CT findings. 1.8% had changes in therapy as a direct result of their CT results, including 4 operative procedures. No patient with a negative CT results deteriorated during the subsequent observation period which was also noted in our study. They concluded that CT was an useful test in patients with mild head injury, because it may lead to a change in therapy in a small but significant number of patients and subsequent hospital observation adds nothing to the CT results and is not necessary in patients with isolated minimal head injury.

Stiell et al[42] in their prospective cohort study which was conducted in ten Canadian hospitals included 3121patients of age more than 16years with GCS score of 13-15.Only 67% of the study group underwent CT scanning, remaining 33% underwent the validated and structured 14 day telephone proxy outcome measure administered by a registered nurse. In their study group 8% had clinically important injury on CT, 4% had clinically unimportant injury on CT. One percent of the study group required neurosurgical intervention. They derived a CT head rule which consists of five high-risk factors (failure to reach GCS of 15 within 2hours, suspected open skull fracture, any sign of basal skull fracture, vomiting more than 2 episodes, or age ≥65years) and two additional medium-risk factors (amnesia before impact >30min and dangerous mechanism of injury).

Our study is different from the previous studies in the following aspects

1. Our study is a *prospective study*.
2. All patients with GCS score 15 were included.
3. Patients with *GCS 15 with and without loss of consciousness were included.*
4. Patients in *all age groups were included.*
5. *No historical or clinical criteria were used to select the patients for CT*

scan

Exclusion criteria of our study are those patients who were admitted 24 hours after the incident of injury and those patients who were referred with CT brain done at outside our institutions. We found when patients were referred more than 24hours after injury or referred with a CT brain done at outside institution, they had a higher chance of positive CT which we thought could artificially inflate the total number of positive CT brain and vitiate our study.

All patients with GCS 15 were subjected to CT brain without any historical or clinical criteria for subjecting them to CT scan. The results were evaluated and assessed on the following perspective.

1. To define the incidence of positive CT scan in head injured patients with GCS 15.
2. Whether any of the demographic data (age, sex, mode of injury), historical data (history of loss of consciousness, post traumatic seizure, ENT bleed, vomiting), physical examination data (scalp injury, associated polytrauma, focal neurological deficit), Xray skull finding of the patients with head injury with GCS 15 could predict a positive CT scan.
3. To define the statistically significant risk factors as very high, high risk, medium risk, low risk factors based on odds ratio.
4. To define the various factors which could yield all the positive CT brain patients by recursive partitioning analysis.

5. To analyse the sensitivity, specificity, predictive value of positive and negative CT, likelihood ratio of each factors predicting the positive CT scan.
6. The neurosurgical intervention required in patients with positive CT scan.
7. Duration of hospital stay in patients with positive and negative CT scan.
8. Safe discharge of head injury patients with GCS 15.
9. Medicolegal implications of positive CT scans in head injured patients with GCS 15.
10. Economic advantage of preventing unnecessary CT scan in head injured patients with GCS 15.

1. Incidence of positive CT scan in various settings

In the total study population (n=738)	=	15%
		n=110
In male patients	=	83.6%
In female patients	=	16.4%
In patients with history of RTA	=	64.5%
In patients with history of assault	=	12.7%
In patients with history of accidental fall	=	22%
In patients with LOC	=	76%
In patients with seizure	=	0.9%
In patients with ENT bleed	=	25.5%
In patients with vomiting	=	33%

In patients with scalp injury	=	97%
In patients with associate poly trauma	=	7%
In patients with Xray skull finding	=	33%
In patients with focal neurological deficit	=	4.5%

2. Predictors of positive CT scan

The various factors of demographic data (age, sex, mode of injury), historical data (history of LOC, post traumatic seizure, ENT bleed, vomiting), Physical examination data (scalp injury, associated poly trauma, focal neurological deficit), X ray skull finding were analysed by chi square test, p value of each factor seen. The factors which were statistically significant to identify positive CT brain were as follows in descending order.

1. X ray skull finding
2. Loss of consciousness
3. ENT bleed
4. Focal neurological deficit
5. Vomiting
6. Mode of injury
7. Associated polytrauma

These statistically significant risk factors for positive CT brain were analysed by multivariate statistical analysis like logistic regression analysis and recursive partitioning.

3. Very high, high, medium, low risk factors based on odds ratio

After analysing the statistically significant factors by logistic regression analysis the factors were classified as very high, high risk, medium risk and low risk factors based on odd ratio and co-efficient.

a. Very high risk factor

i. X ray skull finding

ii. Focal neurological deficit

b. High risk factor

i. Loss of consciousness

ii. Associated polytrauma

c. Medium risk factor

i. ENT bleed

ii. Vomiting

d. Low risk factor

i. Mode of injury (dangerous mechanism of injury)

4. The factors which could yield all the positive CT brain patients by recursive partitioning analysis:

Recursive partitioning analysis is a multivariate statistical analysis that yielded a set of *eight statistically significant positive predictors* that could identify all the CT brain positive patients. The eight factors were:

i. X ray skull finding
ii. Loss of consciousness
iii. ENT bleed
iv. Focal neurological deficit
v. Assault
vi. Vomiting
vii. Associated polytrauma
viii. Road traffic accident

If any one of the above risk factors was present in a patient with admission GCS 15, CT scan should be adviced to rule out any intracranial injury.

5. Neurosurgical intervention

Of the 738 patients, 110 had positive CT brain, 13 of them underwent neurosurgical intervention. Ten patients were operated for compound depressed fractures, two craniotomy for evacuation of extradural haematoma, one craniotomy for evacuation of ICH. Stein et al reported the incidence of 5% requirement of surgery in mild head injury patients[39]. Mikhail et al reported an incidence of 8.57% in a prospective study of thirty five selective population[19]. Bourzuck reported an incidence of 0.76% in his retrospective study[2]. Schunk et al reported a high incidence (56%) of requirement of surgery in a retrospective analysis of paediatric population with a incidence of 83% positive CT scans[18].

Our study reports the incidence of neurosurgical intervention in head injured patients with GCS 15 as 1.75% of non selective consecutive population in a prospective analysis.

6. Duration of hospital stay

In our study the average duration of hospital stay of patients in the study group was 3.3 days. The average duration of hospital stay of patients with negative CT scans was 2.8 days and the average duration of hospital stay of patients with positive scan was 5.99 days.

The duration of hospital stay for patients with positive CT scans is significantly prolonged i.e., it is double that of duration of hospital stay for patients with negative CT scan.

The factors that prolonged the hospital stay were:

i. Requirement of close observation and serial neurological examination.
ii. Surgical intervention
iii. For the purpose of follow up CT scan
iv. Anticipation and management of complications
v. Institution of aggressive medical therapy
vi. Management of injuries, other than head injury.

The chance of deterioration of patients with normal initial CT scan was nil in our study. As these patients could be discharged safely, the duration of their hospital stay was shortened significantly.

7. Safe discharge of patients

All patients in our study underwent CT scanning. 15% had positive CT scans and 85% had negative CT scan.

Value of positive CT scan

A patient with a initial positive scan was closely observed, neurologically examined serially, aggressive medical therapy instituted appropriately, surgically intervened when necessary, follow up CT scan was done as and when required and discharged after ascertaining improvement or ascertaining negligible chance of further deterioration and with specific instructions regarding future follow up regarding medications, rehabilitation and awareness of warning signs and symptoms of deterioration.

Value of negative CT scan in safe discharge of patients

The high incidence of negative CT scans in the population of head injury patients with GCS 15 as reported in our study and other similar studies[16,17,24,35,37] might appear to be an over enthusiastic and cost intensive way of investigation with patients with MHI. However, as noted in our study and in other studies[16,17,24,35,37] negative CT scans in MHI have the following advantages.

As no patient in our study and in other studies with negative CT scan deteriorated, these patients with negative CT scan can be safely discharged home. This saves valuable hospital resources and better utilization of the available for more severely head injured patients especially in resources scarce country like India, where hospital service are stretched to their limits.

Moreover, Livingston et al reported that, 31% to 50% of the patients admitted to the hospital in their study had no evidence of repeated neurologic examinations[16]. This percentage accurately reflects clinical practice in busy trauma centers and raises further doubts about the value of hospital observation. Other similar studies also admit the fact that admission to the hospital does not guarantee skilled neurologic observation[16,17,24,35,37]. The accuracy and reliability of home observation are also questionable. It was reported by Saunders et al that less than half of all persons responsible for observation accurately followed discharge instruction and 19% denied ever having been given instructions[16].

More important, a normal CT scan and neurologic examination can accurately triage the patients who can be safely discharged from the emergency department. This approach enabled them more than 80% of all patients sustaining head injury to be discharged, thus allowing better utilization of limited physician, nursing and hospital resources. Stein, also pointed out that patients with normal CT scans should be considered for observation at home, allowing hospital personal to devote full attention to the more seriously injured patients[37].

Our data and other similar studies[2,3,4,17,31,39] conclusively demonstrate that patients with a cranial CT scan, that shows no intracranial injury, and who do not have other body system injuries or a persistence of any neurological finding can be safely discharged from the emergency department without a period of either prolonged inpatient or outpatient observation. Livingstone et al recommends that, implementation of this practice could result in a potential decrease of more than 500,000 hospital admission annually in USA. In resource scarce country like India, where hospital services are stretched to their limits, this is much more important.

8. Medicolegal implications of a positive CT scan

As mentioned earlier, the medicolegal implications of a positive CT scan are as follows:

i. Positive CT scan converts a simple injury into a grievous one.
ii. Discharging patient without subjecting to CT scanning and if the patients is found to have CT scan positive subsequently, may result in risk of litigation, especially in this consumer era.

9. Economic advantages

CONCLUSIONS

In our study we have analysed the risk factor which are statistically significant in predicting positive CT brain in head injury patients with admission GCS 15. These significant risk factors yielded all positive CT brain patients in recursive partitioning analysis. Hence head injury patients with no significant risk factors can be advised to return home without CT brain, thus reducing unnecessary cost.

Incidence of positive CT in our prospective, consecutive, non selective population of 738 patients with admission GCS of 15 was 15%.

1. Neurosurgical intervention was required in 1.76% of our study population.
2. The risk factors which were statistically significant in our study were:
    i. X ray skull finding
    ii. Loss of consciousness
    iii. ENT bleed
    iv. Focal neurological deficit
    v. Vomiting
    vi. Mode of injury
    vii. Associated polytrauma
3. The significant risk factors which yielded all positive CT patients in recursive partitioning analysis were

i. X ray skull finding

ii. Loss of consciousness

iii. ENT bleed

iv. Focal neurological deficit

v. Assault

vi. Vomiting

vii. Associated polytrauma

viii. Road traffic accident

4. Risk factors were further classified as very high risk, high risk, medium risk, low risk factors based on odds ratio and co-efficient as per these:

Very high risk factors	i. X ray skull finding
	ii. Focal neurological deficit
High risk factors	i. Loss of consciousness
	ii. Associated polytrauma
Medium risk factors	i. ENT bleed
	ii. Vomiting
Low risk factors	i. Mode of injury

When all the four factors belonging to very high, high risk factors (positive skull radiograph, FND, LOC, polytrauma) when present together have a 100% sensitivity for positive CT brain.

5. No patient with normal neurological examination and normal CT

deteriorated.

6. **Patients with**
    a. **Admission GCS of 15**
    b. **Normal neurological examination**
    c. **Normal CT**

   can be safely discharged without need for admission or observation.

7. Earlier discharge of patients with negative CT scan and avoiding CT brain in head injury patients without any significant risk factors will reduce the cost and enable rational utilization of manpower.

8. The medicolegal implications of a positive CT scan are as follows; a positive CT scan converts a simple injury in to a grievous one; discharging a patient without subjecting to CT scanning and if such a patient is found to have positive CT scan subsequently may result in risk of litigation, especially in this consumer era.

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Proforma

Risk Factors for Positive CT in Head Injured Patients with Admission GCS 15

Demographic data

Name: I.P. No.

Age:

Sex:

Mode of Injury:

Time interval between injury and admission:

History

History of loss of consciousness (LOC):

LOC in minutes:

History of vomiting – No. of episodes

– Contents

History of seizure – Type of seizure

– No. of episodes

History of Ear, Nose, Throat bleeding

On examination

Admission Glasgow coma scale

To look for scalp injury

To look for associated polytrauma

Higher function examination

Cranial nerve examination

Spinomotor system

Sensory system

Cerebellar functions

Cardiovascular and respiratory system and

Other systems

Investigations

X ray skull – AP, lateral

CT brain

Management

Surgery or conservative management

Outcome

To look for focal neurological deficit

To look for any deterioration or death

Total number of days as in patient

Discharge Glasgow coma scale

Abbreviations used in Master Chart

1 Sex:

Male=1

Female=2

2 Mode of Injury:

RTA=1

Assault=2

Accidental Fall=3

Others=6

3 Loss of Consciousness (LOC):

With LOC =1

Without LOC=9

4 Seizure:

GTCS=1

Focal Seizure=2

Without Seizure=9

5 ENT Bleed:

Nasal Bleed=1

Ear Bleed=2

Nasal and Ear Bleed=3

Without ENT bleed=9

6 Vomiting:

Single=1

Twice=2

Thrice=3

>3 =4

Without vomiting =9

7 Scalp Injury:

With Scalp Injury =1

Without Scalp Injury =9

8 Polytrauma:

With polytrauma =1

Without polytrauma =9

9 Xray Skull Finding:

With positive X ray skull finding =1

Without X ray skull finding =9

10 CT Brain Finding:

With positive CT brain =1

With negative CT brain =9

11 Focal Neurological Deficit (FND):

With FND =1

Without FND=9

12 Management

S = Surgery

C = Conservative

13 Repeat CT Brain

R = Resolving contusion

14 Outcome

D = Discharge