International Journal of Research in Medical Sciences
Shingada KV et al. Int J Res Med Sci. 2019 Oct;7(10):3782-3788
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20194310

Original Research Article

A clinico-radiological study of mild traumatic brain injury using the national emergency x-radiation utilization study decision instrument

Krupa V. Shingada[1]*, Manjusha M. Litake[2], Kedar M. Tilak[3]

[1]Casualty Medical Officer, [2]Department of Surgery, [3]Medical Officer, Sassoon General Hospitals, Pune, Maharashtra, India

Received: 06 August 2019
Revised: 01 September 2019
Accepted: 07 September 2019

***Correspondence:**
Dr. Krupa V. Shingada,
E-mail: krupashingada91@gmail.com

ABSTRACT

Background: While traumatic Brain Injury (TBI) is one of the leading causes of morbidity and mortality in the Indian subcontinent, little is known regarding its basic characteristics. While CT scanning plays an important role in primary assessment of TBI, it is not always indicated in cases of mild TBI. Thus, the present study was carried out to describe the characteristics of cases of mild TBI presenting to a tertiary care hospital in India and determine the need for CT scanning in them using the National Emergency X-radiation Utilization Study (NEXUS) decision instrument.
Methods: In this prospective study, a detailed history was obtained, and clinical examination performed for each patient, followed by calculation of the NEXUS score. CT scan findings were recorded. Outcome measures were safe discharge, need for neurosurgical intervention or death.
Results: Out of the 425 patients, 87.05% were males. Road Traffic Accident (RTA) was the most common mode of injury. 206 patients had significant intracranial injuries, with skull fractures and hemorrhagic contusions being the most common.138 out of these 206 had a positive NEXUS score. ENT bleed and history of loss of consciousness were also found to be important predictors of significant intracranial injuries. 83 patients were discharged safely from the emergency department, 14 required neurosurgical intervention and 2 died during the course of their stay in the hospital.
Conclusions: NEXUS decision instrument can be a useful tool to determine the need for CT scanning in patients of mild TBI.

Keywords: Head injury, Mild traumatic Brain Injury, National Emergency X-radiation Utilization Study

INTRODUCTION

Traumatic Brain Injury (TBI) is a leading cause of mortality, morbidity, disability and socioeconomic losses in the Indian subcontinent. Its global incidence is rising, and it is predicted to surpass many diseases as a major cause of death and disability by the year 2020.

TBI is defined as a nondegenerative, noncongenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness. It can be classified based on severity as per Table 1.

Table 1: Severity of TBI.

	Glasgow Coma Scale (GCS)	Post-Traumatic Amnesia (PTA)	Loss of Consciousness (LOC)
Mild TBI	13-15	<1 day	0-30 mins
Moderate TBI	9-12	>1 to <7 days	>30 mins to <24 hours
Severe TBI	3-8	>7 days	>24 hours

India has the second largest population in the world, but over a quarter of the world's trauma deaths occur in India, with TBI being the leading cause. Little is known, however, regarding the basic characteristics of TBI in India. Among TBI, the commonest form is mild TBI. Though the name suggests the benign nature of the condition in terms of risk to life, the consequences of mild TBI can impair the general health and functioning. Thus, the primary objective of this study was to describe the various characteristics associated with mild TBI, such as epidemiology, clinical characteristics, results of imaging studies and short term outcomes.

It is a well-known fact that Computed Tomography (CT) scanning plays an important role in the primary assessment of the severity of TBI and for the detection of intracranial injuries, especially in moderate and severe TBI. With respect to mild TBI, CT scanning is not always indicated and clinical characteristics can reliably identify patients who are unlikely to have intracranial injuries and who do not require CT imaging. It has been observed that in cases of mild TBI, there is over-use of CT scanning, exposing patients to risks of radiation and increasing the cost of healthcare, while detecting intracranial injuries in a very small percentage.

To address this issue, many previously validated decision instruments are available to guide decision making in patients of mild TBI. The National Emergency X-radiation Utilization Study (NEXUS) decision instrument is one such previously derived and validated instrument, requiring clinicians to prospectively assess TBI patients for the presence or absence of the following specific criteria: evidence of significant skull fracture, scalp hematoma, neurologic deficit, altered level of consciousness, abnormal behavior, coagulopathy, persistent vomiting and age >65 years.

CT scanning is indicated if even one of the 8 criteria is present. If all the criteria are absent, CT scanning can safely be omitted in such patients. Thus, the secondary objective of this study was to apply the NEXUS decision instrument to all patients of mild TBI and evaluate the need for CT scanning in them.

METHODS

The study was a prospective observational descriptive study carried out in a tertiary care hospital in Pune, India. All patients of mild TBI presenting to the ED and meeting inclusion criteria during study period (November 2017 to May 2018)

Inclusion Criteria

All patients of mild TBI with age ≥12 years, presenting to the ED within 24 hours of injury.

Data collection

The patients or their relatives were explained the purpose of the study and written informed consent was obtained. Data was collected using a questionnaire which included demographic information of the patient: age, sex, hospital registration and medico-legal case number; details of the incident: location and time since injury and mode of injury. A detailed clinical examination was performed and pertinent findings were recorded. CT scan findings were classified into 3 categories for the purpose of analysis: significant neurological (including unspecified extra-axial bleed, extradural hemorrhage, hemorrhagic contusion, intra-cerebral bleed, subarachnoid hemorrhage, subdural hemorrhage, midline shift, cerebral edema, skull fracture and pneumocephalus), non-neurological (including facial fractures, hemosinus, pneumoorbit, preseptal edema and soft tissue swelling) and no abnormal findings. The NEXUS score was calculated using definitions described in Table 2 and the need for CT scanning was evaluated in the patients. Short term outcomes were evaluated at discharge for both outpatient and admitted patients. Outcome measures were safe discharge, need for neurosurgical intervention or death.

Statistical analysis

The data obtained from the study was analyzed using simple statistical measures of rate and percentage. Sensitivity, specificity, positive predictive value and negative predictive value were calculated for the NEXUS score using 2x2 table.

RESULTS

The study involved a total of 425 patients. Of these 78.58% had GCS of 15, 10.11% had GCS of 14 and 11.29% had GCS of 13.87.05% patients were males and 12.94% were females. The mean age was 34.89 years with a standard deviation of 13.79, giving a range of 12 to 79 years. Figure 1 depicts the age distribution and Figure 2 depicts the sex distribution of patients.

Table 3 describes details of the incident. Most patients (71.29%) were brought to the hospital by their relatives or friends. Patients presented to the hospital an average of 6.47 hours after injury, with a standard deviation of 6.25, giving a range of 15 minutes to 24 hours.

Table 2: NEXUS Decision Instrument Definitions.

Evidence of significant skull fracture	Includes signs of basilar skull fracture, including, but not limited to, periorbital or peri-auricular ecchymoses, hemotympanum, and drainage of clear fluids from the ears or nose. Signs of depressed or diastatic skull fracture include a palpable step-off of the skull, a stellate laceration from a point source, or any injury produced by an object striking a localized region of the skull.
Scalp hematoma	Refers to swelling secondary to hematoma formation over any portion of the bony calvarium. Injuries that do not involve the calvarium, including hematomas limited to the face and neck, are not considered scalp hematomas.
Neurologic deficit	Refers to any abnormal neurologic finding revealed by detailed testing. This may include motor or sensory deficits (abnormal weakness or sensation in any 1 or more of the 4 extremities, as determined by systematic testing of muscle strength and sensation in all 4 limbs), cranial nerve abnormality (particularly cranial nerve II through XII, as determined by systematic testing of each nerve), cerebellar abnormality as manifested by ataxia, dysmetria, dysdiadokinesis, or other impairment of cerebellar function (as determined by systematic testing of cerebellar function, including tests of ataxia, and finger-nose-finger, heel-to-shin, and rapid alternating movements), gait abnormality or inability to walk normally (may be due to inadequate strength, loss of balance or ataxia; it is determined by systematic testing of gait, including tandem and heel-to-toe walking and Romberg testing), or any other impairment of neurological function.
Altered level of consciousness	Evidenced by a variety of findings, including, but not limited to, a Glasgow coma score of 14 or less; delayed or inappropriate response to external stimuli; excessive somnolence; disorientation to person, place, time or events; inability to remember 3 objects at 5 minutes; perseverating speech; and other neurological impairments.
Abnormal behaviour	Any inappropriate action displayed by the victim. It includes things such as excessive agitation, inconsolability, refusal to cooperate, lack of affective response to questions or events, and violent activity.
Coagulopathy	Any impairment of normal blood clotting such as that which occurs in haemophilia, secondary to medications (Coumadin, heparin, aspirin etc.), hepatic insufficiency and other conditions .
Persistent vomiting	Evidenced by recurrent (more than 1 episode) projectile or forceful emesis (either observed or by history) after trauma.
Age ≥ 65 years	Determined by available history.

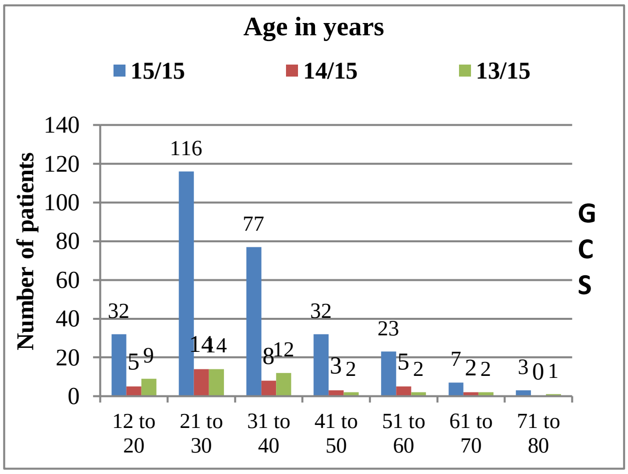

Figure 1: Age Distribution.

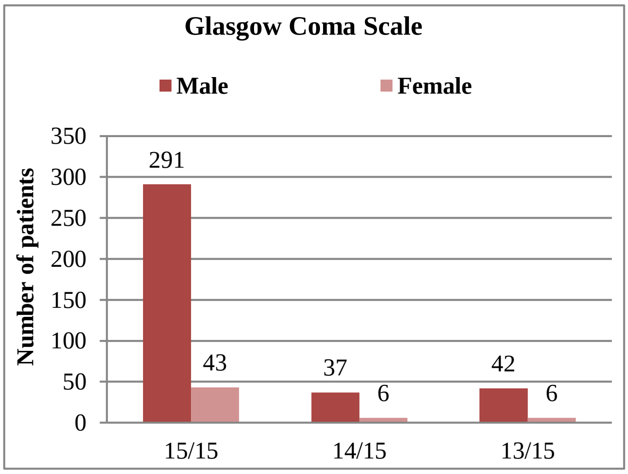

Figure 2: Sex Distribution.

Table 3: Details of the incident.

	GCS 15/15 (n=334)	GCS 14/15 (n=43)	GCS 13/15 (n=48)	Total (n=425)
Brought by				
Self	41 (12.27)	0	0	41 (9.64)
Relative/Friend	239 (71.55)	31 (72.09)	33 (68.75)	303 (71.29)
Bystander	6 (1.79)	3 (6.97)	4 (8.33)	13 (3.05)
Police	19 (5.68)	3 (6.97)	4 (8.33)	26 (6.11)
108	29 (8.68)	6 (13.95)	7 (14.58)	42 (9.88)
Time interval	6.78 ± 6.44 (0.5-24)	4.66 ± 4.18 (0.5-24)	5.98 ± 6.26 (0.25-24)	6.47 ± 6.25 (0.25-24)
Mode of injury				
RTA	177 (52.99)	31 (72.09)	38 (79.16)	246 (57.88)
Assault	105 (31.43)	4 (9.30)	1 (2.08)	110 (25.88)
Fall	45 (13.47)	6 (13.95)	6 (12.5)	57 (13.41)
Other	7 (2.09)	2 (4.65)	3 (6.25)	12 (2.82)

Rows 1 and 3 described as: Number of patients (%); Row 2 described as: Mean±SD (Range).

Table 4: History and clinical examination.

	GCS 15/15 (n=334)	GCS 14/15 (n=43)	GCS 13/15 (n=48)	Total (n=425)
External injury				
Blunt trauma	119 (35.62)	16 (37.20)	16 (33.33)	151 (35.52)
Abrasion	41 (12.27)	4 (9.30)	7 (14.58)	52 (12.23)
CLW	118 (35.32)	17 (39.53)	19 (39.58)	154 (36.23)
Incised	9 (2.69)	0	0	9 (2.11)
Sutured	58 (17.36)	6 (13.95)	7 (14.58)	71 (16.70)
Other history of				
LOC	67 (20.05)	13 (30.23)	19 (39.58)	99 (23.29)
Seizure	10 (2.99)	1 (2.32)	4 (8.33)	15 (3.52)
PTA	1 (0.29)	0	0	1 (0.23)
Stable vitals	325 (97.30)	43 (100)	45 (93.75)	413 (97.17)
Sensorium				
Conscious	334 (100)	31 (72.09)	25 (52.08)	390 (91.76)
Oriented	334	0	0	334
Disoriented	0	31	25	56
Irritable	0	2	4	6
Drowsy	0	12 (27.90)	23 (47.91)	35 (8.23)
Disoriented	0	12	23	35
Irritable	0	1	2	3
Pupils				
BE RTL	330 (98.80)	42 (97.67)	46 (95.83)	418 (98.35)
BUnE RTL	2 (0.59)	0	2 (4.16)	4 (0.94)
Not assessed	2 (0.59)	1 (2.32)	0	3 (0.70)
Plantars				
Flexor	326 (97.60)	42 (97.67)	48 (100)	416 (97.88)
Extensor	0	0	0	0
Absent	2 (0.59)	1 (2.32)	0	3 (0.70)
Not assessed	6 (1.79)	0	0	6 (1.41)
Other neuro deficits	4 (1.19)	2 (4.65)	1 (2.08)	7 (1.64)
Associated injuries				
Major	118 (35.32)	12 (27.90)	17 (35.41)	147 (34.58)
Minor	122 (36.52)	18 (41.86)	13 (27.08)	153 (36.00)
None	94 (28.14)	13 (30.23)	18 (37.50)	125 (29.41)
ENT bleed	69 (20.65)	9 (20.93)	17 (35.41)	95 (22.35)
Under influence	106 (31.73)	21 (48.83)	28 (58.33)	155 (36.47)

All rows described as: Number of patients (%).

Table 5: CT scan findings.

	GCS 15/15 (n=334)	GCS 14/15 (n=43)	GCS 13/15 (n=48)	Total (n=425)
EAB (unspecified)	15 (4.49)	12 (27.90)	5 (10.41)	32 (7.52)
EDH	15 (4.49)	3 (6.97)	4 (8.33)	22 (5.17)
HC	68 (20.35)	22 (51.16)	26 (54.16)	116 (27.29)
ICB	8 (2.39)	0	3 (6.25)	11 (2.58)
SAH	55 (16.46)	13 (30.23)	17 (35.41)	85 (20.00)
SDH	24 (7.18)	8 (18.60)	10 (20.83)	42 (9.88)
Midline shift	14 (4.19)	5 (11.62)	3 (6.25)	22 (5.17)
Cerebral edema	9 (2.69)	1 (2.32)	2 (4.16)	12 (2.82)
Skull fracture	74 (22.15)	23 (53.48)	25 (52.08)	122 (28.70)
Pneumocephalus	25 (7.48)	8 (18.60)	8 (16.66)	41 (9.64)
Facial fracture	77 (23.05)	12 (27.90)	16 (33.33)	105 (24.70)
Hemosinus	42 (12.57)	10 (23.25)	11 (22.91)	63 (14.82)
Pneumoorbit	18 (5.38)	3 (6.97)	5 (10.41)	26 (6.11)
Preseptaledema	24 (7.18)	5 (11.62)	4 (8.33)	33 (7.76)
Soft tissue swelling	34 (10.17)	9 (20.93)	8 (16.66)	51 (12.00)
NAD	145 (43.41)	7 (16.27)	4 (8.33)	156 (36.70)

EAB: Extra-axial bleed, EDH: Extradural hemorrhage, HC: Hemorrhagic contusion, ICB: Intracranial bleed, SAH: Subarachnoid hemorrhage, SDH: Subdural hemorrhage, NAD: No abnormality detected. All rows described as: Number of patients (%).

Table 6: Management and outcomes.

	GCS 15/15 (n=334)	GCS 14/15 (n=43)	GCS 13/15 (n=48)	Total (n=425)
Outpatient	83 (24.85)	0	0	83 (19.52)
Admitted	251 (75.14)	43 (100)	48 (100)	342 (80.47)
Neurosurgical intervention	12 (3.59)	2 (4.65)	0	14 (3.29)
Treatment				
Anticonvulsants	121 (36.22)	33 (76.74)	32 (66.66)	186 (43.76)
Mannitol	104 (31.13)	24 (55.81)	24 (50.00)	152 (35.76)
Outcome				
Discharged	333 (99.70)	43 (100)	47 (97.91)	423 (99.52)
Death	1 (0.29)	0	1 (2.08)	2 (0.47)

Road traffic accident (RTA) was the most common mode of injury, comprising 57.88% of cases. 25.88% cases were due to assault, 13.41% cases due to fall and 2.82% due to other mechanisms of injury (fall of object on head, railway accident etc).

Table 4 describes details of history and clinical examination. History of loss of consciousness was present in 23.29% of patients, which was found to be an important predictor of significant neurological findings on CT scan, with a p value of 0.0058. History of seizures was present in 3.52% of patients, which was not found to be associated with significant neurological findings (p value 0.88). The most common external head injury observed was contused lacerated wound (CLW), seen in 36.23% of patient; while blunt trauma or no visible external head injury was seen in 35.52% of patients. 16.7% patients had wounds that were already sutured at another hospital.97.17% patients had stable vital signs. Most patients with unstable vital signs had other major injuries. Out of the 390 conscious patients, 334 were oriented to time, place and person, 56 had some form of disorientation and 6 were irritable. Out of the 35 drowsy and disoriented patients, 3 were irritable. 418 (98.35%) patients had bilaterally equal pupils, both reacting to light. 4 patients had unequal pupils, while in 3 patients pupils could not be assessed due to severe facial injuries. 416 (97.88%) patients had flexor plantar reflex. 3 patients had absent plantar reflex, all of whom had some form of spinal injury.

Table 7: NEXUS score vs CT scan findings.

	Significant neurological CT findings	Non-neurological and no abnormal CT findings
Positive NEXUS score (≥1/8)	138 (a)	24 (b)
Negative NEXUS score (0/8)	68 (c)	195 (d)

In 6 patients, the plantar reflex could not be assessed due to severe lower limb injuries. 34.58% patients had associated major injuries, which included chest trauma, abdominal trauma, severe limb injuries and facial fractures. 36% patients had associated minor injuries and 29.41% patients had no associated injuries. ENT bleed was present in 22.35% patients, which was another important predictor of significant neurological findings on CT scan, especially occult skull fractures, with a p value of <0.0001. 36.47% patients were found to be under the influence of alcohol at the time of presentation, which was not found to be associated with significant neurological findings (p value 0.21).

Table 5 describes the CT findings in our patients. 48.47% patients had significant neurological findings, with skull fracture and hemorrhagic contusions being most common. 14.82% patients had only non-neurological findings, with facial fractures being the most common. 36.7% patients had no abnormal CT findings.

Table 8: Statistical data based on Table 7.

	Formula	Value
Sensitivity	a/(a+c) x 100	66.99
Specificity	d/(b+d) x 100	89.04
Positive Predictive Value	a/(a+b) x 100	85.18
Negative Predictive Value	d/(c+d) x 100	74.14

Table 6 describes management and outcomes of the patients. 83 patients were safely discharged from the ED, all of whom had presented with a GCS of 15/15. Out of the remaining 342 patients that were admitted, 14 required neurosurgical intervention while 2 died during the course of their stay in the hospital. Average length of stay in the hospital was 5.36 days. Medical management involved antibiotics (all patients), anticonvulsants (43.76%) and mannitol (35.76%). Authors also calculated the sensitivity (66.99), specificity (89.04), positive predictive value (85.18) and negative predictive value (75.28) of the NEXUS score, which is compiled in Tables 7 and 8.

Table 9: Comparison of similar studies.

Parameter	Present study	Mower et al	Ro et al
Correctly identified patients with significant brain injuries	138/206	759/767	511/576
Correctly identified patients requiring neurosurgical intervention	10/14	420/420	135/142
Correctly identified patients without any significant CT findings	195/263	2185/11003	1104/2375
Sensitivity	66.99	98.95	88.71
Specificity	89.04	25.58	46.48
Positive Predictive Value	85.18	8.48	28.67
Negative Predictive Value	74.14	99.7	94.43

DISCUSSION

As per the literature reviewed concerning the use of NEXUS decision instrument to identify the need for CT scanning in patients of mild TBI, our study was among the first of its kind done in India. A study carried out by Mower et al in the United States showed that the NEXUS decision instrument reliably identified patients who required neurosurgical treatment of their injuries as well as those who had significant brain injures evident on CT scan and identified nearly one-quarter of all patients as being low risk for injury and safe to exclude from scanning. Another study carried out by Ro et al in Korea showed that the NEXUS decision instrument had the highest reduction rate for CT scan (as compared to other previously validated decision instruments - Canadian Head CT Rule and New Orleans Criteria), but failed to identify all patients undergoing neurosurgical interventions. In the present study, authors were able to identify 10 out of 14 patients requiring neurosurgical intervention. All 4 patients, who required neurosurgical intervention despite a negative NEXUS score, presented initially with a GCS of 15/15 and had extra-dural hemorrhage as the primary lesion on CT scan. authors were also able to identify 138 out of 206 patients with significant brain injuries on CT scan. All patients who had significant brain injuries on CT scan despite a negative NEXUS score, presented initially with a GCS of 15/15. Authors were able to identify 195 out of 263 patients with no significant CT findings. Table 9 compares the results of the above studies.

A study performed by Stein et al, in the United States showed that the NEXUS decision instrument had a sensitivity of 100%.

CONCLUSION

From the results of our study, authors can conclude that a positive NEXUS score can be a good predictor of need for CT scanning in patients of mild TBI. It can also be concluded that history of loss of consciousness and ENT bleed are important predictors of significant brain injury, while alcohol intoxication and history of seizures are not always reliable in predicting significant brain injury.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Shingada KV, Litake MM, Tilak KM. A clinico-radiological study of mild traumatic brain injury using the national emergency x-radiation utilization study decision instrument. Int J Res Med Sci 2019;7:3782-8.