Acute traumatic brain injury presentations and the use of head CT scans in the Emergency Department

Alice Rogan (alice.rogan@otago.ac.nz)
University of Otago Wellington https://orcid.org/0000-0003-1305-0325

Vimal Patel
Hutt Valley District Health Board

Jane Birdling
Wellington Regional Hospital Emergency Department

Harnah Simmonds
Wellington Hospital

Jessica Lockett
Wellington Hospital

David McQuade
Wellington Regional Hospital Emergency Department

Peter Larsen
University of Otago Wellington

Original research

Keywords: Traumatic brain injury, CT head scan, guideline adherence

Posted Date: August 3rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-51284/v1

Abstract

Objective: The use of CT head scanning for traumatic brain injury (TBI) is a vital diagnostic tool, guided by risk stratification tools. This study aims to review the use of CT head scans for TBI in two Australasian Emergency Departments (ED) in New Zealand.

Methods: Retrospective observational design of patients referred for head CT from ED to exclude a significant intracranial injury between 1st September 2018 and 31st August 2019. Clinical data were collected regarding presenting patterns, identification of injuries on CT scan and adherence to CT guidelines.

Results: Out of 425 cases reviewed, a clinically significant injury was identified in 41 (10%) patients. Patients who reported loss (32% vs 20% $p < 0.05$) or possible loss of consciousness (34% vs 22% $p < 0.05$) and had GCS < 13 (17% vs 8%, $p < 0.05$) or focal neurology (10% vs 3%, $p < 0.05$) were more likely to have a significantly intracranial injury on CT. Interestingly, 17 (41%) patients with significant injury were GCS 15 with no focal neurology. NICE guidelines were adhered to in 364 (86%) patients. In the 14% of cases that did not meet guideline criteria, all CT head scans were negative.

Conclusion: CT head scans are a valuable tool in TBI and guidelines successfully identify those with significant intracranial injuries. However, the rate of significant injury for the total population requiring head CT remains low, with over 90% of head CTs in the population normal, despite high guideline compliance perhaps identifying a role for novel objective tests in ED guidelines internationally.

Introduction

Traumatic brain injury (TBI) is a common emergency department (ED) presentation.[1,2,3] Early recognition of TBI in ED is essential to provide timely treatment. Diagnosis and management can be challenging; the injury location and premorbid condition of a patient can lead to marked variation in the symptoms and clinical signs identifiable at presentation.

TBI diagnosis is determined following clinical history, neurological examination and use of CT head imaging. CT head scan use has increased exponentially over the last few decades.[4] They have become a vital diagnostic tool for clinicians and have resulted in quicker diagnoses and better patient outcomes. However, the majority of TBIs that present to EDs are mild.[3] It is hard in this group in particular to determine if a CT scan will be beneficial. Only 5% of head CT scans in patients with mild TBI are positive[5] however, the significance of missing an injury on CT scan has so far justified this ongoing liberal use.[6,7,8]

The concern with the low rate of positive findings on CT scans are that the scans are not risk free due to the radiation exposure.[9,10] In addition, they confer a significant cost to the health care system not only from the radiology costs, but those related to ED waiting times and LO.S[11] This variability and escalating CT use has led to the development of clinical guidelines and pathways to aid decision making. These

tools include the Canadian CT head rule or the New Orleans Criteria[12] which combine Glasgow Coma Scores (GCS) with other clinical risk factors to determine which patients should undergo imaging. International consensus agrees on certain definitions of injury severity according to GCS scores (mild 13–15, moderate 9–12, severe 3–8).[1]

In New Zealand, the Accident Compensation Corporation (ACC) have produced evidence based guidelines for CT head scanning based on the NICE guidelines[13] advising only to request CT head scans in trauma patients when indicated by a validated clinical decision rule. This is in keeping with the Choosing Wisely campaign statements published by the Australasian College of Emergency Medicine (ACEM) and supported by the Royal Australasian and New Zealand College of Radiologists (RANZCR).[14]

This study aims to characterize the use of CT head scans in two emergency departments. In particular it will aim to review presenting patterns, injury identification with CT scans and adherence to clinical guidelines.

Methods

This study was a retrospective observational study of patients presenting to either a Level 1 Tertiary Trauma ED (Wellington Regional Hospital) or a Level 5 District General Hospital (Hutt Valley Hospital) ED who were referred for a head CT to exclude acute TBI between 1st September 2018 and 31st August 2019. NICE CT head guidelines are used as clinical decision aids at both sites (See Table 1).[15] CT head scans are available 24 hours at both sites. The neurosurgical unit for both sites is Wellington Hospital. Research was conducted in accordance with ethical approval obtained from the University of Otago Human Ethics committee (Reference HD20/001). The STROBE checklist for observational studies was followed when preparing this study.

Table 1
Nice Guidelines for CT head in Adults

Criteria for performing a CT head scan in adults	
For adults who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified: *A provisional written radiology report should be made available within 1 hour of the scan being performed*	• GCS less than 13 on initial assessment in the emergency department
	• GCS less than 15 at 2 hours after the injury on assessment in the emergency department
	• Suspected open or depressed skull fracture
	• Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign)
	• Post-traumatic seizure
	• Focal neurological deficit
	• More than 1 episode of vomiting.
For adults with any of the following risk factors who have experienced some loss of consciousness or amnesia since the injury, perform a CT head scan within 8 hours of the head injury: *A provisional written radiology report should be made available within 1 hour of the scan being performed*	• Age 65 years or older
	• Any history of bleeding or clotting disorders
	• Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 meter or 5 stairs)
	• More than 30 minutes' retrograde amnesia of events immediately before the head injury

Patients with TBI were screened using the radiology database. The words ‘injury’ and ‘trauma’ were flagged from the CT head indication field. Cases were included in the analysis if patients were over 18 years of age with a clear history of trauma presenting within 48 hours of the suspected injury. Patients were excluded if they had a pre-existing acute brain injury, if the CT scan was cancelled after the initial request or if the patient was not seen by an emergency department doctor.

Patient records were reviewed and data collected included demographics, presenting features, CT head indication, CT head result and CT wait times. Adherence to the NICE guideline was reviewed based on documentation of CT indication. A clinically important positive head CT finding was defined as the presence of any of the following criteria: skull fracture, pneumocephalus, intracranial haemorrhage or contusion, traumatic infarction, diffuse axonal injury or signs of herniation. Data were de-identified and entered into a REDCap database. Data analysis was completed using SPSS software.

Results

Between 1st September 2018 and 31st August 2019, 4319 head CT requests were received from Wellington Emergency Department and 1422 from Hutt Emergency Department for all conditions. In some cases more than one request related to the same case for example if a CT angiogram or CT facial bones was requested at the same time. After duplicates were removed, 536 patients were identified including 314 patients from Wellington ED and 222 from Hutt ED. 111 cases were excluded: 76 patients presented > 48 hours since injury, 28 patients had no clear trauma, 5 CTs were cancelled, 1 patient was reviewed by a medical registrar and 1 patient had sustained a TBI 48 hours previously. Therefore, following screening 425 cases were analysed, 261 from Wellington and 164 from Hutt.

Baseline characteristics of all patients and two comparator groups (age and department) are displayed in Table 2. The age group cut off at 65 years matches the NICE guideline risk stratification criteria.

Table 2
Baseline Characteristics

Characteristic		**All (n = 425)**	**< 65 (n = 202)**	**> 65 (n = 223)**	**Wellington (n = 261)**	**Hutt (n = 164)**
Age	Median (IQR)	67 (32.5–82.5)	32 (24–50)	82 (76–88)	66 (31-81.5)	70 (40.5–83)
Gender	Male	252 (59)	**143 (71)**	**109 (49)***	155 (59)	97 (59)
N (%)	Female	170 (40)	58 (28.5)	112 (51)	105 (40.5)	65 (40)
	Transgender	1 (1)	1 (0.5)	0 (0)	1 (0.5)	0 (0)
Ethnicity	New Zealand European	277 (65)	**110 (54.5)**	**167 (75)***	158 (60.5)	119 (73)
N (%)	Maori	59 (13)	**49 (24.3)**	**10 (4.5)***	33 (13)	26 (16)
	Pacific Islander	13 (3)	8 (4)	5 (2.2)	10 (4)	3 (2)
	Other European	43 (10)	15 (7)	28 (13)	34 (13)	9 (5)
	Other	31 (9)	20 (10)	13 (6)	26 (6.5)	7 (4)
Mechanism	Fall > 1 m or > 5 stairs	20 (5)	13 (6.5)	7 (3)	10 (4)	10 (6)
N (%)	High speed MVA	37 (9)	**34 (17)**	**3 (1)***	**14 (5)**	**23 (14)****
	Fall from standing	245 (57)	**58 (29)**	**187 (84)***	**158 (60.5)**	**87 (53)****
	Sport	33 (8)	30 (15)	3 (1)	25 (10)	8 (5)
	Assault	36 (9)	**32 (16)**	**4 (2)***	22 (8)	14 (8.5)
	Unknown	24 (6)	13 (6)	11 (5)	12 (5)	12 (7)

*p value < 0.05 comparison between age groups

**p value < 0.05 comparison between EDs

[#] Any report of alcohol or drug ingestion or use recorded in notes was deemed as intoxication

Characteristic		All (n = 425)	< 65 (n = 202)	> 65 (n = 223)	Wellington (n = 261)	Hutt (n = 164)
	Other	28 (6)	21 (10)	7 (3)	19 (7)	9 (5)
Trauma	Isolated head trauma	371 (87)	174 (86)	197 (88)	236 (90)	135 (82)
N (%)	Multi-trauma (fracture, major limb injury)	34 (8)	10 (5)	24 (11)	17 (6.5)	17 (10)
	Major trauma	19 (5)	17 (8)	2 (1)	7 (3)	12 (7)
Coagulopathy	Warfarin	40 (9)	**3 (1.5)**	**37 (17)***	24 (9)	16 (10)
N (%)	NOAC	57 (13.5)	**2 (1)**	**55 (37)***	32 (12)	25 (15)
	Other	11 (2.5)	2 (1)	2 (1)	9 (3.5)	2 (1.5)
Intoxication#	Alcohol	97 (22.8)	**78 (39)**	**19 (8.5)***	**71 (27)**	**26 (16)***
N (%)	Drugs	29 (7)	**26 (13)**	**3 (1)***	18 (7)	11 (7)
Lowest recorded GCS	15	285 (67)	**115 (57)**	**170 (76)***	167 (64)	118 (72)
N (%)	14	63 (15)	**41 (20)**	**22 (10)***	38 (15)	25 (15)
	13	13 (3)	7 (3.5)	6 (3)	11 (4)	2 (1)
	9–12	18 (6)	24 (8.5)	5 (2.5)*	15 (6)	7 (4)
	< 9	15 (4)	8 (4)	7 (3.5)	9 (3.5)	6 (4)
Presenting Features	Loss of consciousness	92 (22)	**55 (27)**	**37 (16)***	60 (23)	32 (19.5)
N (%)	Possible loss of consciousness	99 (23)	**59 (29)**	**39 (17)***	56 (21.5)	42 (26)

*p value < 0.05 comparison between age groups

**p value < 0.05 comparison between EDs

Any report of alcohol or drug ingestion or use recorded in notes was deemed as intoxication

Characteristic		All (n = 425)	< 65 (n = 202)	> 65 (n = 223)	Wellington (n = 261)	Hutt (n = 164)
	Headache	199 (47)	**123 (61)**	**76 (34)***	119 (45.6)	80 (49)
	> 1 episode vomiting	47 (11)	**42 (21)**	**5 (2)***	34 (13)	13 (8)
	Seizure	23 (5)	**18 (9)**	**5 (2)***	15 (6)	8 (5)
	Amnesia (anterograde or > 30 min retrograde)	69 (16)	**48 (24)**	**21 (9)***	43 (16.5)	26 (16)
	Confusion/repetitive questioning	124 (29)	64 (32)	60 (27)	81 (31)	43 (26.2)
	Suspected open or depressed skull fracture	6 (1)	4 (2)	2 (1)	4 (1.5)	2 (1)
	Sign of base of skull fracture	11 (3)	8 (4)	3 (1)	6 (2)	5 (3)
	Evidence of trauma above the clavicles	244 (57)	114 (56)	130 (58)	152 (58)	92 (56)
	Focal neurology	25 (6)	13 (6)	12 (5)	16 (6)	9 (5.5)
*p value < 0.05 comparison between age groups						
**p value < 0.05 comparison between EDs						
# Any report of alcohol or drug ingestion or use recorded in notes was deemed as intoxication						

The median patient age was 67 (IQR 32.5–82.5). Most patients presented with isolated head trauma (87%) and the majority were injured following a fall from standing height (57%). Based on GCS scores, 85% of patients had a mild injury, 6% had moderate head injuries and 4% had severe head injuries. Patients < 65 were more likely to have a headache, a GCS < 15 and have risk factors such as loss or possible loss of consciousness and amnesia. Patients > 65 were more likely to be on anticoagulation therapy.

Indications for CT scanning & Compliance with NICE Guidelines

The frequency and proportion of patients undergoing CT head scanning according to risk factors stated in the NICE guidelines are depicted in Table 3.

Table 3
CT Indication according to risk factors identified in NICE guidelines

Risk Factor		**All**	**< 65**	**> 65**	**Trauma Centre (Wellington)**	**District General Hospital (Hutt)**
Risk factor requiring CT head within 1 hour of recognition as per NICE Guidelines **N (%)**	GCS < 13	37 (9)	23 (12)	14 (6)	24 (9)	13 (8)
	Deterioration in condition following initial assessment	12 (3)	9 (4.5)	3 (1.3)	8 (3)	4 (2.5)
	GCS < 15 2 hours after injury on assessment in the ED	61 (14)	**41 (20)**	**20 (9)***	41 (16)	20 (12)
	Suspected open or depressed skull fracture	7 (2)	**6 (3)**	**1 (0.5)***	4 (1.5)	3 (2)
	Any sign of base of skull fracture	12 (3)	9 (4.5)	3 (1)	7 (3)	5 (3)
	Post-traumatic seizure	16 (4)	**14 (7)**	**2 (1)***	10 (4)	6 (4)
	Focal neurological deficit	16 (4)	8 (4)	8 (4)	12 (5)	4 (2)
	> 1 episode of vomiting since the head injury	41 (9)	**29 (14)**	**8 (4)***	30 (11.5)	10 (6)
	Current anticoagulation treatment	102 (24)	**7 (3.5)**	**95 (43)***	60 (23)	42 (26)
Risk factor requiring CT head within 8 hours of the head injury as per NICE Guidelines in patients with some loss of consciousness or amnesia	Age > 65	162 (38)	0	113 (51)*	**65 (25)**	**97 (60)****
	Retrograde amnesia > 30 minutes	38 (9)	**29 (14)**	**8 (4)***	22 (8)	15 (9)
	Dangerous Mechanism	56 (13)	**46 (22)**	**10 (4.5)***	**22 (8)**	**32 (19.5)****

*p value < 0.05 comparison between age groups

**p value < 0.05 comparison between EDs

Risk Factor		All	< 65	> 65	Trauma Centre (Wellington)	District General Hospital (Hutt)
No clear indication for CT head according to NICE guidelines	N (%)	61 (14)	28 (14)	33 (15)	41 (16)	20 (12)
CT Report	Time to CT report (min) Median (IQR)	27 (11–55)	25 (10–67)	28 (13–53)	**20 (7–41)**	**43 (21–100)****
	Within 60 minutes N (%)	327 (77)	150 (74)	176 (79)	222 (85)	105 (64)
*p value < 0.05 comparison between age groups						
**p value < 0.05 comparison between EDs						

The most common indication for CT scanning at both sites was age > 65 with some loss of consciousness or amnesia (38%). In those < 65, 22% underwent CT scanning because of a dangerous mechanism with some loss of consciousness or amnesia (vs 4.5% $p < 0.05$) and 14% underwent CT scanning because of > 30minutes of retrograde amnesia (vs 4% $p < 0.05$).

The results showed that 61/425 (14%) of CT head scans performed did not clearly meet NICE criteria. Twenty-four of these cases had CTs requested because of their age, but they did not have any loss of consciousness or amnesia and no other risk factors were present. In 14 cases, patients were intoxicated with alcohol and it was noted that this was limiting assessment. In those < 65, 43% of those not meeting criteria were intoxicated with alcohol affecting assessment. CT head reports were reported within 1 hour in 77% of cases as recommended by NICE guidelines.

CT Results and Characteristics of Significant Injuries

The frequency and proportion of clinically significant injury (positive CT scan) and the range of injuries identified is displayed in Table 4. From the 425 CT results examined 41 (10%) were positive. All of the CT head scans with positive findings were indicated by NICE guidelines. None of the 61 patients who did not meet NICE criteria had a positive finding on CT. Therefore, in the subgroup with a NICE guideline indication for head CT, 41 of 364 patients (11.2%) had a positive finding.

Table 4
CT results and injuries identified

		All	< 65	> 65	Trauma Centre (Wellington)	District General Hospital (Hutt)
Clinically significant injury identified	Yes **N (%)**	41 (10)	19 (9)	22 (10)	29 (11)	12 (7)
Injuries identified **N (%)**	Skull Fracture	11 (3)	8 (4)	3 (1)	8 (3)	3 (2)
	Pneumocephalus	2 (0.5)	2 (1)	0	2 (1)	0
	Subdural bleed	8 (2)	3 (1.5)	5 (2)	6 (2)	2 (1)
	Extradural bleed	1 (0.5)	1 (0.5)	0	1 (0.5)	0
	Subarachnoid bleed	4 (1)	2 (1)	2 (1)	1 (0.5)	3 (2)
	Other intracranial bleed	9 (2)	4 (2)	5 (2)	6 (2)	3 (2)
	Contusion	9 (2)	5 (2.5)	4 (2)	7 (3)	2 (1)
	Traumatic infarction	0	-	-	-	-
	Diffuse axonal injury	0	-	-	-	-
	Brain herniation	0	-	-	-	-
Other **N (%)**	Inconclusive scan	3 (1)	2 (1)	1 (0.5)	3 (1)	0
	Other incidental finding	28 (7)	14 (7)	14 (6)	15 (6)	13 (8)
*p value < 0.05 comparison between age groups						
**p value < 0.05 comparison between EDs						

The characteristics of patients who had a positive CT head scan are displayed in Table 5.

Table 5
Characteristics of patients identified with clinically significant injury on head CT scan

		Clinically significant injury identified	**Yes** **N = 41** **N (%)**	**No** **N = 384** **N (%)**
Baseline Characteristics	Demographics	Male	**28 (68)***	**224 (58)**
		NZ European	24 (58.5)	253 (66)
		Maori	5 (12)	54 (14)
		Pacific Islander	2 (5)	11 (3)
		Other European	4 (10)	39 (10)
		Other	6 (14)	27 (7)
		Age < 65	19 (46)	183 (48)
		Alcohol intoxication	7 (17)	90 (23)
	Trauma	Isolated head injury	39 (97.5)	332 (86.5)
		Headache	21 (51)	179 (47)
	Risk factors	Coagulopathy	10 (24)	97 (25)
		Loss of consciousness	**13 (32)***	**79 (20)**
		Possible LOC	**14 (34)***	**85 (22)**
		> 1 episode of vomiting	3 (7)	44 (11/.5
		Seizures	0	23 (6)
		Retrograde amnesia > 30 min	8 (19.5)	61 (16)

*p value < 0.05 comparison between groups

		Clinically significant injury identified	Yes N = 41 N (%)	No N = 384 N (%)
		Repetitive Questioning/confusion	13 (32)	111 (29)
		Focal neurology	7 (17)	19 (5)
		Suspected skull fracture	1 (2)	5 (1)
		Suspected base of skull fracture	2 (5)	9 (2)
		Trauma above the clavicles	26 (63)	218 (57)
	TBI Severity	Mild (GCS 13–15)	32 (80)	329 (92)
		Moderate (GCS 9–12)	5 (12)	18 (5)
		Severe (GCS < 9)	3 (7)	12 (3)
CT Head Indication	Risk factor requiring CT head within 1 hour of recognition as per NICE Guidelines	GCS < 13	**7 (17)**	**30* (8)**
		Deterioration in condition following initial assessment	2 (5)	10 (3)
		GCS < 15 2 hours after injury on assessment in the ED	8 (19.5)	53 (14)
		Suspected open or depressed skull fracture	1 (2)	6 (1.5)
		Any sign of base of skull fracture	2 (5)	10 (3)
		Post-traumatic seizure	1 (2)	15 (4)
		Focal neurological deficit	**4 (10)**	**13* (3)**
		> 1 episode of vomiting since the head injury	2 (5)	39 (10)
		Current anticoagulation treatment	9 (21)	93 (24)

*p value < 0.05 comparison between groups

		Clinically significant injury identified	Yes N = 41 N (%)	No N = 384 N (%)
	Risk factor requiring CT head within 8 hours of the head injury	Age > 65	18 (44)	144 (37.5)
		Retrograde amnesia > 30 minutes	4 (10)	34 (9)
		Dangerous Mechanism	9 (22)	47 (12)
CT	Guidelines	NICE criteria met	**41 (100)***	321 (84)
		CT within 8 hours of injury (%)	75	60
		Arrived to ED within 8 hours of injury (%)	79	76
		Time to CT Report (min) Median (IQR)	31 (12–95)	26 (11–54)
		CT report within 60 minutes N (%)	29 (71)	300 (78)
*p value < 0.05 comparison between groups				

Patients with a positive CT scan were significantly more likely to report loss or possible loss of consciousness and on examination were more likely to have a GCS < 13 and focal neurology. Interestingly, 17/41 (41%) of patients with a significant injury identified had a GCS of 15 and no focal neurology. Nine of these 17 patients were on anticoagulation, 8 were > 65 with possible loss of consciousness or confusion, 4 had a dangerous mechanism with possible loss of consciousness, 2 had > 1 vomit, 1 had > 30minutes of retrograde amnesia, 1 had a suspected BOS fracture and 1 had a suspected skull fracture. Regarding patient outcomes, 1% (4/425) of patients required neurosurgical intervention and 3% (14/425) required ICU. 40% (171/425) were discharged from ED and 24% (101/425) were admitted to an ED observation unit.

Discussion

Our results show that 10% of patients who present to ED with TBI had a clinically significant injury identified on CT scan, and 1% required neurosurgical intervention. The majority of head injuries occurred in males, were mild and due to isolated head trauma. Those with a reduced GCS and focal neurology

were more likely to sustain an intracranial injury. Interestingly, one in four patients with a positive CT had a GCS 15, no focal neurology and were not on anticoagulation therapy.

NICE guidelines were adhered to in 86% of cases. Importantly, all significant injuries were identified with the use of NICE criteria in our study and those who did not meet criteria had negative head CT scans. This implies the guideline is relevant, valid and its clinical application is supported by ED doctors. A systematic review[16] investigating the adherence to guidelines in TBI showed that internationally compliance was quite variable between 18-100%. Adherence was highest in centres using guidelines based on strong evidence. Adherence to the NICE CT-scan guidance was highest, reaching 70-100% in the five studies referenced.[16]

Despite high compliance, this study does not prove that the NICE guideline is always clinically safe. In a larger study[17] 2.4% of patients with a positive CT scan did not meet NICE criteria. It is reasonable for clinicians to sometimes deviate from guidelines if their clinical judgement compels them to. However, one could argue that patients with negative CTs who did not meet NICE criteria had unnecessary exposure to radiation. This could be true for 14% of patients in this study which also has an impact on radiology use and ED length of stay.

Ninety percent of CT head scans performed in this study were negative. It is unlikely improving guideline compliance to 100% will significantly reduce the proportion of scans that are negative. Looking only at those patients meeting guideline indications, 11.2% were positive compared to 9.6% in the total cohort, so there would be a very small difference. Additional tools beyond guidelines would therefore be needed to significantly reduce the need for CT scans to exclude a clinically significant injury.

One in ten scans (10%) performed revealed a clinically significant injury. Prevalence of significant injury in Europe and Australasia has been reported at 8-9%.[17,18] The slightly higher incidence in this study may represent better selection of patients for CT in our study or conversely it could mean that the doctors were being over cautious and under ordering scans. It is not possible to determine this from our study and further prospective analysis would be required. Both departments included in this study have a high level of Emergency Medicine Specialist supervision which could result in better risk stratification. To the authors' knowledge, no significant injuries were missed during the study period. The most common injury identified on CT scan were skull fractures followed by intracranial bleeding, similar to findings in other studies.[17,19,20]

Unsurprisingly, it was significantly more likely for those who had lost or may have lost consciousness, had a GCS <13 and those with focal neurology to have a significant injury on CT scan. Remarkably, 40% of patients with a significant CT finding had a GCS of 15 with no focal neurology. Furthermore, half had no headache and 80% were classed according to GCS scores as having a mild head injury. This is not an anomalous outcome as other research supports these findings; for example, studies from Europe and the UK show that between 58-64% of patients with significant intracranial injuries seen on CT scan had a GCS 15.[17,20] Clinically this makes risk stratification without the aid of clinical tools and guidelines

difficult and means that clinicians cannot be reassured when a patient appears clinically unharmed. Significant intracranial pathology cannot be excluded based solely on clinical history, examination and GCS determination, again exposing the limitations of this approach and justifying the ongoing use of the NICE guidelines despite the low yield of injuries seen following CT head scanning.

CT head scans remain a vital diagnostic tool for ED clinicians. They are widely available, easily interpreted and able to detect life-threatening injuries rapidly.[21] However, in mild TBI particularly, finding the balance that minimizes unnecessary radiation exposure and economic costs whilst ensuring that patients with potentially dangerous intracranial hemorrhages are identified remains challenging.[21] Because of the current limitations excluding TBI clinically in ED, research into the detection and use of objectively measured clinical biomarkers has increased exponentially over the last decade. Evidence supports the use of biomarkers as negative predictors of acute TBI detected on CT scans.[5,22] In Scandinavia and other areas of Europe, guidelines are in use that include biomarkers as objective tests to aid decisions regarding which patients require CT scans as part of their management.[22,23] It has decreased CT rates by 32% and is estimated to save 71 euros per patient.[23]

This study highlights some key learning points for ED clinicians as displayed in Table 6. The limitations of this study relate to the data collection process and retrospective design. The method used to identify patients for this study is likely to have missed patients who did not have the words ‘injury’ or ‘trauma’ in the CT head indication field. Given our baseline demographics and presenting features are similar to international literature its likely our sample can still draw valuable conclusions. Furthermore, compliance with guidelines was measured based on documentation rather than knowing specifically what the clinician asked and identified. However, it is largely accepted that clinical documentation including key decisions should be recorded as standard. Future prospective studies reviewing all TBI presentations including those who do not undergo CT scan would be useful to further review guideline adherence.

Table 6

Key Learning Points

· Using validated clinical decision tools such as NICE guidelines to determine which patients should undergo CT head scanning following TBI is safe and effective
· The most common significant CT head findings in TBI patients are skull fractures and intracerebral bleeding
· Loss of consciousness is the most predictive presenting symptom to signify a significant CT head finding- take this seriously
· Significant intracranial pathology cannot be excluded based solely on clinical history, examination and GCS determination

Conclusion

CT head scans are a valuable tool in TBI and guidelines successfully identify those with significant intracranial injuries. This study supports the ongoing use of clinical guidelines given the rate of significant injuries seen in patients with an absence of other clinical symptoms. However, the rate of significant injury for the total population requiring head CT remains low, with over 90% of head CTs in the population normal. This finding persists despite high guideline compliance, potentially highlighting a need to explore the use of novel objective biomarkers in ED TBI guidelines internationally.

Declarations

Ethics approval and consent to participate

Research was conducted in accordance with ethical approval obtained from the University of Otago Human Ethics committee (Reference HD20/001).

Consent for publication

All authors agreed upon the final reading of this manuscript and met the specified author requirements.

Availability of data and materials

The data that supports the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors have no conflicts of interest or financial disclosures.

Funding

No funding was sought for this study.

Authors' contributions

Project design by AR, DM, PL, data collection AR, VP, JL, HS, JB, analysis AR, PL, write up AR, PL, DM, VP, JB, HS, JL, final article review and agreement by all authors. The authors have no conflicts or competing interests to declare

Acknowledgements

The authors would like to thank Hutt and Wellington Emergency Departments for their data contributions; the research offices at CCDHB and HVDHB for their local approval and support; the RAG-M and University of Otago Health Committees for their approval and the University of Otago (Wellington) Department of Surgery and Anaesthesia for their expertise and support.

References

1. Wang KK, Yang Z, Zhu T, et al. An update on diagnostic and prognostic biomarkers for traumatic brain injury. Expert Rev Mol Diagn. 2018;18(2):165–80. doi:10.1080/14737159.2018.1428089.
2. Feigin VL, Theadom A, Barker-Collo S, et al. Incidence of traumatic brain injury in New Zealand: A population-based study. Lancet Neurol. 2013. doi:10.1016/S1474-4422(12)70262-4.
3. King D, Hume PA, Hardaker N, Pearce A, Cummins C, Clark T. Traumatic brain injuries in New Zealand: National Insurance (Accident Compensation Corporation) claims from 2012 to 2016. J Neurol Sci. 2019;399:61–8. doi:10.1016/j.jns.2019.01.049.
4. DeAngelis J, Lou V, Li T, et al. Head CT for minor head injury presenting to the Emergency Department in the Era of choosing wisely. Western Journal of Emergency Medicine. 2017;18(5):821–9. doi:10.5811/westjem.2017.6.33685.
5. Bazarian JJ, Biberthaler P, Welch RD, et al. Serum GFAP and UCH-L1 for prediction of absence of intracranial injuries on head CT (ALERT-TBI): a multicentre observational study. Lancet Neurol. 2018;17(9):782–9. doi:10.1016/S1474-4422(18)30231-X.
6. The Use. of CT Scanners in the Emergency Department. www.austinpublishinggroup.com.
7. Baloescu C. Diagnostic Imaging in Emergency Medicine: How Much Is Too Much? Ann Emerg Med. 2018;72(6):637–43. doi:10.1016/j.annemergmed.2018.06.034.
8. Kelly A-M, Kerr D, Kelly A-M. *Are Too Many Head CT Scans Ordered in Emergency Departments?*.
9. Brenner DJ, Hall EJ, Phil D. *Computed Tomography-An Increasing Source of Radiation Exposure*. Vol 357.; 2007. .
10. Fayngersh V, Passero M. Estimating radiation risk from computed tomography scanning. Lung. 2009;187(3):143–8. doi:10.1007/s00408-009-9143-9.
11. Lagerstedt L, Egea-Guerrero JJ, Bustamante A, et al. H-FABP: A new biomarker to differentiate between CT-positive and CT-negative patients with mild traumatic brain injury. PLoS ONE. 2017;12(4). doi:10.1371/journal.pone.0175572.
12. Stiell IG, Clement CM, Rowe BH, et al. *Comparison of the Canadian CT Head Rule and the New Orleans Criteria in Patients With Minor Head Injury*. https://jamanetwork.com/.
13. Composite CM *Y CM MY CY CMY K*.
14. AUSTRALASIAN COLLEGE FOR EMERGENCY MEDICINE:. *TESTS, TREATMENTS AND PROCEDURES HEALTH PROFESSIONALS AND CONSUMERS SHOULD QUESTION ACEM Is the Not-for-Profit*

Organisation Responsible for Training Emergency Physicians and Advancing Professional Standards in Emergency Medicine in Australia and New Zealand.

15. Howkins J, Ngoma C, Sattar H, Sukumar J. Emergency department use of NICE guidelines for CT imaging in head trauma: an audit cycle. Clin Radiol. 2017;72:15. doi:10.1016/j.crad.2017.06.017.
16. Cnossen MC, Scholten AC, Lingsma HF, et al. Adherence to Guidelines in Adult Patients with Traumatic Brain Injury: A Living Systematic Review. J Neurotrauma. August 2016. doi:10.1089/neu.2015.4121.
17. Foks KA, van den Brand CL, Lingsma HF, et al. External validation of computed tomography decision rules for minor head injury: Prospective, multicentre cohort study in the Netherlands. BMJ. 2018;362. doi:10.1136/bmj.k3527.
18. Pozzato I, Meares S, Kifley A, et al. Challenges in the acute identification of mild traumatic brain injuries: Results from an emergency department surveillance study. BMJ Open. 2020;10(2). doi:10.1136/bmjopen-2019-034494.
19. Seidel J, Bissell MB, Vatturi S, Hartery A. Retrospective Analysis of Emergency Computed Tomography Imaging Utilization at an Academic Centre: An Analysis of Clinical Indications and Outcomes. Can Assoc Radiol J. 2019;70(1):13–22. doi:10.1016/j.carj.2018.10.004.
20. Marincowitz C, Lecky FE, Allgar V, et al. Development of a Clinical Decision Rule for the Early Safe Discharge of Patients with Mild Traumatic Brain Injury and Findings on Computed Tomography Brain Scan: A Retrospective Cohort Study. J Neurotrauma. 2020;37(2):324–33. doi:10.1089/neu.2019.6652.
21. Amyot F, Arciniegas DB, Brazaitis MP, et al. A Review of the Effectiveness of Neuroimaging Modalities for the Detection of Traumatic Brain Injury. doi:10.1089/neu.2013.3306.
22. Calcagnile O, Undén L, Undén J. Clinical validation of S100B use in management of mild head injury. BMC Emerg Med. 2012;12. doi:10.1186/1471-227X-12-13.
23. Undén L, Calcagnile O, Undén J, Reinstrup P, Bazarian J. Validation of the Scandinavian guidelines for initial management of minimal, mild and moderate traumatic brain injury in adults. BMC Med. 2015;13(1). doi:10.1186/s12916-015-0533-y.