**CT head imaging in head injury patients that present after 24 hours of injury: A descriptive study**

**Correspondence to:**

**Dr Carl Marincowitz, CT3 Emergency Medicine, Emergency Department, Hull Royal Infirmary, Anlaby Road, Hull, HU3 2JZ**

**Cm444@doctors.org.uk**

**Other Authors:**

**Dr Victoria Allgar, Senior Statistician Hull York Medical School, John Hughlings Jackson Building, University of York Heslington, York, YO10 5DD**

**and**

**Mr William Townend, Consultant Emergency Medicine, Emergency Department, Hull Royal Infirmary, Anlaby Road, Hull, HU3 2JZ**

**Key Words: Head Injury, Delayed presentation and Computed Tomography Imaging**

**Word Count: 2447**

**Abstract**

Background:

NICE guidelines, used to triage the 1.4 million patients attending the ED with head injury, in England and Wales annually for CT imaging are based on research conducted in populations presenting within twenty-four hours of injury. We therefore aim to compare guideline use and outcomes in head injury patients that undergo CT imaging presenting within and after 24 hours of injury.

Methods:

Emergency Department (ED) trauma Computed Tomography (CT) head scan requests from Hull Royal Infirmary, over a period of 6 months, were matched to ED records. Case note review of adult patients that had undergone CT head imaging was completed and data extracted on: time to presentation; the presence of a guideline indication for imaging; CT findings; and outcomes. Logistic regression was used to assess whether presentation after 24 hours affected the guideline’s ability to predict significant injuries.

Results:

650 CT head scans matched to case records were available for analysis. Overall, 8.6% (56/650) showed a traumatic abnormality; 1.2% (8/560) required neurosurgery and 0.3% (2/650) died. Of this sample, 15.5% (101/650) of CT head scans were for patients presenting after 24 hours. The CT abnormality rate was 8.4% (46/549) for those presenting within, and 9.9% (10/101) for those presenting after 24 hours. The sensitivity of the guidelines for intracranial injuries was 98% (95% CI: 87.0-99.9%) in those presenting within 24 hours and 70% (95% CI: 35.4-91.9%) in those presenting after 24 hours of injury.

The presence of a guideline indication was found to be statistically predictive of significant traumatic pathology and this was unaffected by time of presentation

Conclusion:

Head injury patients presenting after twenty-four hours of injury are a clinically significant population. Although existing clinical-decision rules appear to accurately predict traumatic CT abnormalities in head injury patients irrespective of delay in presentation, their sole use in patients presenting after 24 hours may result in significant injuries not being identified. Other factors may warrant investigation in this group.

Introduction

Head injuries account for an estimated 1.4 million annual Emergency Department (ED) attendances in England and Wales [1]. Ninety-five per cent of such attendances are for minor/mild head injuries [1]. Only 1% of these patients have neurosurgical interventions and 5% of patients have injuries of sufficient significance to warrant hospital admission [2]. Research in this area has concentrated on developing clinical decision rules to aid the clinical risk stratification of mild/minor head injury patients into: those who can be discharged on the basis of their clinical history and examination; and those who require a CT head scan to rule out significant intra-cranial pathology. Decision-rule research has almost exclusively been conducted on patients presenting within twenty-four hours of injury [3]. In the UK the National Institute for Health and Care Excellence (NICE) guidelines are used to aid this risk assessment. They are based upon the Canadian CT head Rule (CCHR), and this is used widely internationally [1]. This was derived and validated in patients presenting within twenty-four hours of injury [3-6].

Patients presenting after twenty-four hours of injury are a potentially distinct sub-population. They could be lower risk, as there is evidence that mild/minor head-injury patients that have injuries requiring neurosurgery will deteriorate within twenty-four hours [7-9]. Alternatively, they could be a self-selecting higher risk group attending due to the worsening or persistence of symptoms [10]. The lack of research about this group is acknowledged in the research literature [10-12]. There are few studies that even estimate the size of this population. One study found that approximately a third of a cohort of patients presenting after four hours of injury presented after twenty-four hours [11]. In contrast, an older study found only 6.7% of ED head-injury patients to present after twelve hours of injury [13].

If patients presenting after twenty-four hours represent a lower-risk group, then a lower comparative rate of intra-cranial injury would be expected. A single study has found that comparable risk factors to those present in NICE guidelines are predictive of traumatic CT abnormalities in head-injury patients presenting after four hours of injury [11]. However, how well the guidelines identify injuries in patients presenting after 24 hours, a group where the CCHR has not been validated, has not been assessed.

Aim:

The aim of this study is to compare guideline use and outcomes in head injury patients that undergo CT imaging presenting within and after 24 hours of injury.

The specific objectives were to:

1) Estimate the proportion of adult head-trauma CT scans performed for patients presenting after twenty-four hours of injury.

2) Compare the prevalence of traumatic CT findings in head-injury patients that undergo CT head imaging presenting within and after twenty-four hours of injury.

3) Compare the use and sensitivity of the 2007 NICE guidelines in head-injury patients that undergo CT head imaging presenting within and after twenty-four hours of injury.

Methods

*Study Participants*

Six months of all ED CT head requests at Hull Royal Infirmary (HRI) from Nov 2011 were available through the electronic requesting system. These were reviewed and all requests obviously not for head trauma removed. The remaining electronic requests were matched to the HRI ED electronic records and reporting systems. These electronic records included: scanned ED patient encounter records; CT head scan images; CT head scan reports; patient discharge letters (including notification of cause of death to the patient’s General Practitioner (G.P.) where applicable); and operation notes. Where information was incomplete the patients’ physical case notes were reviewed. Included patients had to have had a CT head scan for the sole investigation of head trauma and be over sixteen years of age.

*Exclusion Criteria*

Cranial CT scans requested as part of trauma series were excluded. Attendances were excluded from the final analysis where the ED records were incomplete, including where timing of presentation was not possible.

*Data Extraction*

Data extraction was undertaken, as outlined by an a priori audit protocol, for: demographic information; mechanism of injury; presence of individual NICE indications for a CT (indications based on NICE guidelines 2007); whether presentation was within or after twenty-four hours of injury; whether the patient was re-attending with an existing injury; CT head findings; neurosurgical outcomes; and death.

*Outcomes*

For the purposes of this study a significant CT head finding had to be of a new traumatic intra-cranial injury, including skull fractures, contusions and any type of intra-cranial haemorrhage. Existing findings and non-traumatic abnormalities were not recorded. Neurosurgical outcomes were defined as: intubation; any form of invasive intra-cranial pressure monitoring; craniotomy; burr hole procedure; and any surgical procedure for the treatment of a skull fracture. Deaths up to 18 months following a head injury were included as an outcome where an intra-cranial injury caused by a documented head injury was either the primary or a contributory cause of death.

*Statistical Analysis*

Descriptive statistics (mean (sd) and n (%)) were calculated for demographic and presenting characteristics of the patients that underwent CT and, by group presenting within and after 24 hours of injury. The groups were compared for the outcome measures: prevalence of traumatic CT findings; whether or not there was a neurosurgical intervention; and death. The proportion in each group who had an indication for the completed CT head scans was also compared. Pearson Chi-Square test or Fishers Exact test are used to compare groups. The sensitivity of the guidelines for neurosourgical intervention and significant traumatic CT findings was calculated for each group. This analysis was specified a priori in an audit protocol.

Logistic regression analysis was undertaken post hoc with traumatic CT finding as the dependant variable and the independent variables: presence of an indication for CT head scan; presentation within or after 24 hours of injury; and the interaction between the two independent variables. This was included to explore whether presence of a CT head indication affects traumatic CT finding differently in those with delayed presentation. Given the proportion of intra-cranial injuries was 8.6% and there were 650 CT head scans included in the analysis, 5 explanatory variables could be investigated [14].

Sensitivity and logistic regression analysis was repeated with CT head scans associated with re-attendances excluded to ensure this was not acting as a confounding factor or causing clustering in the logistic regression analysis. This is unlikely given the small number of such patients. All analyses were undertaken on SPSS (v22), a p-value of < 0.05 was considered to indicate statistical significance and a 95% confidence interval was calculated for outcomes of interest.

*Research Ethics*

Collection of these data was undertaken as part of a clinical audit assessing CT head requesting practice against national NICE guidelines. A formal Integrated Research Application System (IRAS) application was made for the use of the data to address the research questions posed in this paper. The relevant Health Research Authority Research Ethics Committee were satisfied that formal ethical approval was not required for the secondary use of audit data for this project.

Results

In the study period, there were 2240 ED CT head requests. Of these requests 676 matched the inclusion criteria for adult head trauma. The remaining 1564 CT head scans were requested for the investigation of: stroke, headaches, seizures, confusion and reduced Glasgow Coma Scale (GCS). Complete ED records were only available for 650 of these requests and therefore 26 CT head scans were not included in analysis. Of the 650 included CT scans, 101 were for patients presenting after twenty-four hours of injury.

Table 1 shows the descriptive summary of the total sample and for those presenting within or after twenty-four hours of injury. The mean age was 53.0 (SD=24.0), which was similar between groups. Overall, 61% were male, and there was a higher proportion of males in those presenting within 24 hours compared to after 24 hours. The vast majority of patient presented with minor head injuries and this was similar in both groups. The proportion of patients re-attending with an existing injury was only 3%, but there were more re-attenders in the delayed presentation group (16% versus 0.2%). The majority of patients had fallen, or been assaulted, with little variation between groups. A higher proportion of patients presenting within 24 hours of injury had risk factors associated with the circumstances of injury present, such as loss conscious and the presence of a dangerous mechanism of injury. They were also more likely to be recorded as being intoxicated (41.3% versus 7.9%). A higher proportion of patients presenting after 24 hours of injury had NICE risk factors present associated with on-going symptoms including: vomiting, seizures and focal neurological deficits.

**Table 1: Characteristics of patients by time of presentation after injury**

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Overall n=650 | Within 24 hours n=549 | After 24 hours n=101 |
| Age (Mean (sd) | 53.0 (24.0) | 53.5 (24.2) | 50.4 (23.0) |
| Sex (n (%) Male) | 394 (60.6%) | 346 (63.0%) | 48 (47.5%) |
| Re-attendance (n (%)) | 17 (2.6%) | 1 (0.2%) | 16 (15.8%) |
| Initial GCS 13,14 or 15 (n (%)) | 620 (95.5%) | 521 (94.8%) | 99 (98.0%) |
| Mechanism of Injury | Overall | Within 24 hours | After 24 hours |
| Fall | 405 (62.3%) | 355 (64.7%) | 50 (49.5%) |
| Assault | 145 (22.3%) | 122 (22.2%) | 23 (22.8%) |
| RTC | 46 (7.1%) | 37 (6.7%) | 9 (8.9%) |
| Sports | 13 (2.0%) | 7 (1.3%) | 6 (5.9%) |
| Accident (non-Specified) | 27 (4.2%) | 14 (2.6%) | 13 (12.9%) |
| Unknown | 14 (2.2%) | 14 (2.6%) | 0 |
| Presence of risk factor | | | |
| Factor | Overall | Within 24 hours | After 24 hours |
| Intoxicated at time of injury Alcohol Drugs | 325 (36.2%) 229 (35.2%) 6 (0.9%) | 227 (41.3%) 222 (40.4%) 5 (0.9%) | 8 (7.9%) 7 (6.9%) 1 (1.0%) |
| Dangerous Mechanism | 82 (12.6%) | 77 (14.0%) | 5 (5.0%) |
| Retro-grade amnesia greater 30 mins | 101 (15.5%) | 100 (18.2%) | 1 (1.0%) |
| Post-traumatic amnesia | 282 (43.4%) | 266 (48.5%) | 16 (15.8%) |
| LOC | 270 (41.5%) | 241 (43.9%) | 29 (28.7%) |
| Vomiting | 115 (17.7%) | 87 (15.8%) | 28 (27.7%) |
| Signs of Basal Skull fracture | 25 (3.8%) | 22 (4.0%) | 3 (3.0%) |
| Signs of depressed/open Skull fracture | 629 (3.2%) | 17 (3.1%) | 4 (4.0% |
| Post-traumatic seizure | 24 (3.7%) | 15 (2.7%) | 9 (8.9%) |
| Focal Neurological Deficit | 34 (5.2%) | 23 (4.2%) | 11 (10.9%) |
| Age≥65 | 221 (34.0%) | 192 (35.0%) | 29 (28.7%) |

*Outcomes*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Outcome** | **Overall n=650** | **Within 24 hours n=549** | **After 24 hours n=101** | **P value** |
| Traumatic CT finding | 56 (8.6%) | 46 (8.4%) | 10 (9.9%) | p=0.62 |
| Neurosurgical intervention | 8 (1.2%) | 5 (0.9%) | 3 (3.0%) | p=0.11 |
| Death | 2 (0.3%) | 1 (0.2%) | 1 (1.0%) | p=0.29 |
| No NICE indication | 114 (17.5%) | 75 (13.7%) | 39 (38.6%) | p<0.001 |

Table 2 summarises overall outcomes and as stratified by time of presentation. 8.6% of the CT scans showed a significant traumatic abnormality and the proportion of injuries identified by CT imaging was similar in the 2 time groups. Overall, 1.2% of patients required neurosurgery and the proportions were also similar in patients presenting within and after twenty-four hours of injury. Two patients died, with 1 death in each time group. There were 56 traumatic CT findings and these results are summarised in Table 3 and classified by the major abnormality where there were multiple findings.

Table 2: Outcome measures

Table 3: Type of traumatic CT finding

|  |  |  |  |
| --- | --- | --- | --- |
| **Outcome** | **Total**  **n=56** | **Within 24 hours**  **n=46** | **After 24 hours**  **n=10** |
| Extra-dural | 6 (10.7%) | 5 (10.9%) | 1 (10.0%) |
| Sub-dural | 14 (25.0%) | 8 (17.4%) | 6 (60.0%) |
| Sub-arachnoid | 9 (16.1%) | 8 (17.4%) | 1 (10.0%) |
| Skull Fracture | 8 (14.3%) | 7 (15.2%) | 1 (10.0%) |
| Contusion | 4 (7.1%) | 4 (8.7%) | 0 |
| Intra-cerebral Haemorrhage | 6 (10.7%) | 6 (13.0%) | 0 |
| Skull Fracture+ Contusion | 3 (5.4%) | 2 (4.3%) | 1 (10.0%) |
| Skull Fracture+ intra-cerebral/Sub-arachnoid haemorrhage | 6 (10.7%) | 6 (13.0%) | 0 |

*Presence of a Guideline Indication*

There was no guideline indication present for 13.7% of those presenting within twenty-four hours of injury and 38.6% of those presenting after twenty-four hours of injury. This was a statistically significant difference (p<0.001).

*Sensitivity analysis*

Table 4 shows the outcome measures and presence of a guideline indication stratified by time of presentation. In those who presented within 24 hours, the sensitivity of the guidelines for traumatic intra-cranial CT findings was 97.8% (95% CI: 87.0-99.9%) and 100% (95% CI: 51.7-100%) for neurosurgical outcomes or death. In those who presented after 24 hours the sensitivity of the guidelines for traumatic intra-cranial CT findings was 70% (95% CI: 35.4-91.9%) and 75% (95% CI: 21.9-98.8%) for neurosurgical outcomes or death.

**Table 4: Outcome measures by NICE indication and time to presentation after injury.**

|  |  |  |
| --- | --- | --- |
|  | **NICE Indication for CT Head** | **No NICE indication for CT head** |
| **Patients Presenting within 24 hours (549)** | n=474 | n=75 |
| Intra-cranial Injury | 45 (9.5%) | 1 (1.3%) |
| Neurosurgical intervention | 5 (1.1%) | 0 |
| Death | 1 (0.2%) | 0 |
| **Patients Presenting after 24 hours (101)** | n=62 | n=39 |
| Intra-cranial Injury | 7 (11.3%) | 3 (7.7%) |
| Neurosurgical intervention | 2 (3.2%) | 1 (2.6%) |
| Death | 1 (1.6%) | 0 |

Logistic regression was used to explore traumatic intra-cranial CT head abnormalities and the relationship between the presence of an indication for a CT head scan and presentation within or after twenty-four hours of injury. In the model presence of a guideline indication predicted abnormal traumatic findings (p=0.04), whilst whether presentation occurred after twenty-four hours of injury did not (p=0.12). The interaction between NICE indication and time of presentation was not significant (p=0.19). Hence there was no evidence that a NICE indication affects a traumatic CT finding differently in those presenting within and after 24 hours of injury. The Hosmer-Lemeshow Goodness of Fit Test has an associated P value of 1.

*Re-attending Patients*

There were 17 patients that re-attended with the same injury. Of these 16 had not undergone CT head imaging at their first presentation and underwent cranial CT imaging at their re-presentation. One patient underwent CT head imaging at their first presentation and an intra-cranial haemorrhage was identified. This was managed conservatively and they were discharged. They re-presented due to worsening symptoms and underwent a further CT head scan. This showed no new pathology and therefore was not counted as a positive scan in analysis. Sixteen of the completed scans for re-attending patients were completed for presentations after twenty-four hours of injury.

Re-attending head injury patients have previously been identified as a high-risk group [15]. Analysis was repeated with CT head scans associated with re-attending patients excluded to test whether the differences the found were due this potentially confounding factor. The proportion of injury for patients presenting within and after twenty-four hours remained similar: 8.4% and 7.1% respectively. The sensitivity of the guidelines for patients presenting within twenty-four hours is unaltered by the exclusion or re-attenders. For patients presenting after twenty-four hours the sensitivity for intra-cranial injury decreases slightly to 66.7% (24.1-94% 95% C.I.). Significantly, the only patient with a neurosurgical outcome where there was no guideline indication for a CT head scan, was a re-attending patient.

When re-attending patients were excluded from the logistic regression analysis, the presence of a guideline indication for a CT head remained statistically significant as a predictor of intra-cranial injury and whether presentation occurred within or after twenty-four hours of injury did not. The interaction between the presence of NICE indication and time of presentation remained not significant.

Discussion:

This study has identified head injury patients presenting after twenty-four hours of injury as being clinically significant population that accounted for 15.5% of cranial CT scans for adult head trauma. A similar rate of CT identified traumatic brain injury was detected in this group as in patients presenting earlier. The presence of a CCHR based CT head indication was found to be predictive of significant traumatic pathology irrespective of time of presentation. However, in patients presenting after 24 hours the strict application of the guideline would have failed to identify a higher proportion of significant injuries including an injury that required neurosurgery.

This is a small study with small numbers of patients presenting after 24 hours and with traumatic CT findings. There are also other potential limitations. Patients presenting after twenty-four hours were found to be significantly less likely to have NICE indications pertaining to the circumstances of injury such as loss of consciousness and the presence of a dangerous mechanism of injury. This is likely due to patients with dangerous mechanisms of injury or immediate symptoms presenting earlier after their injuries. However, it could reflect recall bias where patients presenting in a delayed manner are less likely to remember these factors and therefore be correctly assessed. This would undermine the validity of conclusions drawn about the difference in the application and sensitivity of the NICE guidelines.

This study has only evaluated a cohort of head injury patients that have undergone CT imaging and therefore no estimate of the specificity of the guidelines can be made. The estimated prevalence of intra-cranial injury is only for this patient group and will be higher than the prevalence of such injuries in all head injury patients. Patients that did not have CT scans but had serious intra-cranial pathology that failed to represent to the HRI within the 6 month period may also have been missed. A small number of incomplete records meant that some eligible patients were excluded from analysis. This is a potential source of selection bias, although the low number of such patients makes this risk small. Finally, as this study uses a retrospective case note review for data extraction it is limited by how accurately and completely information was recorded.

To the knowledge of the authors, this is the first study undertaken that directly compares a cohort of delayed presentation head injury patients to a non-delayed comparator population. It has identified head injury patients presenting more than twenty-four hours following an injury as a significant clinical population The overall prevalence of significant injuries was found to be 8.6% which is comparable to that reported in other studies [15-18]. The prevalence of traumatic intra-cranial pathology and neurosurgery was comparable in the two groups. This would suggest that patients presenting after twenty-four hours are not a lower risk group.

The strict application of current head injury decision rules to patients presenting after 24 hours of injury may risk missing a high proportion of clinically significant injuries (30% in this cohort). Tellingly, clinicians appear to be aware of this and were found to be statistically significantly more likely to request a CT head scan when no NICE indication was present in this group.

Conclusion:

Further research is required to identify the risk factors that predict significant intra-cranial injuries in patients presenting after twenty-four hours of injury. Clinicians should be aware that this group has a distinct risk-profile and that a lack of a guideline indication for a CT scan does not rule out significant intra-cranial injuries in this group.

Acknowledgements:

Paul Williams a research nurse based at Hull Royal Infirmary provided invaluable help with the data collection involved in this project.

Competing interests:

None

1. NICE. National Clinical Guidance Centre. (2014). CG 176 Head Injury Triage, assessment, investigation and early management of head injury in children, young people and adults. National Institute for Health and Care Excellence. In: NICE, ed. UK: DOH, 2014.

2. Pandor A, Goodacre S, Harnan S, et al. Diagnostic management strategies for adults and children with minor head injury: a systematic review and an economic evaluation. Health Technol Assess 2011;**15**(27):1-202.

3. Harnan SE, Pickering A, Pandor A, et al. Clinical decision rules for adults with minor head injury: a systematic review. The Journal of trauma 2011;**71**(1):245-51.

4. Stiell IG, Wells GA, Vandemheen K, et al. The Canadian CT Head Rule for patients with minor head injury. Lancet 2001;**357**(9266):1391-6.

5. Smits M, Dippel DW, de Haan GG, et al. External validation of the Canadian CT Head Rule and the New Orleans Criteria for CT scanning in patients with minor head injury. Jama 2005;**294**(12):1519-25.

6. Smits M, Dippel DW, de Haan GG, et al. Minor head injury: guidelines for the use of CT--a multicenter validation study. Radiology 2007;**245**(3):831-8.

7. Alahmadi H, Vachhrajani S, Cusimano MD. The natural history of brain contusion: an analysis of radiological and clinical progression. J Neurosurg 2010;**112**(5):1139-45.

8. Reynolds FD, Dietz PA, Higgins D, et al. Time to deterioration of the elderly, anticoagulated, minor head injury patient who presents without evidence of neurologic abnormality. The Journal of trauma 2003;**54**(3):492-6.

9. Choudhry OJ, Prestigiacomo CJ, Gala N, et al. Delayed neurological deterioration after mild head injury: cause, temporal course, and outcomes. Neurosurgery 2013;**73**(5):753-60; discussion 60.

10. New South Wales Government Ministry of Health (2012). Closed Head Injury in Adults - Initial Management. Available from: http://www0.health.nsw.gov.au/policies/pd/2012/pdf/PD2012\_013.pdf.

11. Barrow A, Ndikum J, Harris T. Late presentations of minor head injury. Emergency medicine journal : EMJ 2012;**29**(12):983-8.

12. Marincowitz C, Smith CM, Townend W. The risk of intra-cranial haemorrhage in those presenting late to the ED following a head injury: a systematic review. Systematic reviews 2015;**4**(1):165.

13. Hemphill RR, Santen SA, Kleinschmidt PE. Delayed presentation after head injury: is a computed tomography scan necessary? Academic emergency medicine : official journal of the Society for Academic Emergency Medicine 1999;**6**(9):957-60.

14. Stoltzfus JC. Logistic regression: a brief primer. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine 2011;**18**(10):1099-104.

15. Voss M, Knottenbelt JD, Peden MM. Patients who reattend after head injury: a high risk group. Bmj 1995;**311**(7017):1395-8.

16. Albers CE, von Allmen M, Evangelopoulos DS, et al. What is the incidence of intracranial bleeding in patients with mild traumatic brain injury? A retrospective study in 3088 Canadian CT head rule patients. Biomed Res Int 2013;**2013**:453978.

17. Haydel MJ, Preston CA, Mills TJ, et al. Indications for computed tomography in patients with minor head injury. N Engl J Med 2000;**343**(2):100-5.