ORIGINAL ARTICLE

Cranial computed tomography in trauma: the accuracy of interpretation by staff in the emergency department

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Objectives: Cranial computed tomography (CT) is replacing skull radiography in head trauma. Rapid radiological opinions on these images may not always be available. We assessed the ability of our permanent emergency department staff to interpret the images.

Methods: A retrospective series of 100 consecutive cases was reviewed and interpreted by five permanent emergency department medical staff, and their interpretation compared with the consensus opinion of two radiologists.

Results: An overall agreement of 86.6% (95% confidence interval (CI) 83.4 to 89.9) was achieved, with a false negative rate of 4.2% (95% CI 3.9 to 4.3). No findings that would have changed the overnight management of any patient were missed.

Conclusions: Our results for CT scans are similar to studies of interpretation of other radiographic images in emergency departments. Our emergency staff could safely make the initial interpretation of cranial CT images in trauma out of hours, and formal reporting may wait until a suitably experienced radiologist is available.

Discrepancies in plain radiograph interpretation between emergency department (ED) staff and radiologists have been the subject of study by various groups.[1–6] Rates of disagreement in the range of 8–11% are reported; however, many of the misinterpretations have no clinical impact.[4] Initial interpretation of plain radiographs by ED staff, supported by subsequent radiologist reports, has been standard practice for many years. Differences in the interpretation of computed tomography (CT) head scans between clinicians and neuroradiologists have also been investigated. Mehta *et al* showed a disagreement between clinicians and neuroradiologists in over 20% of cases and suggested that management change would be seen in 6.6%.[7] Similarly, Alfaro *et al* found discordance in 38.7% of cases, in 11.4% of which the disagreement was major.[8] This study was not confined to trauma cases, and the timescale in management change was not significant in most cases. They concluded that mismanagement due to clinicians' opinion of the images is rare.

Recent clinical guidelines in the UK from the National Institute of Clinical Excellence[9] (NICE) and the Scottish Intercollegiate Guidelines Network[10] (SIGN) promote the widespread use of cranial CT in head injury, with skull radiographs being relegated to a few specialist uses. This will result in a large increase in the number of cranial CT scans performed. The NICE guidelines state that image interpretation should be carried out by a "competent clinician", but who this should be is not stated. In this study we ask whether ED staff could make the initial interpretation of these images in the same way as they do for plain radiographs, or if this would result in serious missed diagnoses, which would alter immediate management.

METHODS

All out of hours CT scans performed in our hospital are recorded by our computerised radiology management system and a manual paper record kept by the radiographers. These records and the radiology request forms were searched to identify 100 consecutive cases where the patient presented with a known or suspected history of trauma. Cases where there were medical reasons for the examination but no suspicion of trauma were excluded. The study group was a mixed population of adults and children.

The images and original radiologists' reports were reviewed by two experienced consultant radiologists (BM and LH). In three cases the original report was equivocal. Using the images, clinical history, and outcomes, a consensus "reference standard" report was reached in the 100 cases. The findings were classified into normal (n = 59), abnormal related to presentation (n = 36), and abnormal but incidental finding (n = 5).

Original hard copy laser images were reviewed by five permanent members of the ED medical staff (two consultants, three staff grades). A unique study number identified each case. The images were not anonymised but all were at least a year old and were randomly ordered to minimise the risk of cases being recognised. The images were viewed using our standard head window levels in all cases (level +35, width 60 Hounsfield units). Where available in the patient's folder, bone window images were also provided. A short history for each case was given, which was transcribed from the original request form. The readers recorded their interpretations of the images using a combination of free text and diagrammatic representation of the scan image. They were asked to indicate in each case if neurosurgical referral was warranted on the basis of the imaging findings.

The ED staff reports were compared with the radiological consensus, and cases classified into true positive, true negative, false positive, and false negative interpretations. For the purpose of false negative classification, missed incidental findings were not included, as they were classified as true negatives.

RESULTS

The results from the ED readers compared with the radiological standard are given in table 1.

Abbreviations: CT, computed tomography; ED, emergency department; NICE, National Institute of Clinical Excellence; SIGN, Scottish Intercollegiate Guidelines Network

Table 1 Results from the ED readers compared with the radiological standard

Reader	True negative	True positive	False negative	False positive
A	49	35	4	12
B	53	33	4	10
C	54	32	5	9
D	57	34	5	4
E	54	32	5	9

The false negative rates ranged from 4 to 5%, with a mean of 4.2% (95% confidence interval (CI) 3.9 to 5.3%). Mean agreement with the gold standard is 86.6% (95% confidence interval 83.4 to 89.9%). Review of the false negative responses showed that seven cases accounted for all 23 false negative readings (table 2).

No case was a false negative for all five readers. Radiologically, all the false negative cases had subtle findings, and none was considered to merit immediate transfer to the regional neurosurgical unit under NICE guidelines.[9]

Review of the false positive responses showed a wider spread of cases. In total, 43 false positive reads were spread across 25 different scan areas. Most were imaging artefacts or normal anatomical variants. A large but normal cisterna magna was identified by four readers as a possible abnormality needing a surgical opinion. Various streak artefacts were called bleeding in three cases (six reading episodes).

No abnormality warranting immediate neurosurgical referral was missed by the clinicians in the study.

DISCUSSION

Cranial CT is likely to replace skull radiography for patients with significant head injury in the near future. Initial interpretation of these images by competent clinicians will be required. If ED staff could do this, it is likely to be the most rapid and cost effective process, but it must be shown to be safe.

Overall accuracy of ED staff in the initial interpretation of radiographs has been studied in previous papers.[1–5] False negative rates around 1–3% of examinations are common, and as high as 11% are seen. Vincent *et al*[6] assessed junior ED staff on a set of purely abnormal films and found an error rate of 35%. Most missed diagnoses do not adversely affect clinical outcome in the period between initial interpretation and radiological review.[4 11]

We assessed the accuracy of ED staff in the interpretation of cranial CT images in the trauma setting. The overall accuracy of 86.6% compares with results in plain film interpretation, as does the false negative rate of 4.2%. Abnormalities in post-trauma CT scans are more likely to be life threatening than other radiographic findings from the ED, therefore it is important that initial interpretation has a high sensitivity. We found no false negative reads in which a missed diagnosis would have adversely affected patient outcome overnight. Although the guidelines[9 10] state that all new surgically significant abnormalities should be discussed with a neurosurgeon, a number of abnormalities are listed as not being significant, including localised subarachnoid haemorrhage, isolated pneumocephaly, and closed depressed fractures not penetrating the inner table. All of our false negative reads were in this group. Although accuracy and sensitivity were good in our study, there was significant interobserver variation. Robinson *et al*[12] found a significant variation in opinion even when experienced radiologists were studied. Our results were obtained from staff with no formal training in CT interpretation. There is good evidence that accuracy can be improved with suitable training.[2 13 14] False positive reports leading to unnecessary neurosurgical referral should therefore reduce with training and experience.

Table 2 Findings undetected by the readers

False negative case	Misread by readers (n)	Finding not detected
A	1	Closed depressed fracture
B	4	Small amount of intracranial air
C	4	Blood in sylvian fissure
D	4	Subarachnoid haemorrhage at tentorium
E	4	Subarachnoid frontal haemorrhage
F	4	Small amount of intracranial air
G	2	Subarachnoid haemorrhage

The use of ''night hawk'' radiologists is seen in North America,[15] but with current radiology manpower in the UK this is impractical for most hospitals. Training departments could use trainee radiologists who are being taught image interpretation and need this experience; however, their performance is variable and may not be better than permanent ED staff. Our results from permanent ED staff are similar to those obtained from studies of radiologists in training.[16–18] Teleradiology is available and widely used in the UK, but is relatively slow and has not been used for the volume of work needed to meet the recent head injury guidelines. Ours is the smallest district hospital in England, yet we perform over 850 skull radiographs per year, with over 600 (70%) being requested outside normal working hours. Replacing skull radiographs with CT will have a large impact on radiology departments. As subspecialisation amongst radiologists increases, it is becoming more frequent to find that the on call radiologist does not perform CT during his normal work. Teleradiology to neurosurgical centres is generally available to discuss problem cases. Centralised CT reporting centres could be established, but the few currently available have proved too expensive for our hospital to employ them.

It has been longstanding practice for ED staff to make the initial interpretation of radiographs from their department. Imaging findings are only part of the picture in deciding whether trauma patients need neurosurgical referral. The clinical setting is also relevant. The level of staff we studied (consultant and staff grades) are available to our department at all times and we feel that they could safely make the initial interpretation of cranial CT scans in these cases. The key immediate question is: ''is there structural intracranial damage?'',[10] and with training and audit, ED staff should be able to answer this. Subsequent review by radiologists will detect some additional abnormalities and clarify the false positive readings. Inevitably, some patients presenting with a history of possible trauma are in fact medical cases such as stroke. While guidelines refer to trauma, it is not possible to compartmentalise trauma cases entirely. Radiological review in conjunction with ongoing audit will be required.

Direct access to cranial CT for trauma or possible trauma is desirable, and our study suggests that ED staff could safely carry out initial interpretation.

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