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ORIGINAL RESEARCH

EMA

# Head computed tomography guidelines are being followed

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## Abstract

**Objective:** Several guidelines have been developed to direct the ordering of head computed tomography (CT) for patients, but most are clinical presentation-specific. Recently, an integrated guideline for ordering emergent head CT for patients who present to the ED of Western Hospital, Footscray, Victoria, Australia, was developed in response to concerns raised regarding perceived over-utilization of head CT for ED patients. Our aim was to determine compliance with the guideline.

**Methods** This was an explicit retrospective medical record review of patients who presented to the ED of Western Hospital between 1/04/2004 and 17/6/2004 and had a head CT as part of their assessment. Clinical information for these cases was compared with guideline recommendations. Data are described by descriptive statistics.

**Results** Of the 231 cases that were included in the study, 65 (28.1%, 95% confidence interval 23–35%) had abnormal CT findings. Guidelines were adhered to in 217 (93.9%, 95% confidence interval 91–97%) cases. For the cases where the guidelines were not adhered to (14; [6.1%]), there was only one abnormal scan the clinical significance of which is not clear.

**Conclusion** The study found that compliance with head CT guideline was high. This suggests that the guideline is both clinically relevant and supported by ED doctors or conversely that the guideline is concordant with existing ordering practices of the ED.

**Key words:** *evidence-based practice, guidelines, head computed tomography.*

## Introduction

Computed tomography (CT) scanning is a valuable tool for assessing pathological intracranial conditions such as intracranial collections and skull fractures following head injury, stroke, hydrocephalus, subarachnoid haemorrhage (SAH) and tumours. Given the serious nature of these conditions, a missed or delayed

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diagnosis could result in adverse effects for the patient and have serious medicolegal consequences for the practitioner and the hospital.

However, studies have shown considerable variability in ordering practice with respect to head CT, particularly for minor head injury.[1] Although risk to patients has not been evidenced by over-ordering of radiology investigations,[1] cost for health services and delays for patients are inevitable.[2] Reducing variability in ordering practices might lead to decreased ED waiting times, lower radiology costs and increased detection and treatment of serious pathology.

In response to perceived over-utilization of head CT by hospital executive and the Radiology Department, a guideline was developed in January 2004 for application in the ED at Western Hospital, Footscray, Victoria, Australia, with the aim of ensuring that patients who might derive short-term benefit from a head CT received one, without inappropriate over-utilization.

The aim of the present study was to investigate ED medical staff compliance with this standardized head CT guideline.

## Methods

### Setting

The present study was conducted in the ED of Western Hospital, a 300-bed community teaching hospital with an annual ED census of 32 000. It has all specialties on-site with the exception of cardiothoracic surgery and emergency neurosurgery. The ED is staffed by a mixture of FACEM, training registrars and junior medical staff with consultant on-site supervision 18 h per day, 7 days a week.

### Guideline development

An evidence-based medicine approach to guideline development, including a search of and evaluation of available literature, was undertaken by one of the authors (AMK). The evidence collected was then subject to multidisciplinary review involving the heads of Neurology, Neurosurgery, Surgery, Medicine and Emergency Medicine departments. The final guideline incorporated findings and recommendations of a number of studies.[3–10] A copy of the guideline is included as Appendix I. Implementation was by staff education and posters, without the support of computer-assisted test ordering which is not available in the study hospital. Education occurred at scheduled registrar and junior medical staff training sessions. It is not possible to quantify what proportion of staff were exposed to the education. The formal education process was supplemented with 'on-the-job' education and guideline reinforcement.

### Assessment of compliance with the guideline

This was performed by explicit retrospective medical record review of patients who presented to the ED between 1 April 2004 and 17 June 2004 and had a head CT as part of their investigations. The period studied began 3 months after the guideline was implemented and staff at the time were unaware that compliance would be assessed.

Patients were identified from an existing Department of Radiology database that identifies tests ordered from individual hospital departments. Cases were excluded if the CT was a follow-up scan ordered by the treating unit after the result of an initial CT was known, where the scan was performed after ED discharge as an outpatient or where the scan was performed after admission to an inpatient unit.

Data were collected onto an explicit data collection tool by an investigator who was not blinded to the aim of the study (TB). It included demographics, date and time of presentation to ED, date and time of head CT scan, time elapsed between ED presentation and CT scan, presenting problem, history of trauma, head CT result and presence or absence of the guideline criteria. If a criterion was not recorded in the file it was assumed to be absent.

Abnormal results were defined as acute pathological changes (e.g. infarct, hypodensity, haemorrhage, fracture, tumour, collection, hydrocephalus) as reported on the final radiology report. Note, CT were reported by various grades of Radiology staff from consultants to registrars. No attempt was made to determine seniority of reporter.

If one or more of the guideline criteria were fulfilled, the case was considered to have followed the guideline. Cases were determined not to have followed the guideline if there was no documentation in the patient's medical record of symptoms relating to the criteria. An independent emergency physician, blinded to the CT result, reviewed cases of doubt and where the guideline was not followed. This was done to determine if CT request was considered reasonable, despite head CT guideline recommendation, for these onerous cases.

The target sample size was 200, being feasible within the available study time and of a size sufficient to have acceptably narrow confidence intervals (CI) for the primary outcome. It was not powered for subgroup analyses.

The primary outcome of interest was compliance with the head CT ordering guideline. Data were analysed by descriptive statistics. Subgroup analysis of trauma and non-trauma groups was undertaken.

Interrater reliability of data extraction was tested on 27 records, for the items 'CT result' and 'compliance with the guideline'. For CT result, agreement was 26/27 (96%, kappa 0.75). For compliance with guideline, agreement was 26/27 (96%, kappa 0.91).

The study was approved by the institutional ethics committee. Individual consent was not required for case enrolment.

## Results

During the study period there were 6582 ED presentations. The radiology database search identified 245 eligible cases, representing 3.5% of ED presentations during the study period. Fourteen cases were excluded from the study, leaving a final sample of 231 patients. Sample derivation is shown in Figure 1.

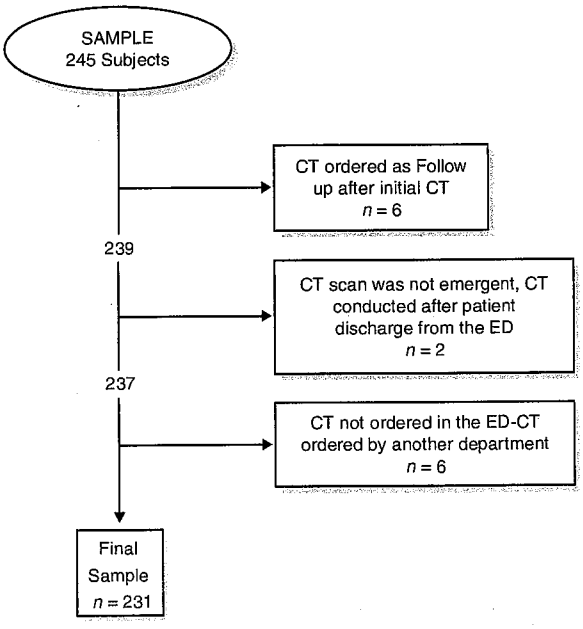


**Figure 1.** Sample description. CT, computed tomography.

For the 231 presentations included in the analysis, the median age was 69 years (range 16–95) and there were marginally more men than women, 120 (51.9%) and 111 (48.1%), respectively. The median time elapsed between ED presentation and CT scan was 118 min (range 14–897 min). There were more non-trauma cases than trauma cases, 181 (78.4%) and 50 (21.6%), respectively.

Presenting conditions for the sample are shown in Table 1. Motor weakness (47/231; 20.3%) was the most common presenting symptom, followed by head injury (13.4%), migraine/headache (13.4%), fall/collapse (13.0%) and altered conscious state (8.7%).

One hundred and sixty-six head CT were reported as normal (71.9%, 95% CI 66–77%), and 65 (28.1%, 95% CI 23–34%) were reported as abnormal. Infarcts were the most common abnormality, present in 22 (33.8%) cases. Other abnormalities included hypodensity (12, 18.5%), haemorrhage/SAH (10, 15.4%), haematoma (6, 9.1%), fracture (5, 7.7%), swelling (3, 4.6%), intracranial mass (3, 4.6%), ischaemia (2, 3.1%) and hyperdensity (2, 3.1%).

There were 181 non-trauma cases in the present study. Of these, 60 (33.1%, 95% CI 27–40%) had abnormal head CT. Abnormal scans were found in 14 of 37 of patients with suspected SAH (37.8%, 95% CI 24–54%), 43/117 of patients presenting with new focal neurological signs (36.7%, 95% CI 29–46%), 20/58 of

**Table 1.** Presenting problem

| Triage-assessment categories | No. cases (percentage) |
|---|---|
| Motor weakness | 47 (20.3) |
| Head injury | 31 (13.4) |
| Migraine/headache | 31 (13.4) |
| Fall/collapse | 30 (13.0) |
| Altered conscious state | 20 (8.7) |
| Seizure | 12 (5.2) |
| Confusion | 12 (5.2) |
| Dizzy | 8 (3.5) |
| Aphasia | 7 (3.0) |
| Numbness (sensory deficit) | 7 (3.0) |
| Unwell | 5 (2.2) |
| Intoxicated | 5 (2.2) |
| Motor vehicle collision | 4 (1.7) |
| Diplopia | 4 (1.7) |
| Nausea/vomiting | 3 (1.3) |
| Other† | 5 (2.2) |
| Total | 231 |

†*Other includes assault, cardiac arrest and psychiatric issues (e.g. suicide attempt).*

**Table 2.** Non-trauma cases: number of cases and number of abnormal CT results satisfying criteria

| Category | Criterion | No. satisfying criteria | No. of abnormalities *n* (%) (95% CI) |
|---|---|---|---|
| Non-trauma without seizure (158 patients) | Altered conscious state | 58 | 20 (34.4%) (24–47%) |
| | New focal neurological signs | 117 | 43 (36.7%) (29–46%) |
| | Suspected SAH | 37 | 14 (37.8%) (24–54%) |
| | HIV patient with headache | 0 | |
| | Patient aged 60+ and headache | 27 | 8 (29.6%) (16–48%) |
| Non-trauma patients with seizure (9 patients) | New focal neurological signs | 3 | 0 (0%) (0–56%) |
| | Alteration in conscious state | 7 | 0 (0%) (0–35%) |
| | Fever | 0 | |
| | Trauma | 2 | 0 (0%) (0–66%) |
| | HIV | 0 | |
| | Persistent headache | 0 | |
| | History of neoplasia | 0 | |
| | Anti-coagulated | 1 | 0 (0%) (0–80%) |
| No criteria met | | 14 | 1 (7.1%) (1–31%) |

*CI, confidence interval; CT, computed tomography; SAH, subarachnoid haemorrhage.*

**Table 3.** Trauma cases: number of cases and number of abnormal CT results satisfying criteria

| Category | Criterion | No. satisfying criteria | No. of abnormalities *n* (%) (95% CI) |
|---|---|---|---|
| Trauma (27 patients) | GCS < 13 | 6 | 2 (33.3%) (10–70%) |
| | Head injury (nil neurological exam possible) | 8 | 0 (0%) (0–32%) |
| | New focal neurological signs | 11 | 4 (36.4%) (15–65%) |
| | Head injury + LOC + anti-coagulation | 9 | 3 (33.3%) (12–65%) |
| | Intoxication + GCS < 13 + head injury | 4 | 2 (50.0%) (15–85%) |
| | Head injury + planned anaesthesia | 1 | 0 (0%) (0–80%) |
| Trauma and GCS 13–15 (39 patients) | Failure to reach GCS = 15 in 2 h | 5 | 2 (40.0%) (12–77%) |
| | Suspected open skull fracture | 7 | 1 (14.3%) (2.6–51%) |
| | >2× vomiting | 3 | 2 (66.7%) (20–94%) |
| | >65 years old | 19 | 6 (31.6%) (15–54%) |
| | Amnesia before impact of >30 min | 11 | 2 (18.2%) (5–48%) |
| | Dangerous mechanism of injury | 33 | 7 (21.2%) (11–38%) |

*Note: patients might qualify for both subgroups. CI, confidence interval; CT, computed tomography; GCS, Glasgow Coma Score; LOC, loss of consciousness.*

patients with an altered conscious state (34.4%, 95% CI 24–47%) and 8/27 of patients aged over 60 with headache had abnormal scans (29.6%, 16–48%). No abnormalities were found in non-trauma patients presenting with seizure. The frequency of each criterion and the rate of abnormal scans are shown in Table 2. Note that more than one criterion was met in some patients.

There were 50 trauma cases in the present study. Of these cases, five (10%, 95% CI 4.4–21%) had abnormal scans. The majority of trauma patients presented with Glasgow Coma Score (GCS) 13–15 and a specified dangerous mechanism of injury (Table 3).

The ordering guideline was followed in 217 (93.9%, 95% CI 91–97%) cases, of which 64 (29.5%, 95% CI 24–36%) were positive. Guidelines were not followed in 14 cases (6.1%, 95% CI 3.6–9.9%), and of these there was only one abnormal CT scan. This patient was a 48-year-old woman presenting with headache and nausea. The scan showed a midline hypodensity, the clinical significance of which was judged by treating clinicians to be doubtful. Of the 14 cases outside the guideline, five were considered justified on expert review. The justified cases were a patient with atypical headache with a past history of SAH, a patient with a remote past history of

brain tumour who presented with headache and nausea, a 91-year-old with sudden unexplained recurrent vomiting, a patient with a 9 week history of headache previously seen by general practitioner (GP) and ED who was referred by his GP with request for CT and a patient referred for outpatient CT who was offered a same-day test because of an available slot.

## Discussion

Practice guidelines can be an important means by which evidence-based recommendations can be disseminated, resulting in improved health care outcomes.[11] The present study found that compliance with the CT scan ordering guideline was high and that the rate of abnormal scans was 28.1%. It should be noted that this does not imply that the guideline itself is safe and accurate.

The positive CT rate is high when compared with rates reported in other published studies of between 4 and 24%[5,7,8,12–14] and with a previous study conducted in the same department that found an abnormality rate of 21.6%. It is possible that introduction of the guideline has contributed to better selection of patients for CT resulting in a high positive rate. It is also possible that the guideline has inappropriately restricted ordering so some patients with significant intracranial pathology might have been missed. The present study is unable to determine which of these is the case. There is also no available evidence defining what is a 'safe' negative CT rate in the context of emergency presentations. Research to define this would be useful in further refining ED staff approach to the use of this test.

The 94.8% compliance with the guidelines found in the present study is very high when compared with compliance to guidelines in other studies. In Müller *et al.*'s study regarding the compliance with the Scandinavian guidelines for management of mild head injury, they found only a 25% compliance rate.[15] Huizenga *et al.*'s study of adherence to guidelines for management of severe head injury found adherence ranging between 46 and 83%. Their study investigated guidelines for the management of severe head injury.[16]

Possible explanations for the high compliance rate include an effective education and implementation strategy and that the guideline is logical and reflective of current practice. The latter is much more likely to be the case. Van Walraven[17] comments that the combination of current physician practices with study recommendations in the development of clinical practice guidelines increases their impact. Huizenga *et al.*[16] found that compliance with their guideline might not have been related to effective dissemination, but that the information had passively filtered into standard graduate medical education and clinical practice. At the study ED, it is usual practice for ED consultants or registrars to approve CT requests by more junior staff. Thus, the compliance seen might be a reflection of the more senior doctors' knowledge and attitudes towards test ordering rather than the result of effective implementation. This is supported by a small informal survey of knowledge of the guideline (by TB) that found that awareness was low to moderate (less than 50% of the sample).

We regard the non-compliance rate with the guideline of 5.2% as acceptable. Evidence-based guidelines are derived to target the population, and are based on the probability of an event occurring. It is impossible to factor all variations of patients' clinical presentations and circumstances into a single guideline, so an allowance for clinical judgement must be made. Important additional factors for consideration by clinicians include availability, compliance with outpatient investigation, patient convenience, past medical history and patient anxiety/expectation.

The challenges of guideline utilization include maintaining compliance and keeping them up to date with available evidence. We are addressing the latter by an annual review of the evidence. The former is more problematic and will require ensuring ongoing awareness of the guideline by consultant and registrar staff, perhaps supported by 'snapshot' audits as a monitoring and feedback tool.

Limitations of our study include those inherent in retrospective record review studies such as inadequate documentation. However, as we treated the absence of data as being negative, this will bias towards an underestimation of compliance with the guideline. Our sample was predominantly made up of non-trauma patients, so the sample sizes in the trauma subgroups are small. We were only able to look at the cases that had CT scans, not those that might have met the criteria but did not have a scan. We did not follow up patients who did not have a CT to determine their outcome. The study was conducted at a single centre, so generalization to other centres cannot be assumed.

## Conclusion

The study found that compliance with head CT guideline was high. This suggests that the guideline is both

clinically relevant and supported by ED doctors or conversely that the guideline is concordant with existing ordering practices of the ED. The high rate of positive head CT is concerning and raises questions about whether the head CT ordering rate is too low.

### Author contributions

AMK conceived the study, TB, DK and AMK designed the study, TB collected the data, and all authors contributed to data interpretation, manuscript preparation and refinement.

### Competing interests

None declared.

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## Appendix I

### Head CT ordering guideline

*Criteria for ordering of emergent head CT from the emergency department*

The purpose of these guidelines is to ensure that patients for whom diagnostic or therapeutic decisions may be altered by a head CT have timely access to this investigation while being cognizant of the resource constraints of the Radiology Department. Where possible, they are based on evidence as referenced. Other indications relate to situations with high clinical risk as evidenced by coronial or clinical risk review processes.

Non trauma

- Unexplained alteration in conscious state
- New onset focal neurological signs
- Suspected subarachnoid haemorrhage
- HIV patients with new onset headache irrespective of neurological findings
- Patients aged over 60 years with acute or recent onset unexplained headache
- Patients with a seizure who have new focal neurological signs, persistent alteration of conscious state, fever, recent trauma, a suspicion of HIV, a persistent headache, history of neoplasia or who are anti-coagulated

Trauma

- Unexplained GCS less than 13
- Head injury in a patient unable to complete neurological exam (e.g. dementia)
- New focal neurological deficit

- Head injury with loss of consciousness in patients with known coagulation deficit (includes warfarin therapy)
- Intoxication with drugs or alcohol with GCS less than 13 and evidence of injury to the head or concern re acute intracranial bleeding
- Patient with clinical evidence of head injury who will undergo general anaesthesia (e.g. laparotomy) within 4 h of admission
- GCS 13–15 with failure to reach GCS 15 within 2 h, suspected open skull fracture, any sign of base of skull fracture, more than 2 episodes of vomiting, age greater than 65 years, amnesia before impact greater than 30 min, or dangerous mechanism of injury