Major trauma CT scanning: the experience of a regional trauma centre in the UK

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ABSTRACT

Introduction Trauma remains a major cause of mortality and morbidity, particularly among young adults. A major trauma (whole-body) CT protocol based upon mechanism of injury was investigated in a busy emergency department.

Methods Trauma patients presenting in two 3-month periods before and after the introduction of a major trauma CT protocol were identified. The mechanism of injury, Injury Severity Score, radiological imaging performed and injuries detected were recorded.

Results More eligible patients received major trauma CT scanning post-protocol than pre-protocol (87/114 (76%) vs 44/94 (47%)). There were no adverse effects attributable to major trauma CT. Seventeen injuries were detected post-protocol that would not have been detected had imaging been conducted based on clinical suspicion rather than mechanism of injury. In three cases an immediate intervention was required.

Conclusion Our major trauma CT protocol, based on mechanism of injury, resulted in substantial changes in clinical management in a small number of patients without any increase in adverse events. However, it is not a substitute for clinical acumen in the initial assessment of trauma patients.

INTRODUCTION

Injury is the most common cause of death for young adults in the UK.[1] Blunt force trauma accounts for a large proportion of these deaths.[1–3] Over the last two decades, strenuous efforts have been made to reduce mortality rates by improving prehospital and hospital care of the traumatically injured patient. However, there are concerns that early improvements in trauma care have not been continued in recent years.[4] Indeed, a 2007 report from the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) reported that less than half of severely injured trauma patients received 'good care'.[1]

The use of whole-body or major trauma CT scanning for multiply injured patients is proliferating in the USA[5] and in Europe.[6] Sweden, in particular, has been using major trauma CT scanning in 94% of its hospitals since 2001.[6] NCEPOD recommend the routine use of CT scanning for patients presenting with multiple injuries.[1] Modern multi-detector CT (MDCT) allows for rapid scanning and interpretation of results without compromising image quality,[7] and facilitates rapid transit of the critically injured patient through the emergency department (ED).[8 9] This means that CT scanning can now be used as an alternative to plain radiographs during the primary survey, rather than as an adjunct to the secondary survey. Nevertheless, it is still recognised that major trauma CT scans may cause delay in the management of haemodynamically unstable patients[6] or those requiring immediate operative intervention.[10]

Traditionally, injured patients undergo definitive imaging based upon clinical examination findings. However, the notion that CT scanning can be used to assess several body regions based upon mechanism of injury rather than because of clinical suspicion is well established in patients with impaired consciousness and is becoming more widespread in other patient groups.[11] This idea is driven by increasing evidence that clinical examination may be unreliable in the setting of acute trauma,[3 5 10 11] and many injuries are often unsuspected in the ED.[5 8]

There are well-established national guidelines for the use of CT scanning in acute head injury[12] and evidence that CT detects injuries in trauma patients better than plain x-rays for several body regions.[8 13–17] Studies suggest that clinical management in patients with multiple injuries is changed based solely on the findings at CT scanning in up to 25% of cases.[5 8 18]

The aim in this observational study was to assess the effect of the introduction of a major trauma CT protocol for the detection of clinically significant injuries in the ED of a regional trauma centre in the UK.

METHODS

The ED of the University Hospitals of Coventry and Warwickshire (UHCW) operates a major trauma alert policy whereby any patient who is suspected of having multiple or serious injuries is fast-tracked into the resuscitation area for initial assessment and management. We identified all such trauma patients presenting at this unit in a 3-month period before and after the implementation of a major trauma CT protocol. The protocol was used to identify suitable patients for major trauma CT scanning based on mechanism of injury alone, compared with those patients who required targeted CT scanning of one particular body region (figure 1). Before the introduction of this protocol, major trauma CT scanning would be used based on clinical suspicion at the discretion of the senior ED doctor attending the patient and the duty radiologist. The major trauma CT protocol was implemented in October 2007. We reviewed the trauma alert and hospital records from two 3-month periods before (July–September 2007) and after (December 2007–March 2008) the introduction of the protocol. We also identified any other patients with multiple injuries who were fast-tracked straight to the resuscitation area but were not recorded as trauma alerts.

A **Major-Trauma CT** aims to identify all significant injuries in the polytrauma patient in a timely fashion.

The CT examination consists of:

- Head & C-spine
- Thorax
- Upper limbs
- Abdomen & pelvis
- Proximal femora

Total time including patient handling = 12 mins

For patients arriving in the Emergency Department the following **Mechanism of Injury** should trigger an immediate request for **"Major-Trauma CT"**:

Penetrating trauma
Gunshot wound (including air rifle)
Blast injury (bomb / explosion)

Blunt trauma
Combined velocity ≥ 50 km/h
Motor vehicle crash with ejection
Motorcyclist or pedestrian hit by vehicle >30 km/h
Fall > 3 metres
Fatality in the same vehicle
Entrapment > 30 minutes
Crush injury to thorax / abdomen

ALL other patients with injuries should have targeted CT

Figure 1 Major trauma CT protocol at University Hospitals of Coventry and Warwickshire.

We reviewed the following sources of information: ambulance triage sheet (where available); medical notes; ED trauma chart (where available); Picture Archiving and Communications System (PACS) for radiological image reports; and the hospital's Clinical Results Reporting System for theatre reports and subsequent clinical letters. The following data were recorded: patient age and sex; mechanism of injury; observations (respiratory rate, blood pressure and pulse) and Glasgow Coma Score on-scene and on arrival at the ED; initial radiological imaging performed; injuries detected by discharge from ED; further radiological imaging performed; injuries discovered after leaving ED; and surgical and other clinical interventions.

Injuries detected on radiological imaging were identified from the formal reports on PACS made by either a senior specialist registrar or consultant radiologist. Injuries reported or recorded at surgical intervention were identified from the operating surgeon's theatre record.

An Injury Severity Score (ISS) was calculated retrospectively for each patient using the 2005 revision of the Abbreviated Injury Scale (AIS).[19]

Where statistical analysis was appropriate, the InStat computer programme (Graphpad Software, San Diego, USA) was used. Non-parametric comparisons were made using the Mann–Whitney U test. For all statistical tests a p value of <0.05 was considered to be statistically significant. Data are presented as absolute values of mean±SD unless otherwise stated.

RESULTS

We identified 265 patients (126 pre-protocol, 139 post-protocol). Full medical records were available for 254 patients (116 pre-protocol, 138 post-protocol). Only partial data from computerised records were available for the remaining 11 patients, so these patients were excluded from the analysis.

The demographic data were similar for both groups of patients and are shown in table 1 and figure 2. There were no significant differences between the groups in terms of age, ratio of male to female patients and ISS. Paediatric patients were defined as aged ≤16years. Eleven patients died from traumatic injuries and one additional patient (a 79-year-old man) died from an exacerbation of chronic obstructive pulmonary disease (COPD) after initially having been admitted following a fall from height.

Table 1 Demographic data

	Overall	Pre-protocol	Post-protocol
Age (years)	35.4±17.7	33.1±16.4*	37.3±18.7*
Men	183/254 (72.0%)	76/116 (65.5%)	107/138 (77.0%)
Children	14/254 (5.5%)	8/116 (6.9%)	6/138 (4.3%)
Died	12/254 (4.7%)†	4/116 (3.4%)	8/138 (5.8%)†

*p = NS.
†Includes one patient who died of non-traumatic injuries.

Road traffic collisions (RTC) were the most common presenting mechanism of injury, followed by falls from height. Most RTC involved vehicle occupants rather than pedestrians or cyclists. These data are shown in table 2. The thorax was the most common body region injured both pre- and post-protocol, followed by the head.

The majority of the patients admitted as a 'major trauma alert' fulfilled the criteria for a major trauma CT scan based on their mechanism of injury alone: 94 (81%) pre-protocol and 114 (82%) post-protocol. Those patients who had a major trauma CT scan had a significantly higher ISS than those who did not (pre-protocol 14.0±11.1 vs 6.9±6.2, $p<0.001$; post-protocol 12.9±10.7 vs 7.4±8.7, $p<0.01$).

Imaging

Before the major trauma CT protocol was introduced, only 47% (44/94) of the patients with a suitable mechanism of injury had a major trauma CT scan, at the discretion of the attending doctor. The majority of the other pre-protocol patients suitable for major trauma CT had a targeted CT scan (31/50), but 38% (19/50) of suitable patients received plain x-rays alone in their evaluation. After the major trauma protocol was introduced, 76% (87/114) of the patients who met the criteria had a major trauma CT scan. One other patient also received a major trauma CT scan. Of the other suitable patients, 48% (13/27) had a targeted CT scan and 52% (14/27) had plain x-rays alone. In 7 patients pre-protocol and 32 patients post-protocol there was no radiological injury found on imaging. For those undergoing major trauma CT, 3/44 (7%) pre-protocol and 14/87 (16%) post-protocol had no radiological injury.

Patients requiring immediate transfer to the operating theatre

Before the major trauma CT protocol, one patient was transferred directly to the operating theatre without imaging as there was clinical evidence of peritoneal involvement from a penetrating abdominal wound. Eight other patients went straight to theatre from the ED (3 after having had a major trauma CT scan, 4 after targeted CT scanning and 1 after plain x-rays only). In the post-protocol period, 12 patients went straight to theatre from the ED (8 after a major trauma CT scan, 3 after targeted CT scanning and 1 after (limb) x-rays only).

During the course of this study, both pre- and post-protocol, there were no reported adverse events while in the CT scan room. There were no reports of undue delay in those patients who went straight to the operating theatre from the ED.

Missed injuries

After the introduction of the protocol, 17 injuries were found that had not been detected at that point (ie, had a major trauma

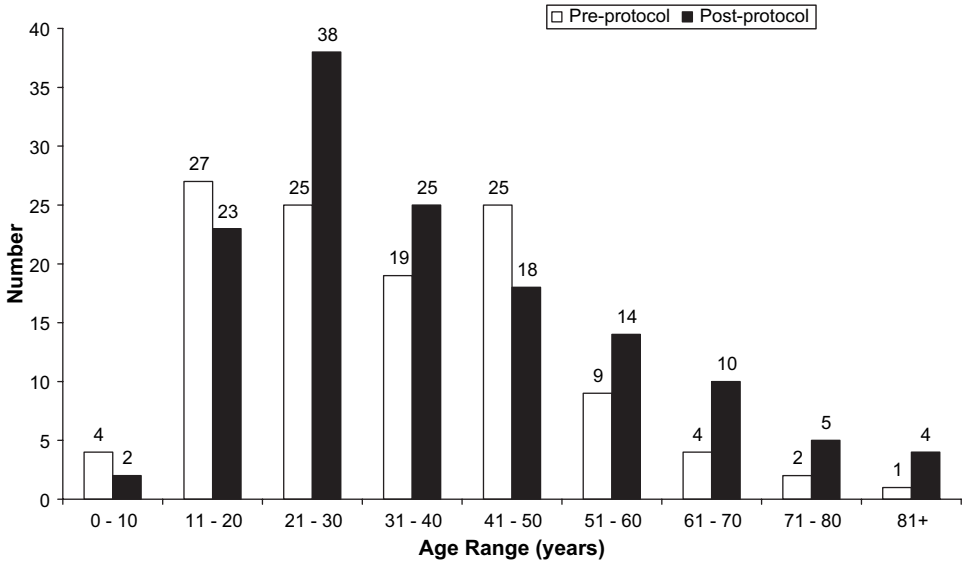

Figure 2 Breakdown by patient age.

CT scan not been perfomed, clinical suspicion alone would not have prompted a targeted CT scan of the relevant body area to detect the injury). For three of these patients, the early detection of these otherwise unanticipated injuries directly altered the subsequent clinical management of the injuries. These findings are shown in more detail in table 3.

Similarly, of those patients whose mechanism of injury indicated a major trauma CT scan but who did not get one, four injuries would have been detected earlier had the protocol been followed (table 4). Three of these occurred before the major trauma CT protocol was introduced.

Despite the fact that the major trauma CT scan detected several previously unsuspected injuries, one case serves to highlight the continued importance of clinical acumen and examination skills. One patient correctly had a targeted CT scan, as per the protocol, which was initially reported as normal. However, based on clinical suspicion, the patient went straight to the operating theatre from the ED for an exploratory laparotomy where a splenectomy was performed for a major splenic injury.

DISCUSSION

We have reviewed the implementation of a major trauma CT protocol and its effect on the radiological imaging performed and injuries detected in the ED of a regional trauma centre in the UK.

Table 2 Mechanism of injury

	Overall	Pre-protocol	Post-protocol
RTC	167	76	91
Driver/passenger	109	46	63
Motorcyclist	28	16	12
Pedal cyclist	6	3	3
Pedestrian	24	11	13
Fall from height	50	23	27
Penetrating trauma	15	5	10
Blunt assault	12	8	4
Crush injury	9	4	5
Burns	1	1	0
Shooting (shotgun)	2	0	2
Total	256*	117*	139*

*Two patients had two distinct mechanisms of injury.
RTC, road traffic collision.

Our results indicate that the use of a major trauma CT protocol improves the early detection of otherwise unsuspected injuries.

In the 3 months after the introduction of the protocol, 17 injuries were found in patients who had a major trauma CT scan that otherwise would not have been detected—in 3 of these cases the immediate clinical management was changed as a result. In the 3 months before the introduction of the protocol, only one such injury was found (in a patient who had a major trauma CT scan performed at the discretion of the attending doctor) and three serious injuries were not discovered until after the patients were admitted to the ward.

The two groups of patients (pre- and post-protocol) had a similar mix of age, sex, ISS and mechanism of injury. The case mix in this study is also similar to national figures from NCEPOD[1]: the majority of patients were young men in their second and third decades and the most common mechanism of injury was RTC followed by falls. A similar pattern has also been reported in Europe[20] and the USA.[5] However, not all of our patients were 'severely injured' (ISS >16), unlike the patients in the NCEPOD report.[1]

The other key finding was that there were no reported adverse events related to the use of the major trauma CT protocol; that

Table 3 Unanticipated injuries detected because major trauma CT scanning was performed (and subsequent interventions)

Body region	Injury	Intervention (and notes)
Pre-protocol		
Thorax	'Moderately large' left-sided pneumothorax	Intercostal drain insertion
Post-protocol		
Head	3× minor contusions	
Thorax	7× minor lung contusions	
	Small haemopneumothorax	Intercostal drain insertion
Abdomen	Liver contusion	
	Intra-abdominal haematoma	
	Active splenic haemorrhage	Laporotomy and splenectomy
	Liver laceration and haemoperitoneum	Laporotomy and repair of duodenal perforation (the latter not specifically seen on CT)
	(Small) bladder perforation	
Pelvis	Two pubic rami fracture with intra-pelvic haematomas	

Table 4 Injuries whose detection was delayed because major trauma CT scanning was not performed according to the protocol

Body region	Injury	Intervention (and notes)
Pre-protocol		
Thorax	Widespread bilateral pulmonary contusions	Spent an extra 24 h being observed (further imaging after review on observation ward)
Thoracic spine	Fractures of T3 spinous process and of vertebral bodies of T4/T5	Conservatively managed (stable fractures, further imaging after ward review)
Abdomen	Complex lacerations to lower pole spleen	Conservatively managed (documented negative FAST in ED, further imaging after ward review)
Post-protocol		
Pelvis	Pelvic ring fracture	Conservative management

is, there were no adverse events in the CT scan room. There was no apparent delay in transferring patients to the operating theatre when this was required, but we found that the data to allow us to quantify this were not reliably or accurately recorded.

Nonetheless, these results would suggest that the use of a major trauma CT protocol may improve the early management of patients with serious injuries without causing additional risk. Furthermore, a recent database study in Germany of 4621 patients with blunt trauma also concluded that whole-body CT scanning independently predicts survival.[21] However, there are several issues worthy of further comment.

In accordance with the NCEPOD guidelines, the CT scan room at UHCW is immediately adjacent to the resuscitation room. This may not be the case in other hospitals. The scan itself can be completed in 6 min (General Electric Lightspeed 4-slice CT; GE Healthcare, Chalfont St Giles, UK), although we were unable to determine the total 'transit time' through the CT scan room. As the major trauma CT protocol became established we believe that the 'transit time' decreased, but there may be some patients for whom any delay in definitive treatment may be unacceptable. For instance, the Royal College of Surgeons of England recommends that, where visceral injury requires operative management, the start of the operation should be within 60 min of admission.[22]

Another potential issue is the increased rate of 'negative' studies associated with the introduction of the major trauma CT protocol. We found that 14/87 patients (16%) undergoing a major trauma CT scan after the introduction of the protocol had no radiological injury compared with 3/44 (7%) who had a major trauma CT scan at the attending doctor's discretion before the protocol was introduced. Although the numbers are small, it could be suggested that some of these patients had an unnecessary exposure to radiation. Extrapolations from population-based studies suggest that there is a small risk of fatal cancer from exposure to imaging radiation. A single whole-body CT scan increases the background lifetime risk of developing fatal cancer roughly from 25% to 25.05%,[23] and this risk is higher in children.[24] However, a 'single-pass' CT scan—as can be used for major trauma CT—results in a lower radiation exposure than the combined figure for segmental scans of different body areas.[7 25] We believe that the risk of missing potentially life-threatening injury overrides the concerns regarding radiation exposure in this group of potentially seriously injured patients.

There may also be a risk of overtreating as a result of the CT scan; that is, some patients may receive unnecessary interventions due to the CT protocol detecting injuries that may previously have been missed. One patient in this series had an intercostal drain inserted for a small asymptomatic pneumothorax; it could be argued that the intervention was not actually required and the patient was unnecessarily harmed because of a response to the CT finding. However, we would suggest that this 'risk' is far outweighed by the cases that did require prompt intervention—specifically, the three cases of serious pathology. These were two intra-abdominal injuries and a 'moderately large' pneumothorax, which was not formally reported on the portable chest x-ray initially taken in the resuscitation room and would have been missed had the patient not had a major trauma CT scan.

Controversy remains about the selection of patients for major trauma CT scanning. We used a protocol developed in Sweden[6 26] that included patients based upon mechanism of injury, but formal validation of individual mechanisms to trigger a request for major trauma CT scanning is lacking. The higher number of cases where no radiological injury was detected post-protocol may reflect the need to formally validate and refine the criteria required to trigger a request for a major trauma CT scan. This will be an important area for further research.

In our study, 27 of 114 eligible patients post-protocol did not have a major trauma CT scan. The decision not to request a major trauma CT scan was made by the senior doctor involved on the trauma team at the time. The reasons are unclear, although no patient had a scan deferred because they were unstable or went directly to theatre. Despite the protocol, it appears there may still have been selection of patients on clinical suspicion rather than mechanism of injury—this may help explain the significantly higher ISS in patients who had a major trauma CT scan compared with those who did not.

The major trauma CT protocol could not include the legs distal to approximately the mid-shaft of the femur, dependent on the height of the patient, owing to the length of the CT tables that can fit in the scan room. As a result, seven patients had lower limb injuries that were not detected by the time the patient left the ED despite the fact that the patients had a major trauma CT scan. One of these injuries later required operative fixation. This issue may be resolved in the next generation of scanners.

CONCLUSION

We have shown in our hospital environment that the use of a major trauma CT protocol based on mechanism of injury alone is safe. It has resulted in the detection of a number of clinically important injuries that would not otherwise have been diagnosed promptly, and a substantial change in clinical management in a small number of cases. We would stress that the role of clinical examination in the assessment of the trauma patient is not diminished and the need for prompt resuscitation and operative intervention to save a patient's life take precedence over definitive diagnosis in all cases.

Competing interests None.

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