Injury, Int. J. Care Injured (2007) **38**, 43—47

ELSEVIER

INJURY
INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED

www.elsevier.com/locate/injury

The use of chest computed tomography versus chest X-ray in patients with major blunt trauma

Matthias Traub [a], Mark Stevenson [b,*], Suzanne McEvoy [b], Greg Briggs [a], Sing Kai Lo [c], Steven Leibman [a], Tony Joseph [a]

[a] *Trauma Service, Royal North Shore Hospital, St. Leonards, NSW 2065, Australia*
[b] *The George Institute of International Health, Critical Care and Trauma Care Division, The University of Sydney, P.O. Box M201, Missenden Road, Camperdown, Sydney, NSW 2050, Australia*
[c] *Deakin University, Vic., Australia*

Accepted 6 July 2006

KEYWORDS
Blunt chest trauma;
Clinical predictors;
CT chest scan;
Chest X-ray

Summary

Introduction: Computed tomography (CT) scans are often used in the evaluation of patients with blunt trauma. This study identifies the clinical features associated with further diagnostic information obtained on a CT chest scan compared with a standard chest X-ray in patients sustaining blunt trauma to the chest.
Methods: A 2-year retrospective survey of 141 patients who attended a Level 1 trauma centre for blunt trauma and had a chest CT scan and a chest X-ray as part of an initial assessment was undertaken. Data extracted from the medical record included vital signs, laboratory findings, interventions and the type and severity of injury.
Results: The CT chest scan is significantly more likely to provide further diagnostic information for the management of blunt trauma compared to a chest X-ray in patients with chest wall tenderness (OR = 6.73, 95% CI = 2.56, 17.70, $p < 0.001$), reduced air-entry (OR = 4.48, 95% CI = 1.33, 15.02, $p = 0.015$) and/or abnormal respiratory effort (OR = 4.05, 95% CI = 1.28, 12.66, $p = 0.017$). CT scan was significantly more effective than routine chest X-ray in detecting lung contusions, pneumothoraces, mediastinal haematomas, as well as fractured ribs, scapulas, sternums and vertebrae.
Conclusion: In alert patients without evidence of chest wall tenderness, reduced air-entry or abnormal respiratory effort, selective use of CT chest scanning as a screening tool could be adopted. This is supported by the fact that most chest injuries can be treated with simple observation. Intubated patients, in most instances, should receive a routine CT chest scan in their first assessment.

* Corresponding author. Tel.: +61 2 9657 0365; fax: +61 2 9657 0301.
E-mail address: mstevenson@george.org.au (M. Stevenson).

0020-1383/$ — see front matter
doi:10.1016/j.injury.2006.07.006

Introduction

Two-thirds of patients with multiple injuries suffer from blunt chest trauma and severe thoracic trauma is associated with multiple injuries in 70–90% of cases.[5,7] Among blunt injuries to the chest, lung contusion is considered one of the most important factors contributing to the increased morbidity and mortality of patients with multiple injuries.[2,9]

The usual diagnostic work-up in the emergency department for blunt injuries to the chest includes a routine chest X-ray taken in the supine position and an ultrasound. Despite this approach, significant injuries, such as pneumothoraces, haemothoraces, and lung contusions can be missed during the initial trauma assessment.[1,8,11] Another investigation that is relevant to assess blunt trauma to the chest is computed tomography (CT) scanning. Several studies have shown that CT scanning is accurate in visualising intrathoracic injuries, such as pneumothoraces, haemothoraces, and lung contusions.[3,6,10] In addition, the availability, reliability, and low complication rate of CT scans has led to its widespread use in the evaluation of blunt trauma.

A number of authors have suggested that the CT chest scan should be routinely considered in the initial assessment of chest trauma.[6,12] However, this suggestion remains controversial. For example, some studies have reported clinical changes in management after CT scans in up to 70% of cases,[10] whereas others have suggested that routine CT scans do not have a major impact on the management of blunt trauma to the chest.[8,6]

With the wide availability of CT scanners and with the technical improvements in image quality and speed over the past decade, overuse and perhaps overdependence on CT results for the management of patients with chest trauma has occurred. Although CT is an excellent diagnostic tool for chest trauma, it is costly, requires radiation exposure, and removes the patient briefly from direct clinical care at a time when close monitoring of the patient is critical. In a busy trauma or emergency facility, overuse of CT scans can lead to inappropriate delays in patient care.

The purpose of the study is to identify the clinical features associated with further diagnostic information obtained on a CT chest scan compared with a routine chest X-ray in patients sustaining blunt trauma to the chest. This will help to guide decisions about the further investigation and management of blunt trauma to the chest; which is important given that two-thirds of patients with multiple injuries sustain blunt chest trauma.[5,7]

Methods

Study design

A retrospective review of patients with blunt chest trauma who were treated in a Level 1 trauma centre between January 2002 and December 2003 and who had received both CT chest scan and chest X-ray as part of their initial assessment.

Data collection from medical records and the trauma registry was approved by the Northern Sydney Health Human Research Ethics Committee.

Patients

Patients were identified from the hospital's trauma registry. The trauma registry collects data on all trauma patients with either an injury severity score (ISS) greater than 15, an intensive care unit (ICU) admission, a length of stay greater than 3 days, injuries to two or more body regions, who were transferred-into the Level 1 trauma centre, or who subsequently died in hospital. Over the 2-year period, a total of 1101 patients met this criteria and were included in the trauma registry. Of these, 148 (13.4%) had sustained blunt trauma to the chest and had received a CT chest scan (as well as a chest X-ray) during their initial assessment in the emergency department. Seven patients were excluded (2 had penetrating chest injuries and 5 were under the age of 16 years). Consequently, a total of 141 patients met the study's inclusion criteria.

Measurements

Data included in the trauma registry is completed by the trauma team leader (usually an emergency department consultant or registrar). Information on vital signs (Glasgow Coma Score, systolic blood pressure, heart rate, respiratory rate, respiratory effort); injuries sustained and the injury severity score; clinical findings, such as chest wall bruising or tenderness, reduced air-entry and surgical emphysema; laboratory findings including baseline haemoglobin and arterial blood gas results; therapeutic interventions; outcomes was transcribed, systematically, from the medical and trauma registry records into a data form developed for the study. The radiologist's written report was used to identify abnormal findings on both the chest X-ray and the CT scan. Where documented, information on the patient's management both before and after the CT scan was collected.

All CT scans during the study period were performed on a General Electric (Milwaukee, USA) Lightspeed Qxi scanner ("4 slice scanner") using

100 ml of Ultravist 370 (Schering AG, Germany) IV contrast and 2.5 mm slice thickness, reconstructed to 5 mm axial scans from apex to diaphragm and with sagittal reconstructions of the thoraco-lumbar spine with oblique Maximal Intensity Projections of the aortic arch.

Data analysis

In addition to the descriptive statistics, the McNemar's test was used to compare differences in the proportion of detected clinical features using both a CT scan and routine chest X-ray. Backward stepwise logistic regression was employed to identify significant clinical predictors of a positive CT scan. For the purpose of the multivariate analysis, a positive CT scan was one that provided a pathological finding(s) above the median finding(s) detected by a chest X-ray and was considered therefore to have provided additional information compared with the chest X-ray alone. All analyses were conducted using SPSS, Version 12.0 (SPSS Inc., Chicago, IL) software.

Results

Of the 141 patients, 75% ($n = 106$) were men with the patients ranging in age from 17 to 89 years (mean = 47.2 years). The most common mechanism of blunt trauma to the chest was as a result of a motor vehicle crash (37%, $n = 52$), a motorcycle crash (8.5%, $n = 12$), a fall (23%, $n = 33$) or pedestrian injury (17%, $n = 24$). The mean ISS was 24 (range 3—59).

Almost a third of the patients ($n = 45$) arrived intubated or were intubated in the emergency department. Eighteen percent ($n = 26$) of the patients had a chest tube placed prior to CT scan and an additional 11% ($n = 15$) of the chest tubes were placed after obtaining a CT chest scan. No patient required needle thoracocentesis. Forty-two percent ($n = 59$) of the patients underwent an operation including two (1.4%) thoracotomies, 12 (8.5%) laparotomies, 24 (17%) open reductions and internal fixations and 11 (7.8%) craniotomies. Sixty percent of the patients ($n = 85$) needed admission to ICU, where they were intubated for an average of 3 days and stayed for an average of 5 days. The overall mortality rate of the study participants was 12.8% ($n = 18$).

Ninety percent of patients ($n = 127$) had at least one pathological finding on CT scan compared to 58% of patients ($n = 82$) on plain chest X-ray. Additional investigations and/or interventions following CT scan were performed on 19% of patients ($n = 27$). These included aortic angiography ($n = 4$), transoesophageal echocardiography ($n = 4$), and two patients required insertion of an endoluminal stent for aortic injuries. Thoracotomies were performed on two patients; one for a haemothorax and the other a transsected thoracic aorta. Intercostal catheters were required in 15 patients following the CT scan for a pneumothorax that was not seen on a plain chest X-ray or for an additional chest tube for a persisting pneumothorax. Ten percent of patients ($n = 14$) had no abnormality detected on CT scan. Half of those scans involved intubated patients.

A widened mediastinum was suggested in 14 patients following chest X-ray. A haematoma was confirmed on CT scan in six of these; four prevertebral haematomas with vertebral fractures present and two anterior haematomas in the presence of a sternal fracture. In the eight remaining cases, CT scanning could not confirm the suspicion of a widened mediastinum. CT scan picked up an additional 21 mediastinal haematomas, 3 of which were aortic injuries not seen initially on plain X-ray. There were three elevated haemidiaphragms on plain X-ray raising suspicion of diaphragmatic injury. Two

Table 1 Number (%) of positive radiological findings

Radiological findings	Chest X-ray	CT scan	*p*-Value
Rib fractures	47 (33.3%)	68 (48.2%)	<0.001
Scapula fractures	5 (3.5%)	12 (8.5%)	0.016
Vertebra fractures	1 (0.7%)	23 (16.3%)	<0.001
Sternum fractures	0 (0%)	10 (7.1%)	<0.001
Clavicular fractures	13 (9.2%)	13 (9.2%)	1.00
Pneumothorax	9 (6.4%)	31 (22.0%)	<0.001
Haemothorax	10 (7.1%)	16 (11.3%)	0.263
Haemopneumothorax	1 (0.7%)	16 (11.3%)	<0.001
Lung contusion	23 (16.3%)	44 (31.2%)	<0.001
Mediastinal haematoma	10 (7.1%)	25 (17.7%)	0.006
Aorta dissection	0 (0%)	3 (2.1%)	0.250
Ruptured diaphragm	2 (1.4%)	2 (1.4%)	1.00

were confirmed on CT scan and were repaired at subsequent laparotomy. The third case had an elevation on CT scan as well, but was not confirmed clinically. CT scan was significantly better than routine chest X-ray in detecting lung contusion, pneumothorax, mediastinal haematoma, as well as rib fracture, fractured scapula's, fractured sternum and fractured vertebra (see Table 1).

Fifty-nine patients (42%) had additional findings reported by CT scan beyond that found on their chest X-ray, and in a multivariate logistic regression model that included all cases ($n = 141$) and was adjusted for age and gender, a number of clinical features were found to discriminate between findings on a CT chest scan compared to a chest X-ray. These findings were the presence of chest wall tenderness (OR = 6.73, 95% CI = 2.56, 17.70, $p < 0.001$), reduced air-entry (OR = 4.48, 95% CI = 1.33, 15.02, $p = 0.015$) and abnormal respiratory effort (OR = 4.05, 95% CI = 1.28, 12.66, $p = 0.017$).

All patients with a reduced air-entry ($n = 33$) in their clinical assessment had an abnormal CT scan. Furthermore, only 5% (3 of 65) patients with chest wall tenderness and 6% (2 of 35) patients with increased respiratory effort had a normal CT chest scan. Twenty-two percent of patients did not have any of these signs but had an abnormal CT scan.

Discussion

In this study, CT chest scanning was significantly more effective in detecting pneumothoraces and haemopneumothoraces, lung contusions and mediastinal haematomas compared with a chest X-ray. This is in accordance with several studies that have shown a greater sensitivity for a CT chest scan for detecting intrathoracic injuries.[6,12] Furthermore CT chest scan was significantly better at detecting fractured ribs, scapulas, sternums and vertebrae than a chest X-ray.

CT scanning was more sensitive in the detection of parenchymal abnormalities, such as lung contusions. The majority of patients who require intubation for respiratory failure are usually intubated on clinical grounds and often prior to obtaining a CT scan. Although CT scans may confirm the diagnosis of pulmonary contusion, therapy is based on monitoring physiologic variables, as radiographic findings have not been found to correlate with either mortality or the need for intubation.[2]

The relatively low rate of thoracotomy in this study group might be correlated to a relatively low ISS and because of the exclusion of patients with penetrating trauma and supports again the fact that most thoracic blunt trauma can be treated conservatively.[4]

The question of whether the additional information gained with CT scanning changes patient management in this early phase remains controversial. Several studies found changes in patient management of up to 70% in situations where CT chest scans were performed, such as insertion or correction of a chest tube, a change in the mode of ventilation, as well as further investigations and/or interventions.[10] In contrast, other studies have not been able to demonstrate significant therapeutic consequences and consequently, they do not recommend CT chest scans as a routine first assessment.[8,6] In this study, only 19% ($n = 27$) of the patients with an abnormal CT scan had a subsequent investigation and/or intervention as a direct result of the findings. Of these patients, the majority (70%, $n = 19$) had chest wall tenderness, reduced air-entry, increased respiratory effort or a combination of these signs.

With the increasing use of CT scanning, the proportion of CT scans showing no abnormality is likely to increase. While an apparently normal CT result might still be of considerable value in the intubated patient, for the remaining patients, factors such as transport out of the resuscitation area, exposure to radiation, possible reaction to the contrast agent, delay in treatment and additional costs need consideration. Although an abnormal CT scan was found in 90% of patients in this study, the clinical management changed in a minority of these patients on the basis of the CT scan results. Of the 10% of patients with normal scans, half were intubated patients, in whom clinical findings are limited and CT scanning is warranted.

Conclusion

The findings from this research highlight that a CT scan is significantly more likely to yield additional information than a CXR alone under the following circumstances: presence of chest wall tenderness, reduced air-entry and abnormal respiratory effort. Therefore, in alert patients and in the absence of those clinical findings, the results suggest that selective use of CT chest scanning can be considered. This is supported by the fact that most chest injuries can be treated with simple observation. As the clinical information is not obtainable from intubated patients, we suggest that this group receives a routine CT chest scan in their first assessment. Importantly, although the clinical signs we have outlined have some value, clinicians should take into account all of the clinical features and results of other radiological investigations when making a final decision about the use of CT chest scanning. This may be particularly relevant in situations where

a cardiac or aortic injury is suspected as these may not present with the signs that we have identified.

References

1. Hekir MD, Hollands MJ, Deane SA. The accuracy of the first chest X-ray in the trauma patient. ANZ J Med Surg 1990;60:529—32.
2. Johnson JA, Cogbill TH, Winga ER. Determinants of outcome after pulmonary contusion. J Trauma 1986;26:695—7.
3. Karaaslan T, Meuli R, Androux R, et al. Traumatic chest lesions in patients with severe head trauma: a comparative study with computed tomography and conventional chest roentgenograms. J Trauma 1995;39(6):1081—6.
4. Kulshrestha P, Munshi I, Wait R. Profile of chest trauma in a level I trauma center. J Trauma 2004;57(3):576—81.
5. LoCicero III J, Mattox KL. Epidemiology of chest trauma. Surg Clin N Am 1989;69:15—9.
6. Marts B, Durham R, Shapiro M, et al. Computed tomography in the diagnosis of blunt thoracic injury. Am Surg 1994;168(6):688—92.
7. Pinilla JC. Acute respiratory failure in severe blunt chest trauma. J Trauma 1982;22(3):221—6.
8. Poole GV, Morgan DB, Cranston PE, et al. Computed tomography in the management of blunt thoracic trauma. J Trauma 1993;35(2):296—300.
9. Schild H, Strunk H, Stoerkel S, et al. Computertomographie der Lungenkontusion. Fortschr Roentgenstr 1986;145:519—26.
10. Trupka A, Waydhas C, Hallfeldt KK, et al. Value of thoracic computed tomography in the first assessment of severely injured patients with blunt chest trauma: results of a prospective study. J Trauma 1997;43(3):405—11.
11. Wagner RB, Jamieson PM. Pulmonary contusion: evaluation and classification by computed tomography. Surg Clin N Am 1989;69:31—40.
12. Wilson D, Voystock JF, Sariego J, et al. Role of computed tomography scan in evaluating the widened mediastinum. Am Surg 1994;60:421—3.