EMA Emergency Medicine Australasia

Emergency Medicine Australasia (2018) doi: 10.1111/1742-6723.13174

ORIGINAL RESEARCH

Yield of serious axial injury from pan scans after blunt trauma in haemodynamically stable low-risk trauma patients

Jessica ROBERTS,[1] Sara WATTS,[1] Sharon KLIM,[2] Peter RITCHIE[1] and Anne-Maree KELLY[2,3]

[1]Department of Emergency Medicine, Western Health, Melbourne, Victoria, Australia, [2]Joseph Epstein Centre for Emergency Medicine Research, Western Health, Melbourne, Victoria, Australia, and [3]Department of Medicine, Melbourne Medical School – Western Precinct, The University of Melbourne, Melbourne, Victoria, Australia

Abstract

Objectives: Whole body computed tomography (WBCT) scanning for trauma has gained popularity but its role in low-risk patients is controversial. We aimed to determine the rate of serious axial/truncal injury and emergency intervention in conscious, stable patients undergoing WBCT for blunt trauma in two non-trauma centre EDs in the Victorian trauma system.

Methods: Retrospective cohort study by medical record and radiology report review. Patients were included if they were conscious, haemodynamically stable adults presenting by ambulance and having WBCT scan. Exclusion criteria were age <16 years, no history of trauma, Glasgow Coma Scale <14, systolic blood pressure <90 mmHg and intoxication with alcohol or drugs. Data collected included demographics, clinical findings, results of CT scans and emergency interventions (emergency truncal surgery, transfer to a trauma centre and/or transfusion within 24 h). The outcomes of interest were the rate of defined serious axial/truncal injury and emergency interventions.

Results: One hundred and four patients were studied. Median age was 45 years; 67% were men. Median injury severity score (ISS) was 1.5 (interquartile range 0–5); only one patient had an ISS ≥15. Ninety (87%, 78–92%) patients had no defined serious injury. Five (5%) patients had a defined emergency intervention – four trauma centre transfers and one transfusion. Two of these were not trauma-related.

Conclusion: The rate of serious axial/truncal injury was low. The high rate of normal scans makes it likely that the risk:benefit ratio between injury identification and radiation related cancer risk is unacceptably high. This data supports a selective CT strategy in low-risk trauma patients.

Key words: *imaging, trauma, whole body computed tomography scan.*

Key findings

- The rate of serious axial/truncal injury was low challenging the risk:benefit ratio for whole body CT scanning.
- The Victorian trauma system pre-hospital risk assessment algorithm is accurate in discriminating high- versus low-risk trauma patients.
- This data supports a selective CT scan approach in alert, stable adult trauma patients.

Background

Blunt trauma, including road trauma, is a common cause of death and injury. Imaging of trauma patients has been an area of evolution and controversy. Recently whole body computed tomography (WBCT) scan, including head and neck, chest and abdominopelvic CT scans, has gained popularity in trauma centres for assessing patients with severe trauma. The rationale is that it affords earlier and more accurate detection of hidden injuries, allowing earlier intervention and potentially better outcome, but this has not been conclusively proven.[1] On the converse, it adds cost, carries risks of adverse events such as acute kidney injury and contrast-related allergic reaction and represents significant radiation exposure with its associated cancer risk for what is, on average, a young patient group. A recent randomised controlled trial of high-risk trauma patients failed to show a reduction in mortality between WBCT and standard imaging with selected CT scans for the overall cohort and for the polytrauma and traumatic brain injury subgroups.[2] Recent studies have challenged the role of WBCT in stable patients reporting that a selective approach has similar outcomes.[3–5]

Although WBCT may have a role in unstable or unconscious patients,

Correspondence: Professor Anne-Maree Kelly, Joseph Epstein Centre for Emergency Medicine Research, Western Health, St Albans, Melbourne, VIC 3021, Australia. Email: anne-maree.kelly@wh.org.au

Jessica Roberts, MBBS, Emergency Medicine Registrar; Sara Watts, BSc (Hons), MBBS, MRCP, Emergency Medicine Registrar; Sharon Klim, BN, Research Coordinator; Peter Ritchie, MBBS, MPH, FACEM, Emergency Physician; Anne-Maree Kelly, MD, FACEM, FCCP, Director.

Accepted 4 August 2018

the yield for significant clinical abnormality and the risk–benefit ratio of WBCT in the lower risk trauma cohort is unclear. The practice of WBCT is probably most contentious in awake, stable patients at low risk of life-threatening injury. The State of Victoria, Australia has a well-developed trauma system. The system involves pre-hospital triage of high-risk cases to major trauma centres according to a risk algorithm.[6] Patients deemed at low risk by this algorithm are transferred to the nearest appropriate ED, which is usually not a specialist trauma centre. The Victorian trauma system has been shown to reduce mortality compared to historical controls[7] and improve outcome from patients with severe head injury comparable to a similar health system that does not have a trauma system.[8] The nett result of the Victorian trauma system is that most metropolitan ED receives trauma patients at low risk of serious injury. We were unable to identify any previous research specifically addressing the yield of WBCT scans in a low-risk population as defined by pre-hospital trauma triage criteria.

The objective of the present study was to determine the rate of serious axial/truncal injury in conscious, stable patients undergoing WBCT for blunt trauma in a metropolitan, non-trauma centre ED within the Victorian trauma system.

Methods

This is a planned sub-study of a retrospective cohort study performed by medical record and medical imaging report review investigating use of medical imaging in trauma patients. It was conducted in two metropolitan teaching hospitals (not designated trauma centres) with a combined annual adult ED census of approximately 85 000. The study hospitals have a trauma code alert in place. Patients who meet pre-defined mechanism or clinical criteria trigger activation of a trauma alert that primarily involves attendance by the on-call surgical registrar to participate with ED clinicians in assessment and treatment. Although WBCT is

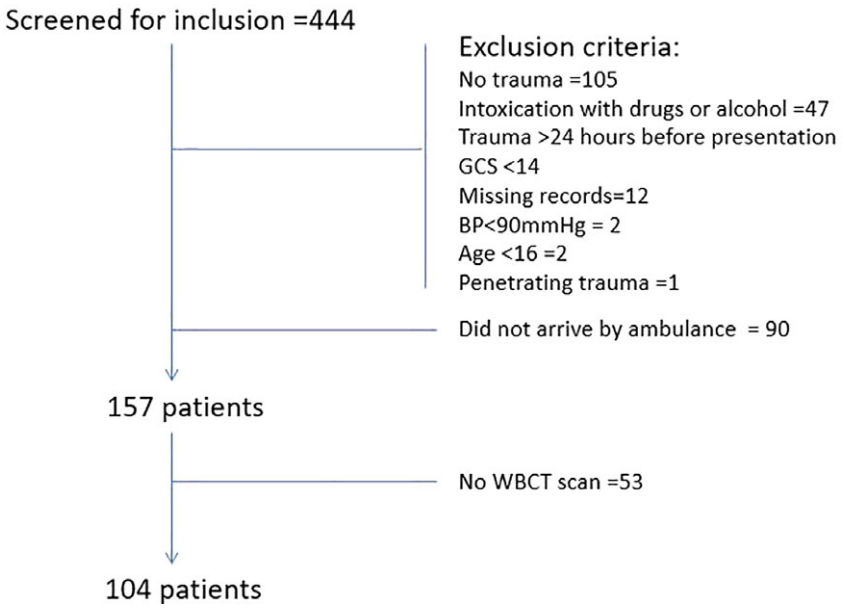

Figure 1. *Sample derivation. BP, blood pressure; GCS, Glasgow Coma Scale; WBCT, whole body computed tomography.*

TABLE 1. *Demographics, cause of injury and rate of serious injury*

Variable	Result (*n* = 104)
Age (IQR) (years)	45 (29–59)
Sex, *n* male, % (95% CI)	70, 67 (57–76)
Cause of injury (*n*, %)	
Motor vehicle crash	52, 50
High fall	13, 12
Motorcycle crash	10, 10
Motor vehicle rollover	6, 6
Pedestrian *vs* vehicle	5, 5
Struck by object	5, 5
Struck by person	4, 4
Pedal cyclist	2, 2
Low fall	3, 3
Animal related	1, 1
Other	3, 3
Injury severity score, median (IQR)	1.5 (0–5), range 0–26
Injury severity score distribution, *n*, % (95% CI)	
0–1	52, 50 (40–60)
2–5	35, 34 (25–44)
6–10	12, 12 (6–20)
11–14	4, 4 (1–10)
≥15	1, 1 (0.05–6)

CI, confidence interval; IQR, interquartile range.

TABLE 2. *Serious axial injury prevalence*

Injury	*n*, % (95% CI) (*n* = 100)
Head	
Intracranial haemorrhage	0, 0 (0–4)
Skull fracture	0, 0 (0–4)
Pneumocephalus	0, 0 (0–4)
Major ocular injury	0, 0 (0–4)
Cervical spine	
Fracture (stable)	4, 4 (1–10)
Fracture (unstable)	0, 0 (0–4)
Acute subluxation	0, 0 (0–4)
Chest	
>2 rib fractures	5, 5 (2–11)
Displaced sternal fracture	1, 1 (0.5–6)
Haemothorax	0, 0 (0–4)
Pneumothorax requiring intervention	0, 0 (0–4)
Injury to heart or great vessels	0, 0 (0–4)
Mediastinal haematoma	0, 0 (0–4)
Chest wall injury with contrast extravasation	0, 0 (0–4)
Spine fracture	2, 2 (0.3–7)
Abdomen-pelvis	
Solid organ injury	0, 0 (0–4)
Suspected hollow organ injury	0, 0 (0–4)
Intra-abdominal or retroperitoneal haematoma	0, 0 (0–4)
Fractured pelvis/acetabulum (excluding hip and undisplaced pubic rami fractures)	1, 1 (0.5–6)
Abdominal wall contusion with extravasation of contrast	0, 0 (0–4)
Spinal fracture	3, 3 (0.8–9)
No defined axial/truncal injury	90, 87 (78–92)

CI, confidence interval.

not mandated for trauma patients meeting or potentially meeting trauma alert criteria, it is strongly encouraged by the surgical service.

Patients were identified for screening by a search of the Medical Imaging Department database for patients having both chest and abdominal CT scan for the period January 2015 to February 2017 inclusive. Patients were eligible for inclusion in the parent study if they were conscious, haemodynamically stable adults who presented as a result of trauma and underwent at least chest and abdomen-pelvis CT. Exclusion criteria were age <16 years, no history of trauma, Glasgow Coma Scale <14, systolic blood pressure <90 mmHg and intoxication with alcohol or drugs. For this sub-study, patients were also excluded if they did not arrive by ambulance and/or did not undergo WBCT.

Definitions of serious injury were based on those used by Ong *et al.*[5] and included:

- Brain: intracranial haemorrhage or contusion, skull fracture, pneumocephalus and ocular haemorrhage/globe injury.
- Cervical spine: fracture, acute subluxation or dislocation.
- Chest: greater than two rib fractures or flail segment, displaced sternal fracture, haemothorax requiring intervention, pneumothorax requiring intervention, injury to heart or great vessels, mediastinal haemorrhage, chest wall contusion with contrast extravasation, spinal fracture, intraparenchymal lung haemorrhage or clinically significant contusion (hypoxia, ventilation, length of stay >2 days).
- Abdomen/pelvis: solid organ injuries, suspected hollow viscus injury, intra-abdominal or retroperitoneal haemorrhage, fracture of the spine or pelvis/acetabulum (excluding femoral and undisplaced pubic rami fractures) and abdominal wall contusion with contrast extravasation.

Data were collected onto a specifically designed case record form, which included patient demographics, mechanism of injury, initial vital signs, clinical findings, results of CT scans and emergency interventions defined as emergency truncal surgery, transfer to a trauma centre and/or transfusion within 24 h of admission. Abbreviated injury score and injury severity score (ISS) were calculated retrospectively by trained coders. Records of patients with defined injuries were reviewed to determine if there were clinical signs in the relevant region that would have prompted selective imaging. Data collectors were not blinded to the objectives of the study.

The outcomes of interest are the rate of serious axial/truncal injury in patients undergoing WBCT for trauma. This is an exploratory analysis. Previous research from higher risk cohorts suggests that up to 89% of WBCT had zero or one significant findings.[5] We hypothesised that our rate of defined serious injury would be <10%. We estimated that 100 patients would provide a confidence interval width of ±5%.

Ethics approval was obtained from the Western Health Low Risk Ethics Panel under the provisions of the National Health and Medical Research

Council quality assurance guidelines (approval number QA2017.18).

Results

Derivation of the cohort is shown in Figure 1. One hundred and four patients were included with a median age of 45 (interquartile range [IQR] 29–59, range 17–89) and 70 (67%) were men. Patient demographics and cause of injury are shown in Table 1. Rates of defined serious injury findings by region and overall are shown in Table 2. Ninety (87%, 95% confidence interval [CI] 78–92%) patients had none of the defined serious axial/truncal injuries. All (14/14, 100%, 95% CI 73–100%) injuries would have been identified

TABLE 3. *Details of patients with defined adverse events*

Patient no.	Demographics and mechanism	Clinical findings	Injuries	Defined adverse event	Comment
1	68 year old man with history of arrhythmia on dabigatran. Arrhythmia resulting in motor vehicle accident	Tender over sternum, tender lower cervical spine; neurologically intact	Fractured spinous process C7 (tip), undisplaced sternal fracture, pericardial effusion (increase in size)	Transfer to trauma centre	Considered too complex for community teaching hospital without cardiothoracic surgical service; injuries not reason for transfer
2	33 year old man, run down by a car	Abrasions to back with focal tenderness over lumbar spine, abdominal tenderness; neurologically intact	Fractured transverse processes L1–4 bilaterally	Transfer to trauma centre	Patient considered to require spinal service not available at community teaching hospital
3	25 year old man, motor vehicle accident with rollover	Pain in thoracic spine but no focal tenderness or neurology	Minor anterior superior endplate wedge compression fractures T4, 5 and 7	Transfer to trauma centre	Patient considered to require spinal service not available at community teaching hospital
4	89 year old woman, hit by taxi, initially stable	Locally tender left ribs and left upper quadrant, bruising left hip	Multiple rib fractures and fractured pelvis, became haemodynamically unstable	Transfer to trauma centre	Considered too complex for community teaching hospital potentially requiring pelvic surgery or embolisation
5	67 year old man, fall from roof	Clinically suspected fractured hip or femur	Fractured hip, undisplaced pubic rami fractures, single rib fracture	Transfusion within 24 h	Anaemic on admission, haematemesis on day 1, dropped haemoglobin further requiring one unit transfusion; transfusion not related to trauma

by selective imaging based on clinical findings.

Five (5%, 95% CI 2–11%) patients had defined emergency interventions. These are summarised in Table 3. There were no cases of emergency truncal surgery. The rate of trauma-related emergency intervention was 3% (3/104, 95% CI 0.8–9%), all transfers to a trauma centre. Two of these were for access to a spinal service, which is not available at the study hospitals. Only one (1%, 95% CI 0.05–6%) transfer was for management of complex and multi-system trauma.

Discussion

Recently, WBCT scans have gained popularity in trauma centres for investigation of patients suffering severe trauma on the rationale that they more quickly and accurately identify injuries and allow earlier intervention if required. Their impact on patient outcome, compared to selective CT scanning, is the subject of some controversy[2–5] and the risk of adverse events is not negligible. Although the logic underlying this practice might be reasonable for unconscious or critically ill patients, it is more tenuous in conscious or haemodynamically stable patients.

Our results show that patients assessed as low risk by the prehospital component of the Victorian trauma system have a low rate of serious injury and that WBCT scan has such a low yield as to be considered unjustified in this patient group. Further the data suggests that a selective imaging approach would have identified all of the injuries (Table 4).

We may in fact have overestimated the number of significant injuries by using the conservative definitions proposed by Ong *et al.*[5] All of the vertebral injuries identified were stable and treated conservatively as was the mildly displaced sternal fracture. If these are not regarded as significant injuries, the rate of serious injury in the cohort is 5% (5/104, 95% CI 2–11%). All multiple rib fractures were suspected clinically, none of them required mechanical ventilation or surgical intervention.

Radiation exposure is associated with cancer risk, although the impact at doses less than 100 mSV is controversial.[9] Some experts believe the excess cancer risk is approximately 5% per 1000 mSV and that the risk associated with lower doses can be linearly extrapolated from this figure.[9] The radiation associated with WBCT has been calculated to be 29.5 mSV – about 10 times the background radiation dose.[10] This would equate to an excess cancer risk of approximately 0.15% per WBCT. However, it is not

TABLE 4. *Presence of clinical features suggesting injury in patients with defined injuries on WBCT*

	Clinical suspicion of injury					
Patient	Head	Neck	Chest	Abdomen/ Pelvis	CT findings	Would selective imaging have identified injury?
A	No	Not examined, in collar	Yes	Yes	Multiple rib fractures, pelvic fracture	Yes
B	Yes	No	Yes	No	Displaced sternal fracture	Yes
C	No	Yes	Yes	No	Thoracic wedge fractures	Yes
D	No	No	No	Yes	Bilateral lumbar spinous process fractures	Yes
E	No	No	Yes	Yes	T3 and 5 spinous process fractures	Yes
F	No	No	No	Yes	Fracture L4 and 5	Yes
G	No	No	No	Yes	Burst fracture L1	Yes
H	No	Yes	Yes	Yes	C6 fracture with strain	Yes
I	No	Yes	No	No	C5 lamina fractures, C4 spinous process	Yes
J	No	Yes	Yes	No	C7 spinous process fracture	Yes
K	Yes	No	Yes	Yes	Multiple rib fractures	Yes
L	Yes	Not examined, in collar	Yes	No	C7 fracture, multiple rib fractures	Yes
M	No	No	Yes	Yes	Multiple rib fractures	Yes
N	No	No	Yes	No	Multiple rib fractures	Yes

WBCT, whole body computed tomography.

appropriate to compare WBCT with no CT as trauma patients who undergo selective imaging will also have radiation exposure, estimated to be about 13 mSV.[10] The difference is an estimated excess cancer rate of 0.065% or 6.5/10 000 patients for patients undergoing WBCT compared to selective imaging. Although this may seem a very small number, our data and accumulated research suggests that this additional risk is being carried for no outcome benefit.[1–5]

Our data also confirms that the Victorian trauma system pre-hospital risk assessment algorithm is accurate with only one (1%) patient meeting major trauma criteria being transferred to our non-trauma centre ED.

The present study has some limitations that should be considered when interpreting the results. The most important is that our results are not generalisable to health systems without a mature trauma system including a paramedic-based trauma triage algorithm. However, they do provide additional data supporting the effectiveness of such systems. Additionally, data was collected retrospectively with the inherent issues of data omission.[11] We do not have data about the outcome of patients who were transferred. Data collectors were not blinded to the study objectives.

Conclusion

Our results show that patients assessed as low risk by the pre-hospital component of the Victorian trauma system have a low rate of serious injury and that WBCT scan has such a low yield as to be unjustified in this patient group. Further it supports selective imaging as all defined axial/truncal injuries would have been identified by a selective imaging approach.

Acknowledgements

The authors thank Dr Wei Lim and Dr Shunkara Naidoo for assistance in developing the concept of the study and identifying the cohort, Dr Chris Paes for assistance with data collection and Dr Michael Bryant for constructive comments on the manuscript. The present study was supported by departmental funds only.

Author contributions

AMK had the concept for the study. The protocol and instruments were refined by all authors. All authors participated in data collection. AMK was primarily responsible for analysis. All authors contributed to data interpretation. AMK drafted the manuscript and all authors refined and approved the final manuscript.

Competing interests

AMK is a member of the editorial board for *Emergency Medicine Australasia*.

References

1. Surendran A, Mori A, Varma DK, Gruen RL. Systematic review of the benefits and harms of whole-body computed tomography in the early management of multi-trauma patients: are we getting the whole picture? *J. Trauma Acute Care Surg.* 2014; **76**: 1122–30.
2. Sierink JC, Treskes K, Edwards MJR *et al.* Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): a randomised controlled trial. *Lancet* 2016; **388**: 673–83.
3. Murphy SP, Hawthorne N, Haase D, Chiku C, Wen J, Rodriguez RM. Low yield of clinically significant injury with head-to-pelvis computed tomography in blunt trauma evaluation. *J. Emerg. Med.* 2017; **53**: 865–70.
4. Moussavi N, Ghani H, Davoodabadi A *et al.* Routine versus selective chest and abdominopelvic CT-scan in conscious blunt trauma patients: a randomized controlled study. *Eur. J. Trauma Emerg. Surg.* 2018; **44**: 9–14.
5. Ong AW, Moyer J, Wordofa FD, Sigal A, Sandel K, Fernandez FB. Trauma surgeon utilization of computerized tomography scanning: room for improvement? *Am. J. Surg.* 2017; **213**: 579–82.
6. Department of Health. *Prehospital Triage Guideline*. 2014. [Cited Jul 2017]. Available from URL: https://www2.health.vic.gov.au/about/publications/policiesandguidelines/Prehospital-Triage-Guideline
7. Cameron PA, Gabbe BJ, Cooper DJ, Walker T, Judson R, McNeill J. A statewide system of trauma care in Victoria: effect on patient survival. *Med. J. Aust.* 2008; **189**: 546–50.
8. Gabbe BJ, Biostat GD, Lecky FE *et al.* The effect of an organized trauma system on mortality in major trauma involving serious head injury: a comparison of the United Kingdom and Victoria, Australia. *Ann. Surg.* 2011; **253**: 138–43.
9. Lim EC. Radiation risk from medical imaging. *Mayo Clin. Proc.* 2010; **85**: 1142–6.
10. Gordic S, Alkadhi H, Hodel S *et al.* Whole-body CT-based imaging algorithm for multiple trauma patients: radiation dose and time to diagnosis. *Br. J. Radiol.* 2015; **88**: 20140616.
11. Gilbert EH, Lowenstein SR, Koziol-McLain J, Barta DC, Steiner J. Chart reviews in emergency medicine research: where are the methods? *Ann. Emerg. Med.* 1996; **27**: 305–8.