AAST Manuscript Submission

CROSS SECTIONAL IMAGING OF THE TORSO REVEALS OCCULT INJURIES IN ASYMPTOMATIC BLUNT TRAUMA PATIENTS

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Introduction

Trauma is the number 1 cause of death for people age 1-44 years, and accounts for 19.2% of years of potential life lost in the United States. Additionally, the medical and loss-of-work cost from traumatic injuries totals well above $500 billion annually in the United States1. Given the magnitude of this problem, it is imperative that the treating practitioners intervene in both a life-saving and cost-effective manner.

There are multiple ways to evaluate and treat trauma patients. Advanced Trauma Life Support (ATLS) directs rapid assessment of the acutely injured patient using physical examination, plain radiographs and ultrasound to increase survival2. The use of torso computed tomography (CT) comes with less clear recommendations. Despite this, torso CT in trauma patients has become much more common.

As CT technology has improved, more injuries are detected in less time3-4. This has led some centers to use CT scan of the torso liberally5-9, whereas other authors advocate use in selected patients10-11. Advocates of selective CT for trauma will argue that benefits do not outweigh the complications, which include IV contrast issues, radiation exposure, and cost12-14.

The use of either torso CT or a ‘pan CT,’ which includes CT head, cervical spine, chest, abdomen, and pelvis, has been shown to be beneficial in severely injured patients that do not have a reliable physical exam5,15-17. However, even in evaluable patients, the sensitivity of physical exam and plain radiographs remain insensitive to detect injuries, and there is controversy with regards to selecting the appropriate patients to undergo torso CT18-22.

The use of pan CT in trauma in stable, unevaluable adult trauma patients is popular. The role of pan CT in the awake, mildly injured, evaluable patient is less clear and still widely debated17,20,22. Similar is true for a torso or thoracoabdominal CT23 .

In our center, both ED and trauma attendings are involved in the initial workup of trauma patients, depending on level of activation. This has led to a wide practice variation in which patients receive a torso CT. The purpose of this study is to review the CT indications, findings, and complications in patients with low ISS to determine the utility of torso CT in this patient cohort.

Methods

A retrospective review of non-intubated, blunt trauma patients aged 15 years or older with an initial GCS of 14 or 15 evaluated in an American College of Surgeons verified level 1 trauma center from July 2012 to June 2015 was performed. Data was obtained from the trauma registry and chart review and included: age, sex, injury type, mechanism, ISS, physical exam findings, all injuries recorded, injuries detected by torso CT, missed injuries, and complications. The Institutional Review Board at St. Vincent Hospital granted permission for this study.

Physical exam findings were captured from trauma or ED notes, and all patients were seen by the ED attending physician. All trauma consults and code 1 activations were seen by the attending trauma surgeon. Physical exam findings were regularly recorded on a template trauma H&P form and were: ‘visible trauma (location),’ ‘chest wall (CW) tenderness to palpation,’ ‘CW crepitus,’ ‘CW ecchymosis,’ Abdominal (Abd) ecchymosis,’ ‘Abd distension,’ ‘Abd tenderness,’ ‘flank ecchymosis.’

Laboratory values obtained included hemoglobin, INR, pH, lactate, base deficit, blood alcohol level, urine drug screen. Initial chest X-ray (CXR) and pelvic XR, if performed, were recorded. Initial CT Chest/Abdomen/Pelvis (C/A/P) were recorded, as well as delayed CT C/A/P. All injuries and incidental findings were recorded. The criteria for a delayed CT was when it was performed after the initial evaluation in the ED. Repeat CTs done for a different reason (re-evaluation, operative planning) were not recorded as such.

Statistical analysis: …

Results

2306 patients were determined eligible for review from the registry. The mean ISS was 8. Initial chest physical exam was normal in 1571 (68%). 829 (52%) of these patients received a CT Chest, and 127 (15%) of these patients were found to have an occult chest injury. 698 (61%) of patients that had an initial CXR also received a CT Chest. 151 (35%) patients with a negative CXR who also had a CT Chest had occult injuries detected. 1,067 (56%) patients with a negative abdominal exam had a CT A/P. 174 (16%) 19% of these patients were found to have an occult injury on CT. 592 (43%) of the patients with normal C/A/P exams received a CT C/A/P. 150 (25%) of these patients demonstrated occult injuries by CT. No consistent pre-scan criteria were identified to accurately rule out CT as an effective adjunct to the work-up. No incidents of contrast-induced complications were noted in the study period. There were no deaths in this cohort.

A total of 19 (0.82%) delayed or missed injuries (18 delayed minor injuries and 1 missed major injury) were recorded in this cohort. There were 3 delayed minor injuries due to no initial CT being performed. 10 delayed minor injuries were reported due to a delay in radiologic read. The missed major injury was a patient noncompliance issue with persistent abdominal pain who decided to go home after a CT A/P only showed minimal free fluid in a female. She returned within 16 hours with perforated viscus requiring laparotomy. One delayed minor injury was in a patient who was initially taken to the OR for an emergent laparotomy for a mesenteric bleed. A delayed CT then showed bilateral rib fractures. Three delayed minor injuries were spinal injuries not detected on CT, but on subsequent MRI. One delayed minor injury was an extraperitoneal bladder rupture not seen on initial CT A/P, but later on a CT cystogram.

Total Initial CT (iCT)

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| --- | --- | --- | --- |
|  | **Total (%)** | **Normal (%)** | **Positive (%)** |
| **iCT C** | 1466 (64) | 945 (65) | 521 (36) |
| **iCT A/P** | 1391 (60) | 1170 (84) | 221 (16) |
| **iCT C/A/P** | 1242 (54) | 717 (58) | 525 (42) |

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| **Delayed/Missed Injuries** | **Cause** | **Explanation** |
| 3 delayed minor injuries | No initial CT | 1. Normal C/A/P physical exam. CXR with pneumothorax (ptx). Delayed CT chest showed hemothorax, 3 rib fractures, and a left diaphragmatic hernia. 2. Normal C/A/P physical exam. CXR with a ptx and rib fracture. Delayed CT C/A/P showed grade 3 liver laceration. 3. Chest wall tenderness. Initial CXR negative. Delayed CT C showed 1 rib fracture. |
| 10 delayed minor injuries | Human error | Delayed or missed radiologic reads. |
| 3 delayed minor injuries | CT insensitive | Vertebral injuries found on MRI after initial CT performed. |
| 1 delayed minor injury | CT insensitive | Initial CT A/P showed pelvic fracture. Extraperitoneal bladder rupture found on CT cystogram. |
| 1 missed major | Human error/patient compliance | Abdominal TTP, CT A/P with minimal free fluid in female. Pt discharged from ED, returns within 16 hours with perforated small bowel requiring laparotomy. |
| 1 delayed minor | Order of treatment | Emergent laparotomy for mesenteric bleed. CT C 6 days later showed bilateral rib fractures. |

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|  | **PPV** | **NPV** | **Sensitivity** | **Specificity** |
| **CXR** | 0.90 | 0.65 | 0.61 | 0.91 |
| **Chest PE** | 0.62 | 0.85 | 0.76 | 0.74 |
| **Abdominal PE** | 0.15 | 0.84 | 0.21 | 0.76 |
| **C/A/P PE** | 0.58 | 0.75 | 0.71 | 0.62 |

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| **Asymptomatic Chest** | **ISS (avg)** | **LOS (Days)** | **n (%)** | **p** |
|  | 7.53 | 4.15 | 1571 (68) |  |
| **w/ CT C** | 8.28 | 3.75 | 829 (53) |  |
| **w/ CT C +** | 12.72 | 4.96 | 127 (15) |  |
| **w/ CT C -** | 7.45 | 3.61 | 702 (85) |  |
| **w/o CT C** | 6.71 | 4.59 | 742 (47) |  |

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| **Asymptomatic Abd** | **ISS (avg)** | **LOS (Days)** | **n** | **p** |
|  | 8.12 | 4.06 | 1903 (83) |  |
| **w/ CT A/P** | 8.77 | 3.87 | 1067 (56) |  |
| **w/ CT A/P +** | 10.56 | 5.6 | 174 (16) |  |
| **w/ CT A/P -** | 8.2 | 3.36 | 893 (84) |  |
| **w/o CT A/P** | 6.77 | 4.45 | 836 (44) |  |

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| **Asymptomatic Chest/Abd** | **ISS (avg)** | **LOS (Days)** | **n** | **p** |
|  | 7.57 | 4.2 | 1375 (60) |  |
| **w/ CT C/A/P** | 8.56 | 3.73 | 592 (43) |  |
| **w/ CT C/A/P w/ C+** | 13.26 | 4.97 | 65 (11) |  |
| **w/ CT C/A/P w/ A/P+** | 12.12 | 5.94 | 65 (11) |  |
| **w/ CT C/A/P w/ C+ & A/P+** | 15.36 | 6 | 22 (4.0) |  |
| **w/ CT C/A/P -** | 7.25 | 3.2 | 442 (75) |  |
| **w/o CT C/A/P** | 6.78 | 4.51 | 783 (57.0) |  |

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| **Normal Chest PE with Abnormal CT C** | **# (%)** |
| Bilateral rib fractures | 5 (0.6) |
| Clavicle fracture | 12 (1.5) |
| Lung contusion | 17 (2.1) |
| Pneumothorax | 25 (3.1) |
| 1-2 rib fractures | 38 (4.7) |
| 3-6 rib fractures | 25 (3.1) |
| >6 rib fractures | 7 (0.87) |
| Scapular fracture | 14 (1.7) |
| Splenic injury | 4 (0.50) |
| Suspected aortic injury | 3 (0.37) |
| Hemothorax | 1 (0.12) |
| Sternal fracture | 6 (0.75) |
| Total chest injuries | 157 (19.5) |
| Total abnormal CT C | 111 (13.8) |

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| **Normal Chest PE and CXR with Abnormal CT C** | **# (%)** |
| Bilateral rib fractures | 3 (1.1) |
| Clavicle fracture | 1 (0.38) |
| Lung contusion | 7 (2.7) |
| Pneumothorax | 6 (2.3) |
| 1-2 rib fractures | 10 (3.8) |
| 3-6 rib fractures | 12 (4.6) |
| >6 rib fractures | 2 (0.77) |
| Scapular fracture | 4 (1.5) |
| Splenic injury | 3 (1.1) |
| Suspected aortic injury | 3 (1.1) |
| Hemothorax | 1 (0.38) |
| Sternal fracture | 5 (1.9) |
| Total chest injuries | 57 (21.8) |
| Total abnormal CT C | 41 (15.7) |

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| **Normal Abdominal PE with Abnormal CT A/P** | **# (%)** |
| Bowel wall thickening | 2 (0.15) |
| Free air | 2 (0.15) |
| Liver I-III | 21 (1.6) |
| Liver IV | 5 (0.38) |
| Liver V | 2 (0.15) |
| Mesenteric stranding | 6 (0.45) |
| Pelvic fracture | 235 (17.7) |
| Renal contusion | 1 (0.07) |
| Renal laceration | 4 (0.30) |
| Spleen I-II | 18 (1.35) |
| Spleen III | 6 (0.45) |
| Spleen IV-V | 7 (0.52) |
| Suspicious small bowel injury | 2 (0.15) |
| Total abdominal injuries | 311 (23.4) |
| Total abnormal CT A/P | 309 (23.2) |
| Total abdominal injuries excluding pelvis | 76 (5.7) |

Discussion

It is not surprising that we are unable to conclude a benefit in mortality in asymptomatic patients receiving a torso CT given the low ISS of this cohort. We are not able to prove a benefit in morbidity for these patients either based on the data. Only 2 patients that had no chest or abdominal findings on physical exam that did not have torso CT were found to have injuries on a delayed torso CT. This is consistent with a Cochrane review by Van Vugt et al published in 2013 comparing selective torso CT versus routine torso CT – there just have not been enough quality trials to base a recommendation18.

One year later, Caputo et al published a systematic review and meta-analysis on whole-body CT versus selective CT in trauma patients that did show a significant mortality benefit for those that receive pan CT, even though their ISS is higher24. This study is different in the fact that Caputo specifically looked at whole body CT and the Cochrane Review was specifically thoracoabdominal CT, as in our study.

Although not randomized controlled trials, there are several studies supporting pan CT in trauma. Salim et al reported findings in a prospective observational study that changed management in 19% of stable trauma patients that received pan CT8. Yeguiayan et al showed a 30-day reduction in mortality from 22% to 16% by using pan CT16, and Self et al showed that 26% of patients receiving CT C/A/P that were already receiving head CT had unexpected findings that changed treatment25.

The first multicenter, randomized controlled trial (REACT-2) by Sierink et al that compared immediate total-body CT with conventional imaging and selective CT concluded that immediate total-body CT is safe, quicker, and does not increase direct medical costs, but does not change in-hospital mortality26. The median ISS (20) was significantly higher than in our cohort, so we do not have a direct comparison with that study group.

The study by Lee et al comparing the cost-effectiveness of pan CT versus selective CT in stable, young adults matches up more closely with our cohort. The average ISS was 5 in this study, compared to 8 in ours. Their population was much more uniform. They concluded that it is cost-effective to use pan CT based on mechanism alone, even in these mildly injured patients. It is noted, that the cost of incidentalomas and contrast-induced complications were not included in that study20. However, one should consider the benefits of serendipitous early detection of malignancy. We do not have data to show for this beyond personal experience, and is perhaps a future area to study.

The risk of radiation exposure is always a concern with CT scans. Sierink et al published a study in 2013 showing an increase in initial radiation exposure after instituting a total-body CT protocol, but that total in-hospital radiation exposure was similar27. Another study also showed an increase in patients receiving more radiation (>20 mSv) after instituting a trauma pan scan protocol28. The REACT-2 trial only showed a 0.3 mSv difference (ie 1 CXR) in radiation exposure of pan-scan vs selectively scanned trauma patients. The exposure to radiation during a CT scan is easy to establish, but the risk of cancer conferred by that exposure is extrapolated and may not be accurate, but best estimates are about 29,000 cancers annually are attributed to CT scans in the United States29. Tien et al published a prospective cohort study of trauma patients’ average radiation exposure of 22.7 mSv level, which would be estimated to result in 190 cancer related deaths per 100,000 patients exposed30. Though still greatly debated, it is our opinion that a single torso CT benefits outweigh this relatively small, theoretical risk in adults.

We show, in our retrospective study of mildly injured blunt trauma patients with a GCS of 14 or 15, that a surprising number of injuries are detected after normal chest and abdominal physical examinations, as well as chest X-ray. 468 injuries (or signs of suspected injuries requiring a change in management) were detected in 420 otherwise asymptomatic, evaluable patients. This is about 30% of the patients with benign torso bedside exam findings. The known lack of sensitivity of CXR is consistent in our study (61%).

Whether occult findings are clinically relevant is an important point. Some may argue that clinical importance is only if a procedure is performed or if early discharge is accomplished. We found the length of stay of a patient receiving negative torso CT was 1 day less than similar patients that did not receive torso CT. Additionally, stratifying patients to level of care (floor versus ICU) has been consistently shown to be important, especially with regards to number of ribs fractured31, even in patients as young as 45 years32. There is also good data to show that significant post hospital morbidity exists for patients after relatively minor thoracic trauma 33-34. Having the knowledge of the full extent of injury may be important in post discharge rehabilitation plans and expectations.

In addition, quicker diagnosis lends to shorter wait time to intervention when needed. Reporting a negative torso CT is reassuring for both the patient and physician. There are also significant medico-legal considerations of missed injury in U.S. trauma centers.

The limitations of this study include its retrospective nature and lack of cost analysis. The blunt mechanisms were also not stratified based on height of fall, motor vehicle rollover or ejection, etc, which hinders further and more specific stratification. Many of the trauma labs were not recorded as many of the patients were trauma alerts or nonactivations, which often do not have several of the labs drawn (ie arterial blood gas, urine drug screen). Focused Assessment with Sonography for Trauma (FAST) exams were not consistently performed in this cohort and therefore were not analyzed. FAST exams are generally used in higher acuity patients in shock, but not liberally at our institution during this time period.

Conclusion

A significant number of occult injuries were detected in stable adult blunt trauma patients with a GCS of 14/15. A negative physical exam combined with a normal CXR do not rule out the presence of occult injuries and the need for torso imaging. In this series, 31% of stable adult blunt trauma patients with GCS of 14/15 and normal physical exams were found to have occult injuries detected by CT. In blunt trauma patients with normal sensorium, physical exam and CXR, the practice of obtaining cross sectional imaging would appear to be beneficial. Identification of occult injuries in this cohort outweighs the small risk associated with CT scan.

Notes

Future areas of study

Cost analysis (though its been done already with initial pan CT).

Cost of incidental findings (unnecessary workup and early detection/treatment)

No way to figure out morbidity of those that may have had occult injuries, but never scanned

Interesting point:

LOS is just about 1 day less in negative CT vs those asymptomatic patients for each C, A/P and C/A/P. Is it statistically significant? Can we assume that’s because they were scanned, so we gained 1 hospital day?

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