TOP TEN TRAUMA PAPERS OF 2012-13

Papers ten through six

Northwest States Trauma Conference

Richard J Mullins, MD
Professor of Surgery, OHSU.

Paper #10 NEW IDEAS ABOUT BLUNT CEREBROBASCULAR INJURIES.

Improving the Screening Criteria for blunt cerebrovascular injury: the appropriate role for computed tomography angiography. Emmett KP, Fabian TC, DiCoco JM, Zarzaur BL, Croce MA. J Trauma 2011: 70: 1058-65. These authors reported a large series of patients who sustained blunt trauma and were treated at the Elvis Presley Trauma Center, and determined that 0.58% of the patients had a blunt cerebrovascular injury. These investigators routinely perform an invasive angiogram, a digital subtraction angiogram, to evaluate the two carotids and two vertebral vessels in patients considered high risk due to mechanism or physical findings. The authors performed 748 digital subtraction angiograms and observed that one half of the injured carotid or vertebral arteries did not have a positive finding on a CT angiogram that was obtained at the same time.

The authors use a five level grading system for severity of arterial injury (i.e. Grade I, minimal changes in intima to Grade V, transected artery) and found that patients had 8 Grade II, 13 Grade III and 2 Grade IV that were not seen on the CT angiogram. The authors have reached a firm conclusion; “Given the unacceptably high number of false negatives with CTA as a screening test, we have continued to use digital subtraction angiography to screen for BCVI at our institution.”


While there is convincing evidence in multiple papers in the past decade that patients with blunt cerebrovascular disease benefit from early diagnosis and treatment with anticoagulants (either heparin or aspirin) most authorities have published papers recommending that anticoagulants not be used in patients with injuries to the head or spine. Callcut and colleagues decided that anticoagulation should not be held, given the previous consequences of strokes, and so have had a policy at their trauma center to treat the patients with blunt cerebrovascular injuries with anticoagulants, regardless of associated neurologic injuries. The investigators report a cohort of 77 patients who had confirmed blunt cerebrovascular injuries as well as traumatic neurological injuries, including 51 who had traumatic brain injury and 21 patients with a spine injury. The authors studied this double injury group because there has been an argument made that anticoagulation should be delayed in patients with neurologic injury that might bleed.
The table below summarizes the highest grade lesion, and the vessel injured. In this series, as in most others, there were Untreated. The investigators identified the vascular injury by CT scan in half the patients, and then confirmed the Grade of injury using a follow up Gold Standard test, cerebral angiogram. “Confirmatory angiography found identical grade lesions compared with the non invasive study in 85% of the patients, with the only discrepancy being two additional grade I vertebral injuries. The authors report that the initial diagnostic test was on day 2, with 86% of patients having a diagnostic study within 72 hours.

<table>
<thead>
<tr>
<th>Grade of injury</th>
<th>Carotid</th>
<th>Vertebral</th>
<th>Untreated with stroke</th>
<th>Treated with a stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>32%</td>
<td>51%</td>
<td>3/17 = 19%</td>
<td>0/31</td>
</tr>
<tr>
<td>Grade II</td>
<td>23%</td>
<td>20%</td>
<td>5/34 = 28%</td>
<td>0/21</td>
</tr>
<tr>
<td>Grade III</td>
<td>38%</td>
<td>4%</td>
<td>7/17 = 44%</td>
<td>2/24</td>
</tr>
<tr>
<td>Grade IV</td>
<td>5%</td>
<td>25%</td>
<td>1/13 = 2%</td>
<td>0/14</td>
</tr>
<tr>
<td>Grade V</td>
<td>2%</td>
<td>0</td>
<td>0/1</td>
<td>n/a</td>
</tr>
</tbody>
</table>

The treating team made the diagnosis of a stroke in three time periods; 3 were present on arrival, 17 strokes occurred more than 24 hours after admission (stroke occurred on median post injury day 5 (range: 2-26), and are considered potentially preventable if the patient had been anticoagulated. There is one stroke (large and lethal) that occurred less than 24 hours after injury when the guidelines suggest that anticoagulation should have been avoided.

The 45 patients in Callcut et al’s study who were treated with anticoagulation, 2 had a stroke; these patients were Grade III lesions. Half the patients were given aspirin, and half therapeutic heparin. In a multivariate analysis of this cohort of 73 patients only one factor was associated with a risk of stroke; treatment with an anticoagulant. The traumatic brain injury worsened in 6% of those given anticoagulant, and 5% of those not given anticoagulant. None of the spine injured patients, whether given anticoagulation or not, had worsening of their spinal cord lesion.

In summary, these papers and others contribute to the growing body of published literature that high risk blunt trauma patients should be identified, and at least be screened with CT angiogram. If the angiogram is positive for a blunt cerebrovascular injury, the patient should be anticoagulated. If the CT angiogram is negative, the patient may still have an injury, and there should be a low threshold for the invasive digital subtraction four vessel carotid and vertebral angiogram soon after admission.


The investigators of this study assembled information on 393 adult patients treated in one of eleven Level I and II trauma centers, and divided the patients into three groups for analysis. Group one were patienta who had immediate surgery; they were hemodynamically more unstable, had a more severe liver injuries, and a half of these patients died. Group 2 were patients initially committed by the treating surgeon to non-operative management and that strategy was successful; these patients had a lower
prevalence of shock on ED admission, less severely injured livers, and only a 5% mortality. The third group was 6% of the total population, who were initially committed to non-operative management, but this failed, and they had an operation on their liver injury; these patients had a more severely injured liver than the injury of those managed successfully without surgery, and a death rate lower than the patients who had immediate laparotomy. The table below summarizes some of the key findings.

<table>
<thead>
<tr>
<th></th>
<th>Immediate surgery</th>
<th>Successful non operative management</th>
<th>Failed non-operative management.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients (%)</td>
<td>131 (33%)</td>
<td>239 (61%)</td>
<td>23 (6%)</td>
</tr>
<tr>
<td>Admission SBP</td>
<td>102 +/- 32</td>
<td>124 +/- 25</td>
<td>110 +/- 21</td>
</tr>
<tr>
<td>HCT</td>
<td>31 +/- 7</td>
<td>37 +/- 27</td>
<td>36 +/- 6</td>
</tr>
<tr>
<td>ISS score</td>
<td>41 +/- 5</td>
<td>21 +/- 11</td>
<td>29 +/- 7</td>
</tr>
<tr>
<td>CT liver grade 4</td>
<td>60%</td>
<td>90%</td>
<td>83%</td>
</tr>
<tr>
<td>CT liver grade 5</td>
<td>40%</td>
<td>10%</td>
<td>17%</td>
</tr>
<tr>
<td>Mortality %</td>
<td>53%</td>
<td>5%</td>
<td>8%</td>
</tr>
</tbody>
</table>

The authors report that hepatic angiography with embolization was performed in 25% of the group committed to non operative management, and this hemostatic intervention contributed to their success at non operative management. In summary this review highlights that patients with severe liver injury who are taken to surgery have a fifty percent mortality, and new treatments that would enable more successful use of non-operative management are needed. While angioembolization is associated with successful non-operative management, the surgeon with a hypotensive patient and a large liver injury faces a dilemma; taking the patient to IR suite may delay performance of a laparotomy that is the patients only chance for survival. A key conclusion of the authors is “There is little reason to intervene surgically in those hemodynamically stable patients, no matter how striking the CT image may be.” On the other hand, a surgeon who explores a patient with a high grade liver injury should fully prepare for the need to rapidly achieve hemostasis through optimal use of exposure, packs, ligation of major bleeding vessels, and possibly isolation of the bleeding liver.

**Paper #8 TPN VS ENTERAL IN ICU**


There is universal agreement among nutrition experts that the optimal method to deliver nutrition to a patient who is critically ill is as a diet into the GI tract. However achieving the goals with enteral nutrition is not practicable is selected patients for a range of reasons including ileus, bowel dysfunction related to sepsis and injured bowel. Thus it is an attractive concept to supplement with parenteral nutrition formulas the calories, protein and fats the patient needs to meet their metabolic balance. Two recent papers have looked at the value of early TPN in large randomized control trials, and the results are different.
The Caspar et al study randomized patients in an ICU who were given enteral as tolerated (but was insufficient to meet estimated caloric needs) to either receive an immediate infusion of TPN as needed to reach goals, or a delay of 8 days before TPN was started in those who needed supplementation. Starting TPN after day 8 was associated with a faster recovery and few complications, indicating that TPN related complications in the first few days of crucial illness may have adverse consequences.

The Heidegger et al study randomized patients on day after ICU admission to receive enteral nutrition as tolerated, which was delivering less than 60% of the energy target, or supplemental parenteral nutrition in addition to the enteral nutrition so that these patients receive 100% of energy targets. The two groups differed in that the supplemental parenteral nutrition groups received substantially more calories; “the mean cumulative energy balance during the intervention period was 124 kcal in the supplemental parenteral nutrition group versus -2317 kcal in the enteral only group. The outcome was nosocomial infections, and the group that was given supplemental nutrition had 20% lower rate.

The conflicting results of these two studies leave physicians and surgeons treating critically ill patients still unsure as to the merits of supplemental parenteral nutrition. In trauma patients the priority of using the GI tract is agreed upon, but it is also the challenge in the multisystem trauma patient that repeated trips to the OR, and the mandate of having the patient NPO before induction of anesthesia means even the best intentions to provide full enteral nutrition support may not be possible. We can expect more studies in this area.

Paper #7  DIAGNOSIS OF INTRAABDOMINAL INJURY

A higher proportion of blunt torso trauma patients are evaluated with a CT scan of their head, face, entire spine, chest, abdomen and pelvis then a decade ago. For some trauma surgeons, routine “pan-scan” has become the standard of care. CT scans are accurate, can be quickly performed, and lack the inter-rater variability of physical examination for signs and symptoms. CT scans are sensitive (i.e. identify an abnormality in most patient’s with an injury) and specific (i.e. are read as normal in most patients who do not have an injury). A major advantage to the reliability of CT scan of the chest, abdomen and pelvis after significant blunt trauma is that providers can promptly decide the disposition of the patient from the ED.

Radiation exposure from a CT scan has been estimated to be 10 mGy. Critics of the increasing dependence upon CT scans to evaluate injured patients have cautioned that radiation exposure increases the individuals risk of cancer. [Computed tomography – an increasing source of radiation exposure. Brenner DJ, Hall EJ. N Engl JMed. 2007; 357:2277-84] Radiation exposure is a exceptional concern for children for whom a dose of ionizing radiation as youths puts them at risk for late onset of cancer decades later. Kim et al calculated that children (under the age of 18) who are treated for serious injury are exposed to a total effective dose of 15milliSivert, which leads to the estimate that 6 to 12 children out of 10,000 exposed to radiation during a work-up for trauma are at risk during their remaining decades of life for early death from cancer. [Effective radiation dose from Radiological Studies in Pediatric Trauma PatientsKim PK, Zhu X, Houseknecht E, Nickolaus D, Mahboubi S, Nance ML World J Surg. 2005; 29: 1557 – 1562]
In response to the concern for radiation exposure, investigators at University of California Davis, have led a research project to develop a reliable method of categorizing into two groups children being evaluated in the Emergency Department following blunt trauma to the torso; those at very low risk for abdominal injury and thus should not have a “pan scan”, and those who are other than very low risk, and are more likely to benefit from CT scans. The UC Davis investigators have published three papers that I will present in this discussion. These studies demonstrated that accurate, and clinically useful decision rules are developed through meticulous systematic efforts.


Holmes and co-investigators in a research group at University California Davis report the results of a study in this paper intended to validate a decision rule that they had developed which used physical examination and laboratory tests to identify children who sustained blunt torso trauma and were considered other than low risk for intra-abdominal injuries. “External validation” of a clinical decision rule means the rule was developed using one cohort of patients, and then the investigators prospectively applied the rule in a new group of trauma patients to determine the accuracy of the rule. In their initial derivation studies the investigators identified six “high-risk” signs, symptoms or lab tests. These tests could be performed within the first minutes of the child’s arrival in the emergency department. As we analyze the results of applying this rule, we would recognize that the primary purpose of the rule was to very reliably determine a cohort who had very low risk; the trauma team providers could with a high level of confidence follow these patients without reliance upon a CT scan. The investigators were not attempting to develop a decision rule which identified a subset of the patients who had a high probability of a positive CT scan for an intra-abdominal injury.

Over 3 years at their Level 1 trauma center, and 1324 children (defined as younger than 18 years) who sustained blunt trauma within 24 hours of ED arrival were recruited into the study. The authors for the purpose of this study intended that emergency medicine providers who evaluated a child would have complete a “standardized data collection form” at the completion of their initial evaluation, prior to the next step in the child’s care that in the majority of children was obtaining a diagnostic CT scan of the chest abdomen and pelvis. The authors had a few children whose abdominal injury was confirmed by laparotomy or laparoscopy. Not unexpectedly in this real time study, 1119 children, or 84%, had the standardized data collection form completed before the child proceeded for work up, and this was the group analyzed.

A patient was considered rule positive if one or more of the six “high risk” findings was identified as present on the standardized data collection form. The six “high-risk” variables were the following: low age-adjusted systolic blood pressure, abdominal tenderness, femur fracture, increased liver enzyme levels (serum aspartate aminotransferase concentration >200 U/L or serum alanine aminotransferase concentrations >125 U/L), microscopic hematuria (urinalysis >5 RBCs/high powered field) or an initial hematocrit level less than 30%.
In this prospective data collection study, a child was considered rule negative if none of the six high risk findings were present; with no risk factors, the authors recommend their rule indicates a CT scan would be negative, and thus needlessly expose the child to radiation.

The authors used the standard statistical methods of analysis, which included calculation of the sensitivity and specificity of the rule and presence of intra-abdominal injury.

<table>
<thead>
<tr>
<th></th>
<th>Intra-abdominal injury</th>
<th>No intra-abdominal injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule positive</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Rule negative</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Sensitivity means the proportion of patients identified as having a positive rule among all with injury

\[ \text{Sensitivity} = \frac{A}{A + C} \]

Specificity means the proportion of patients identified as having a negative rule among all without an injury

\[ \text{Specificity} = \frac{D}{B + D} \]

For the purpose of analysis of their decision rule, the authors wanted to evaluate primarily in this study the patients with a rule negative, (C plus D) and they are specifically concerned about the proportion of false negative \( = \frac{C}{B + D} = 1 - \text{Sensitivity} \). Children influenced by a false negative decision would have the undesirable consequence that a CT scan was not promptly performed that would enable timely diagnosis of an intra-abdominal injury.

The overall results of the study were that the six high risk factors were sensitive and specific. The rule’s sensitivity was 94.9% meaning 149 of the 157 children with an intra-abdominal injury would have been identified as high risk and sent for a CT scan. The rule’s specificity was 37.1% meaning 357 of the 962 blunt trauma children who did not have an intra-abdominal injury were correctly identified as low risk. The clinical consequence of application of this rule is that 365 children, roughly a third of children, with blunt torso trauma could have been identified shortly after their arrival in the ED as not requiring further evaluation with a CT scan, and thus could have avoided the radiation exposure.

The authors report in detail the clinical course of the eight children in the false negative category. Holmes and colleagues report seven of these eight children had blunt solid organ injuries treated with observation in the hospital for 2 to 7 days. One child who had a seat belt sign and no CT scan later developed abdominal tenderness; at laparotomy the injuries were “a serosal tear and mesenteric hematoma neither of which required specific intervention.”

While many of the 365 children in this study who had a negative rule had a CT scan, the authors conclude that they could have been spared that radiation if their decision rule had been applied.
In conclusion, the authors argue that the primary utility of their decision rule was that one third of the children with blunt torso trauma would have been spared exposure to needless radiation. As the authors report; “Observation plays an important role in the evaluation and assessment of some children with blunt torso trauma.” The majority of the 1119 patients were identified as being having a “non-negligible risk” for intra-abdominal injury and had a promptly performed CT scan. While 605 children with blunt torso trauma who it would turn out did not have a significant abdominal injury were assigned to the CT scan group, this was the price that the investigators were willing to pay in their decision rule in exchange for having a very low False Negative rate. In decision rules like these, the investigator must always assess the balance of how many nonbeneficial tests is acceptable in exchange for being very confident the rule does not lead to delayed diagnosis of a serious injury.

Does this adult patient have a blunt intra-abdominal injury? Nishijima DK, Simei DL et al JAMA. 2012; 307: 1517-1527

In this second paper, the University of California at Davis used the published literature, and not data from their own patients, to determine which tests or information have been associated with a patient being categorized as high risk for intra-abdominal injury following blunt trauma. Nishijima and coauthors found a few manuscripts which reported the the results of diagnostic tests performed in the first few minutes of a trauma patient’s arrival in an emergency department, and their eventually determined list of diagnoses. The authors determined the diagnostic accuracy of symptoms, signs on physical examination, laboratory tests, bedside imaging with ultrasonography and chest x-ray, but excluded CT scans which typically require a the patient leave the emergency department. The authors defined as the “gold standards” for determination whether the patient had an intra-abdominal injury on abdominal computed tomography, laparotomy, autopsy and/or clinical course.

The investigators studied the papers and recorded from the papers the sensitivity and specificity for a specific test. The investigators calculated for each diagnostic test two statistical values; the positive likelihood ratio, and the negative likelihood ratio.

Positive likelihood ratio = Sensitivity/(1-specificity)

Negative likelihood ratio = Specificity/(1-sensitivity)

As the value for positive likelihood ratio increased, the test was more likely to indicate that the patients had a significant intra-abdominal injury.

The authors provide an important estimate for trauma care providers as they engage in an academic debate regarding how to reduce the number of needless CT scans without jeopardizing the population. The prevalence of intra-abdominal injury in patients evaluated at a hospital after blunt torso trauma, based upon all of the studies, was 13% [95% CI 10% - 17%]. Furthermore they determined the prevalence of significant injuries, defined as an injury that required a laparotomy or laprosocopy or angioembolizations, as being 4.7%. These two prevalence numbers mean that in the population of blunt torso trauma patients, in a substantial majority of cases, a CT scan will be needless because no injury will be identified.
Nishijima and coauthors conclude that these are the tests which the literature supports are most useful in the development of a decision rule. The skills or performing a physical examination are important, and especially daunting in patients who are unconscious or impaired by drugs and ethanol. A CT scan is in these analyses the gold standard test that can be performed in the ED.

It is emphasized by Nishijima and coauthors that a separate issue is whether the absence of a positive test, i.e. a normal lab value or normal physical examination, can be depended upon to indicate that the patient is risk free.

The authors emphasize an important teaching point; the abdominal bedside ultrasound, the FAST, if positive has a high association with an intra-abdominal injury, but the absence of a positive ultrasound does not significantly reduce the prior probability of an injury.
The “clinical bottom line” from this study is that a patient with significant blunt abdominal trauma has approximately a 13% chance of injury (and a 4.7% prevalence of clinical significant injuries i.e. need surgery or angioembolization), and that the tests listed in the table above when positive indicate the likelihood that this prevalence is higher, and the patient should have further evaluation, and possibly abdominal surgery or angioembolization.


Holmes and coinvestigators from the University of California Davis, selected a third dataset to conduct this effort to develop a decision rule regarding which patients should have a CT Scan; the investigators recruited large consortium of investigators from 20 emergency departments across the US to provide them the data in a prospective manner. Their intent was to use the data to derive a prediction rule for identifying patients who are at very low risk for abdominal injury after blunt torso trauma. The prediction rule is different from the decision rule Holmes reported in the above noted manuscript; in the 2013 manuscript a sequence of seven questions regarding physical examination findings and symptoms are asked and used to separate the population of 12,044 blunt trauma children into 5034 children with an estimated risk of intraabdominal injury of 0.1%, or 7010 children with a risk of intra-abdominal injury between 0.5% and 5.7%, with the variation in risk depending on the prediction criteria.

The prediction criteria that Holmes et al used, in the order these were applied were 1. Evidence of abdominal wall trauma or seatbelt sign, 2. A Glasgow Coma score of 3 to 13, abdominal tenderness, evidence of thoracic wall trauma, Complaint of abdominal pain (NOTE; the authors differentiate in their decision rule between those who complain of abdominal pain, and those who have tenderness when the abdomen is palpated), absent or decreased breath sounds, and finally vomiting.

The prediction rule’s categorization of the patient as having an intra-abdominal injury which required an intervention was calculated based upon the child’s clinical course and future tests. The sensitivity was 97.0%, mean only 3% of the children who subsequently needed treatment were categorized as not requiring the irradiation in a CT scan. The rules specificity was 42.5%, and it had a negative predictive
accuracy of 99.9% that enabled 41.7% of the initial cohort of children with blunt torso trauma to be spared the needless radiation of a diagnostic CT scan.

Holmes and coinvestigators in this study decided to not include as a predictor variable a laboratory result or the information from a Focused Abdominal Sonogram for Trauma (FAST). They explained that they decided to leave these factors out because they could not be sure of consistent reliability of providers at getting results back promptly laboratory tests, and performing a FAST.

Holmes et al end this paper by emphasizing that it is derivation study for the rule, and what is needed next is a external validation where the rule would be followed in patients, and long term outcomes determined.

**Paper #6: TREATMENT OF OCCULT PNEUMOTHORAX**


Trauma surgeons and emergency medicine providers regularly encounter the issue of occult pneumothorax. An occult pneumothorax is defined as a pneumothorax seen on CT scan that is not visible on supine chest x-ray. Usually the occult pneumothorax is a narrow anterior arch-shaped air collection. See below.

![Image of a CT scan showing an occult pneumothorax](image)

Clinicians agree the majority of patients who are not on positive pressure ventilation with an occult pneumothorax can be managed without insertion of a chest tube. In 2011, a consortium of trauma
surgeons from multiple trauma centers pooled data prospectively collected on patients with an occult pneumothorax. The consortium reported only 14% of patients failed no-chest tube management. Furthermore they reported among those who need to have a chest tube inserted, not one patient had an adverse clinical event as a consequence of the delay. In their manuscript the consortium members concluded “the overwhelming majority of blunt trauma patients with occult pneumothorax can be safely observed without tube thoracostomy.” [Blunt traumatic occult pneumothorax: is observation safe? - results of a prospective, AAST multicenter study. [Moore FO, Goslar PW, Coimbra R et al. J Trauma 2011; 70: 1019-23] A patient with an occult pneumothorax managed without a chest tube should have routine follow up chest radiography within 8 to 24 hours to determine if the pneumothorax is increasing in size.

Kirkpatrick and colleagues in their 2013 manuscript describe the results of a randomized prospective study on a high risk group of patients with occult pneumothorax. These patients were at risk because they had endotracheal tubes and were being mechanically ventilated; in some cases briefly for surgery and in other cases for a longer period while they were treated for their injuries in an ICU. Trauma surgeons worry that patients intubated and receiving positive pressure ventilation are at risk during inspiration because elevated airway pressures might force air through pulmonary lacerations into the pleural space, thereby increasing the size of the pneumothorax. A major concern is a ventilated patient may suddenly develop a tension pneumothorax, with associated hemodynamic deterioration. Kirkpatrick and colleagues decided to conduct this randomized control trial of selective use of chest tube because they reasoned that patients in intensive care units of trauma centers would be monitored closely and personnel were immediately available to treat a tension pneumothorax.

Kirkpatrick and colleagues randomized 90 adults into two groups; those who had a chest tube inserted promptly following diagnosis by CT scan of an occult pneumothorax, and those patients who did not have a chest tube immediately inserted. Patients in group initially not treated with a chest tube could have a chest tube inserted at a later time at the discretion of the attending surgeon.

The results were of the study were that the majority of patients who were randomized to not have a chest tube never needed to have one inserted. There were 40 patients who were randomized to tube thoracostomy, and 50 patients who did not have a chest tube immediately inserted. The two groups had similar characteristics; the Injury Severity Scores of 35 indicated they were seriously injured, the majority had as their mechanism of injury a motor vehicle crash, and they had similar measured size of their pneumothorax.

Among the 50 patients assigned to the no-chest tube cohort, 20% subsequently had a chest tube inserted. The indications for chest tube insertion were: 1. for progressions of their pneumothorax (40%), 2. For the development of pleural fluid (60%), 3. for “other” issues (20%).

The outcomes are summarized in the table below. The two groups had similar outcomes as measured by duration of ICU therapy, ventilator associated pneumonia and survival. One patient in the no-chest tube cohort did develop the dreaded problem of a tension pneumothorax. The condition was recognized immediately and the patient fully recovered without adverse consequences after a chest tube was inserted.

<table>
<thead>
<tr>
<th>Outcome criteria</th>
<th>Mandatory chest tube</th>
<th>Selective chest tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension pneumothorax</td>
<td>0</td>
<td>1*</td>
</tr>
<tr>
<td>Respiratory distress episode</td>
<td>30%</td>
<td>42%</td>
</tr>
<tr>
<td>Mortality</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>ICU days (IQR = interquartile range)</td>
<td>5 (IQR 2-11.5)</td>
<td>4 (IQR 1-9.5)</td>
</tr>
<tr>
<td>Ventilator days (IQR = interquartile range)</td>
<td>3 (IQR 0-8)</td>
<td>2.5 (IQR 0-2.5)</td>
</tr>
<tr>
<td>Ventilator Associated Pneumonia (%)</td>
<td>26%</td>
<td>18%</td>
</tr>
<tr>
<td>Tracheostomy (%)</td>
<td>10%</td>
<td>8%</td>
</tr>
</tbody>
</table>

- Managed immediately without adverse consequences.

The authors report three methods for measurement of the size of occult pneumothorax; they preferred a simple system that has been described by Wolfman et al [Occult pneumothorax in patients with abdominal trauma: CT studies. Wolfman NT, Gilpin JW, Bechtold RE et al. J Comput Assist Tomogr. 1993; 17: 56-59]. The authors assigned the 40 patients who were successfully managed with no-chest tube into Wolfman’s three categories, miniscule (37%), anterior (55%) and anterolateral (8%). Thus the authors concluded that size was not a risk factor for failure of no-chest tube management of occult pneumothorax.

Kirkpatrick and colleagues provide a remarkably candid summary of complications associated with inserting a chest tube; they report 15% of “suboptimal chest tube position” (including failure to decompress the pneumothorax, and 15% complications. One argument against the routine use of chest tubes in occult pneumothorax is that the chest tubes may fail to decompress the pneumothorax. Furthermore chest tube insertion is painful and restricts the patient’s mobility. Below is a chest CT of a patient who had a chest tube inserted for a pneumothorax, and it shows “suboptimal chest tube position”; that is the chest tube slipped into the fissure between the left upper and lower lobes, and thus pneumothorax is incompletely evacuated.
In conclusion, Kirkpatrick and coauthors provide a cautious clinical conclusion; they recommend that trauma patients, who are intubated and exposed to positive pressure ventilation, an occult pneumothorax may be safely managed without insertion of a chest tube. However the authors hasten to add that this approach is only possible in hemodynamically stable patients who are closely observed, and in a medical setting where a provider is available to immediately treat a tension pneumothorax. The authors emphasize that the probability the patient will need a chest tube is 20%.

The authors discussed another aspect of management of an occult pneumothorax in a manuscript they published in 2009; the diagnostic value of ultrasound. [The occult pneumothorax: what have we learned? Ball CG, Kirkpatrick AW, Feliciano DV. Can J Surg. 2009 Oct;52(5):E173-9.]. The ultrasound probes used during the focused abdominal sonography for trauma (FAST) exam cam be used to investigate whether the patient has an image that indicates that the parietal and visceral pleura are in contact and sliding back and forth during ventilation. The images are taken in the intercostal spaces adjacent to the upper sternum. The normal real time ultrasound image is that the hyper-resonate “bright” line that is pleural surfaces, during ventilation, has the appearance of “shimmering”. The absence of shimmer is highly reliable indication that the two pleura are not in contact, which would happen when a pneumothorax exists.

If the intent of the ultrasound exam is to identify a pneumothorax the sensitivity and specificity of the shimmer test is summarized below; while not perfect, the ultrasound provides an immediate indication in the trauma resuscitation bay of whether the patient has a high probability of a pneumothorax; if the patient has normal shimmering, and the trauma team plans to obtain a chest/abdominal/pelvis CT, it would be reasonable to defer chest x-ray.

<table>
<thead>
<tr>
<th>SHIMMER PRESENT</th>
<th>SHIMMER ABSENT/EQUIVOCAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATIENT HAS A PNEUMOTHORAX</td>
<td>8%</td>
</tr>
<tr>
<td>PATIENT DOES NOT HAVE A PNEUMOTHORAX</td>
<td>98%</td>
</tr>
</tbody>
</table>