Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Karmy-Jones R, Jurkovich GJ, Nathens AB, et al. Timing of urgent thoracotomy for hemorrhage after trauma: a multicenter study. *Arch Surg* 2001; 136(5):513-518.	Observational-Tx	157 patients	Study hypothesized that it is possible to quantify an amount of thoracic hemorrhage, after blunt and penetrating injury, at which delay of thoracotomy is associated with increased mortality.	Mortality correlated with mean (+/- SD) Injury Severity Score (38 +/- 19 vs 22 +/- 12.6 for survivors; P<.01) and mechanism (24 [67%] for blunt vs 21 [17%] for penetrating injuries; P<.01). Mortality increased as total chest blood loss increased, with the risk for death at blood loss of 1500 mL being 3 times greater than at 500 mL. Blunt-injured patients waited a significantly longer time to thoracotomy than penetrating-injured patients (4.4 +/- 9.0 h vs 1.6 +/- 3.0 h; P=.02) and also had a greater total chest tube output before thoracotomy (2220 +/- 1235 mL vs 1438 +/- 747 mL; P=.001).	2
2. World Health Organization. The top 10 cause of death. Available at: http://www.who.int/mediacentre/factsheets/fs310/en/index.html. Accessed 27 December 2012.	Review/Other-Dx	N/A	Fact sheet on the top 10 causes of death worldwide.	N/A	4
3. Murphy SL, Xu J, Kochanek KD. Deaths: Preliminary Data for 2010. National vital statistics reports; vol 60 no 4. Hyattsville, MD: National Center for Health Statistics. 2010.	Review/Other-Dx	N/A	A report to present preliminary U.S. data on deaths, death rates, life expectancy, leading causes of death, and infant mortality for 2010 by selected characteristics such as age, sex, race, and Hispanic origin.	The age-adjusted death rate decreased from 749.6 deaths per 100,000 population in 2009 to 746.2 deaths per 100,000 population in 2010. From 2009 to 2010, age-adjusted death rates decreased significantly for 7 of the 15 leading causes of death: Diseases of heart, Malignant neoplasms, Chronic lower respiratory diseases, Cerebrovascular diseases, Accidents (unintentional injuries), Influenza and pneumonia, and Septicemia. Assault (homicide) fell from among the top 15 leading causes of death in 2010, replaced by Pneumonitis due to solids and liquids as the 15th leading cause of death. The age-adjusted death rate increased for five leading causes of death: Alzheimer's disease; Nephritis, nephrotic syndrome and nephrosis; Chronic liver disease and cirrhosis; Parkinson's disease; and Pneumonitis due to solids and liquids. Life expectancy increased by 0.1 year from 78.6 in 2009 to 78.7 in 2010.	4
4. Calhoon JH, Trinkle JK. Pathophysiology of chest trauma. *Chest Surg Clin N Am* 1997; 7(2):199-211.	Review/Other-Dx	N/A	Review pathophysiology of chest trauma.	No results stated in abstract.	4

Blunt Chest Trauma
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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
5. Ungar TC, Wolf SJ, Haukoos JS, Dyer DS, Moore EE. Derivation of a clinical decision rule to exclude thoracic aortic imaging in patients with blunt chest trauma after motor vehicle collisions. *J Trauma* 2006; 61(5):1150-1155.	Observational-Dx	1,096 patients	To define a group of patients with blunt chest trauma after motor vehicle collision that did not require aortic imaging based on information available in the emergency department.	22 (2.0%) patients were diagnosed with thoracic aortic injury. The decision rule for exclusion of thoracic aortic injury included findings from the CXR, incorporating left paraspinous line displacement, obscured aortic knob, and mediastinal widening. The rule resulted in a sensitivity of 86% (95% CI: 65% to 97%), a specificity of 77% (95% CI: 75% to 80%), a PPV of 7% (95% CI: 4% to 11%), a NPV of 99.6% (95% CI: 99.0% to 99.9%), a positive likelihood ratio of 3.8 (95% CI: 1.1-12.9), and a negative likelihood ratio of 0.18 (95% CI: 0.05-0.61). This would potentially reduce aortic imaging by 76% (95% CI: 74% to 79%).	3
6. Kaewlai R, Avery LL, Asrani AV, Novelline RA. Multidetector CT of blunt thoracic trauma. *Radiographics* 2008; 28(6):1555-1570.	Review/Other-Dx	N/A	To review and illustrate a spectrum of abnormalities encountered in blunt thoracic trauma at MDCT with multiplanar (2D) and volumetric (3D) reformation.	MDCT can quickly and accurately help diagnose a variety of thoracic injuries in trauma patients. These injuries can be clearly displayed with multiplanar and volumetric reformation.	4
7. Chung JH, Carr RB, Stern EJ. Extrapleural hematomas: imaging appearance, classification, and clinical significance. *J Thorac Imaging* 2011; 26(3):218-223.	Review/Other-Dx	13 cases	To identify radiologic and clinical findings associated with extrapleural hematomas, to formulate an imaging-based classification system for extrapleural hematomas, and to identify any radiologic or clinical factors associated with surgical intervention.	92% of the patients (12/13) were male. The average age of the affected patients was 61 years. Most cases were related to blunt trauma (85%, 11/13). All these patients had additional injuries; rib fractures were most consistently present (81%, 9/11). All cases could be further categorized based on the appearance of their CT scan as biconvex or nonconvex. Biconvex extrapleural hematomas tended to be larger than other types (average size of 4211 mL) and required surgical intervention in 80% of patients (4/5). No specific treatment was necessary in patients with nonconvex extrapleural hematomas.	4

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
8. Bernardin B, Troquet JM. Initial management and resuscitation of severe chest trauma. *Emerg Med Clin North Am* 2012; 30(2):377-400, viii-ix.	Review/Other-Dx	N/A	To provide a review of major thoracic injuries and to provide guidance in the initial management and resuscitation of victims of severe chest trauma.	The incorporation of E-FAST will greatly facilitate the diagnostic approach. Therapeutic gestures such as tube thoracostomy and intubation play an important role in the initial stabilization of these patients. Further imaging with CT scanning allows for better definition of the majority of the injuries and has become the diagnostic modality of choice for aortic injuries. The majority of occult injuries (to CXR) can be easily observed. More than 80% of chest injuries may be managed nonoperatively, with supportive treatment.	4
9. Demehri S, Rybicki FJ, Desjardins B, et al. ACR Appropriateness Criteria((R)) blunt chest trauma--suspected aortic injury. *Emerg Radiol* 2012; 19(4):287-292.	Review/Other-Dx	N/A	To recommend appropriate imaging for patients with blunt chest trauma.	Imaging largely focuses on the detection and exclusion of traumatic aortic injury; a large proportion of patients are victims of motor vehicle accidents. For those patients who survive the injury and come to emergency radiology, rapid, appropriate assessment of patients who require surgery is paramount.	4
10. Barrios C, Malinoski D, Dolich M, Lekawa M, Hoyt D, Cinat M. Utility of thoracic computed tomography after blunt trauma: when is chest radiograph enough? *Am Surg* 2009; 75(10):966-969.	Observational-Dx	374 trauma patients	To show that a CXR and an abdominal CT scan are sufficient to identify most clinically significant thoracic injuries in trauma patients, rendering the thoracic CT scan useful in only a subset of patients.	An abdominal CT scan identified 65% (15/23) of OPTXs, 100% (25/25) of occult hemothoraces, 64% (18/28) of occult pulmonary contusions, and 58% (18/31) of occult rib fractures. No OPTXs seen on the thoracic CT scan alone required tube thoracostomy.	3
11. Brink M, Deunk J, Dekker HM, et al. Added value of routine chest MDCT after blunt trauma: evaluation of additional findings and impact on patient management. *AJR* 2008; 190(6):1591-1598.	Observational-Dx	464 patients	To evaluate the added value of a low-threshold routine thoracic MDCT algorithm compared with a selective MDCT algorithm in adult blunt trauma patients.	Of all 464 patients within the routine MDCT group, 164 patients underwent selective MDCT, which resulted in detection of additional diagnoses compared with conventional radiography in 97 (59%) patients. The routine MDCT algorithm detected additional diagnoses compared with conventional radiography in 201/464 patients (43%). Compared with the selective MDCT algorithm, this was an absolute increase of 104/464 (22%) extra patients, resulting in a change in patient management in 34 (7%; 95% CI: 5%-9.7%), mostly because of additional findings of pulmonary and mediastinal injury.	3

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
12. Tillou A, Gupta M, Baraff LJ, et al. Is the use of pan-computed tomography for blunt trauma justified? A prospective evaluation. *J Trauma* 2009; 67(4):779-787.	Observational-Dx	284 patients	To determine whether a more selective approach could be justified in use the pan-CT scan for the evaluation of blunt trauma.	Of the 284 patients, 48 (17%) had injuries on 52 unsupported CT scans. An immediate intervention was required in 2/48 patients (4%). Injuries that would have been missed included 5/62 unsupported head scans (8%), 2/50 neck scans (4%), 33/116 chest scans (28%), and 12/83 abdominal scans (14%). These missed injuries represent 5/61 patients with closed head injuries (8%) in the series, 2/23 with C-spine injuries (9%), 33/112 with chest injuries (29%), and 12/86 with abdominal injuries (14%). In 19 patients, none of the 4 CT scans was supported; 9 of these had an injury identified, and 6 were admitted to the hospital (1 to the intensive care unit). Injuries that would have been missed included intraventricular and intracerebral hemorrhage (4), subarachnoid hemorrhage (2), cerebral contusion (1), C1 fracture (1), spinous and transverse process fractures (3), vertebral fracture (6), lung lacerations (1), lung contusions (14), small PTX (7), grade II–III liver and splenic lacerations (6), and perinephric or mesenteric hematomas (2).	4
13. Omert L, Yeaney WW, Protetch J. Efficacy of thoracic computerized tomography in blunt chest trauma. *Am Surg* 2001; 67(7):660-664.	Observational-Dx	169 patients; 110 enrolled in control group	To determine whether thoracic CT provides additional information to routine CXR findings, whether the additional information results in a management change, and whether thoracic CT is more useful in patients with particular mechanisms of injury.	Thoracic CT identified injuries not seen on CXR in 66% of the control group and 39% of the mechanism group. Identification of these injuries resulted in a highly significant ($P<0.001$) change in clinical management in 20% of the control group and 5% of the mechanism group. Thoracic CT appears to be most helpful in the acute evaluation of trauma patients when CXR evidence of chest injury exists and provides additional information impacting on the care of the patient 20% of the time. In patients with severe mechanisms of injury and normal CXRs, thoracic CT expeditiously identifies occult chest injuries that require treatment in 5% of this population.	3

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
14. McGonigal MD, Schwab CW, Kauder DR, Miller WT, Grumbach K. Supplemental emergent chest computed tomography in the management of blunt torso trauma. *J Trauma* 1990; 30(12):1431-1434; discussion 1434-1435.	Observational-Dx	50 patients	To examine the efficacy of conventional CXR in comparison to CCT in acutely injured blunt trauma patients.	Hemo- and/or pneumothorax was noted in 12 patients (5 by CXR, 12 by CCT). Pulmonary contusion (PC) was identified in 10 patients (4 by CXR, 10 by CCT). Three additional false positive pulmonary contusions were diagnosed by CXR. Therapy changes based upon CCT findings occurred in 7/7 hemo- and/or pneumothorax and 5/6 pulmonary contusions. The 2 imaging techniques were complementary in detecting fractures. Atelectasis was a common CCT finding (58% incidence). CXR is less sensitive than CCT in the detection of Hemo- and/or pneumothorax (42% vs 100%) and PC (40% vs 100%). Emergent CCT is recommended in stable patients with: 1) blunt high-energy torso trauma, 2) "cross-body" injury pattern, and/or 3) a mechanism of injury suggestive of chest trauma.	3
15. Bridges KG, Welch G, Silver M, Schinco MA, Esposito B. CT detection of occult pneumothorax in multiple trauma patients. *J Emerg Med* 1993; 11(2):179-186.	Review/Other-Dx	90 trauma patients	To assess the prevalence, initial detection, and management of trauma patients with OPTXs.	In 35 cases (38.8%), initial supine CXR study failed to detect a pneumothorax, and the diagnosis was made on CT scan of the chest or abdomen performed within 2 hours of admission. In 15 of these cases (42.8%), identification of the pneumothorax on CT scan resulted in alterations in management, including chest tube placement in 10 patients and intensified monitoring in 5 patients.	4
16. Traub M, Stevenson M, McEvoy S, et al. The use of chest computed tomography versus chest X-ray in patients with major blunt trauma. *Injury* 2007; 38(1):43-47.	Observational-Dx	141 patients	To identify the clinical features associated with further diagnostic information obtained on a CT chest scan compared with a routine CXR in patients sustaining blunt trauma to the chest.	The CT chest scan is significantly more likely to provide further diagnostic information for the management of blunt trauma compared to a CXR in patients with chest wall tenderness (OR = 6.73, 95% CI: 2.56, 17.70, P<0.001), reduced airentry (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 CXR in detecting lung contusions, PTX, mediastinal hematomas, as well as fractured ribs, scapulas, sternums and vertebrae.	3

Blunt Chest Trauma
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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
17. Ball CG, Kirkpatrick AW, Laupland KB, et al. Incidence, risk factors, and outcomes for occult pneumothoraces in victims of major trauma. *J Trauma* 2005; 59(4):917-924; discussion 924-915.	Observational-Dx	761 patients	To define the incidence, predictors, and outcomes for OPTXs after trauma.	Paired CXRs and CT scans were available for 338/761 (44%) patients (98.5% blunt trauma). 103 PTXs were present in 89 patients, 57 (55%) of which were occult; 6 (11%) were seen only on thoracic CT scan. Age, sex, length of stay, and survival were similar between all groups. OPTXs and PTXs were similar in comparative size index and number of images. Subcutaneous emphysema, pulmonary contusion, rib fracture(s), and female sex were independent predictors of OPTXs. 17 (35%) patients with OPTXs were ventilated, of whom 13 (76%) underwent thoracostomy. No complications resulted from observation, although 23% of patients with thoracostomy had tube-related complications or required repositioning.	3
18. Lopes JA, Frankel HL, Bokhari SJ, Bank M, Tandon M, Rabinovici R. The trauma bay chest radiograph in stable blunt-trauma patients: do we really need it? *Am Surg* 2006; 72(1):31-34.	Observational-Dx	157 patients	To evaluate the need for trauma bay CXR in stable blunt-trauma patients who are scheduled for CCT.	Among 95 patients with a "normal" CXR, 38 patients (40%) were found on CCT to have traumatic injuries. Among 62 patients with an "abnormal" CXR, 18 (29%) were found to be normal on CCT. Of the remaining 44 patients, 34 had additional findings on CCT. In 32 patients, CCT led to changes in management. CCT was more sensitive in diagnosing thoracic injuries and led to significant changes in management.	3
19. Ball CG, Kirkpatrick AW, Fox DL, et al. Are occult pneumothoraces truly occult or simply missed? *J Trauma* 2006; 60(2):294-298 discussion 298-299.	Observational-Dx	44 patients	To determine whether perceived OPTXs were truly occult or simply missed and also address factors that contribute to the poor sensitivity of the supine CXR.	Retrospective review identified only 12% to 24% of the OPTXs depending on radiology group. The kappa inter-observer agreement value was 0.55 to 0.56 (poor agreement). PTXs were most commonly identified via the deep sulcus sign (75%-90%). CXRs were considered inadequate in 16% to 25% of OPTX images and in 0% to 18% of images without OPTXs. Thoracic CT scans were recommended in 18% to 33% of patients with inadequate CXRs, but 67% to 82% of patients with adequate CXRs.	3

Blunt Chest Trauma
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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
20. Barrios C, Jr., Pham J, Malinoski D, Dolich M, Lekawa M, Cinat M. Ability of a chest X-ray and an abdominal computed tomography scan to identify traumatic thoracic injury. *Am J Surg* 2010; 200(6):741-744; discussion 744-745.	Observational-Dx	200 patients	To identify the utility of thoracic CT in blunt trauma patients with a normal admission CXR.	143 patients had a normal screening CXR; 36 of these patients (25%) had an abnormal thoracic CT. Thoracic CT changed the management in only 9 of these patients (6%): 2 required serial CXR for occult pneumothorax, 4 received additional imaging of the spine, and 3 were admitted to a monitored bed. 57 patients had an abnormal initial CXR. Of these, 41 (81%) had an abnormal thoracic CT. Thoracic CT changed management in 21 (37%) of these patients: 2 aortic injuries identified, 12 aortic injuries excluded, 2 chest tubes placed, 1 patient taken to the operating room, and 4 patients required further diagnostic evaluation. Thoracic CT was significantly more likely to alter management in patients with an abnormal admission CXR (6% vs 37%, P<0.001).	3
21. Smith CB, Barrett TW, Berger CL, Zhou C, Thurman RJ, Wrenn KD. Prediction of blunt traumatic injury in high-acuity patients: bedside examination vs computed tomography. *Am J Emerg Med* 2011; 29(1):1-10.	Observational-Dx	18 emergency physicians	To prospectively evaluate the ability of emergency physicians to exclude predefined clinically significant injuries on the basis of their initial bedside assessment.	400 patients were enrolled as a convenience sample; 71 were excluded. When a "very low" rating was considered negative and "low," "intermediate," "high," and "very high" were considered positive, emergency physicians were able to detect head, cervical spine, chest, abdominal/pelvic, and thoracic/lumbar spine injuries with sensitivities (95% CI) of 100% (98.6%-100%), 97.4% (94.9%-98.8%), 96.9% (94.2%-98.4%), 97.9% (95.5%-99.1%), and 97.0% (94.3%-98.5%), respectively. For overall diagnostic accuracy, areas under the receiver operating characteristics curve (95% CI) were 0.87 (0.82-0.92), 0.71 (0.62-0.81), 0.81 (0.76-0.86), 0.77(0.71-0.83), 0.74 (0.65-0.84), respectively.	2

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
22. Kaiser ML, Whealon MD, Barrios C, Jr., et al. Risk factors for traumatic injury findings on thoracic computed tomography among patients with blunt trauma having a normal chest radiograph. *Arch Surg* 2011; 146(4):459-463.	Observational-Dx	2,435 patients	To identify risk factors that might predict acute traumatic injury findings on thoracic CT among patients having a normal initial CXR.	2,435 patients with blunt trauma were identified; 1,744 (71.6%) had a normal initial CXR, and 394 (22.6%) of these had acute traumatic findings on thoracic CT. Multivariate logistic regression demonstrated that an abdominal Abbreviated Injury Score of 3 or higher (P=.001; OR, 2.6), a pelvic or extremity Abbreviated Injury Score of 2 or higher (P<.001; OR, 2.0), age older than 30 years (P=.004; OR, 1.4), and male sex (P=.04; OR, 1.3) were significantly associated with traumatic findings on thoracic CT. No aortic injuries were diagnosed in patients with a normal CXR. Limiting thoracic CT to patients with 1 or more risk factors predicting acute traumatic injury findings would have resulted in reduced radiation exposure and in a cost savings of almost $250,000 over the 2-year period. Limiting thoracic CT to this degree would not have missed any clinically significant vertebral fractures or vascular injuries.	4
23. Plurad D, Green D, Demetriades D, Rhee P. The increasing use of chest computed tomography for trauma: is it being overutilized? *J Trauma* 2007; 62(3):631-635.	Review/Other-Dx	2,326 CCT performed	To determine the change in usage of CCT over time and the number of injuries missed on plain CXR with normal findings that required therapy.	There were 2,326 CCT performed, and 1,873 (80.5%) of them were after negative CXRs. The percentage of patients studied with CCT increased incrementally from 2.7% to 28.7% for blunt and from 0.4% to 2.9% for penetrating injury. The identification of occult pneumothorax, hemothorax, rib fractures, and lung contusions significantly increased during the study period with the increased frequency of CCT use. There were 102 OPTXs and/or hemothoraces identified, but only 12 patients underwent tube thoracostomy during the 7-year period. There were 43 patients with blunt aortic injury and 6 (13.9%) of these patients had normal CXR findings. There was no trend in increased blunt aortic injury diagnosed during the study period, although the utilization of CCT was increased.	4

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
24. Millo NZ, Plewes C, Rowe BH, Low G. Appropriateness of CT of the chest, abdomen, and pelvis in motorized blunt force trauma patients without signs of significant injury. *AJR* 2011; 197(6):1393-1398.	Observational-Dx	108 patients	To determine the frequency of clinically significant injuries detected on CT of the chest, abdomen, and pelvis in adult patients involved in motorized blunt force trauma with normal clinical examinations.	11/108 patients (10%; 95% CI: 4.4%-15.6%) had acute injuries detected on CT of the chest, abdomen, and pelvis. None of the injuries required direct medical intervention. Alcohol intoxication or distracting injuries were present in 8 of these patients. The median time in hospital, from emergency department presentation to discharge, was 4.4 days (interquartile range, 2.5-8.5 days) for patients who were admitted and 6.7 hours (interquartile range, 4.8-10.3 hours) for those who were discharged.	3
25. Exadaktylos AK, Sclabas G, Schmid SW, Schaller B, Zimmermann H. Do we really need routine computed tomographic scanning in the primary evaluation of blunt chest trauma in patients with "normal" chest radiograph? *J Trauma* 2001; 51(6):1173-1176.	Observational-Dx	93 patients	To evaluate the role of routine CT scan.	68 patients (73.1%) showed at least one pathologic sign on CXR, and 25 patients (26.9%) had normal CXR. In 13 (52.0%) of these 25 patients, the CT scan showed multiple injuries; among these were two aortic lacerations, three pleural effusions, and one pericardial effusion.	3
26. Brink M, Deunk J, Dekker HM, et al. Criteria for the selective use of chest computed tomography in blunt trauma patients. *Eur Radiol* 2010; 20(4):818-828.	Observational-Dx	508 patients	To derive parameters that predict which high-energy blunt trauma patients should undergo CT for detection of chest injury.	The authors included 1,047 patients, of whom 508 had chest injuries identified by CT. Using logistic regression, the authors identified 9 predictors of chest injury presence on CT (age ≥55 years, abnormal chest physical examination, altered sensorium, abnormal thoracic spine physical examination, abnormal CXR, abnormal thoracic spine CXR, abnormal pelvic CXR or abdominal US, base excess <3 mmol/l and hemoglobin <6 mmol/l). Of 855 patients with ≥1 positive predictors, 484 had injury on CT (95% of all 508 patients with injury). Of all 192 patients with no positive predictor, 24 (13%) had chest injury, of whom 4 (2%) had injuries that were considered clinically relevant.	3
27. American College of Radiology. ACR Appropriateness Criteria®: Suspected spine trauma. Available at: http://www.acr.org/~/media/ACR/Documents/AppCriteria/Diagnostic/SuspectedSpineTrauma.pdf. Accessed 23 October 2012.	Review/Other-Dx	N/A	ACR Appropriateness Criteria guideline on suspected spine trauma.	N/A	4

Blunt Chest Trauma
EVIDENCE TABLE

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28. Fleming S, Bird R, Ratnasingham K, Sarker SJ, Walsh M, Patel B. Accuracy of FAST scan in blunt abdominal trauma in a major London trauma centre. *Int J Surg* 2012; 10(9):470-474.	Observational-Dx	71 patients	To determine how the results of FAST scans were used in a routine inner city emergency department and whether they influenced the subsequent treatment of adult, blunt trauma patients.	100 patients with blunt abdominal trauma presented; 71 had complete data. The accuracy of FAST in blunt abdominal trauma was 59.2%; in these 31 (43.7%) were confirmed by CT and 11 (15%) by laparotomy. There were 29 (40.8%) inaccurate FAST scans, all confirmed by CT. FAST had a specificity of 94.7% (95% CI: 0.75-0.99) and sensitivity of 46.2% (95% CI: 0.33-0.60). PPV of 0.96 (0.81-0.99) and NPV of 0.39 (0.26-0.54). Fisher's exact test shows positive FAST is significantly associated with Intra-abdominal pathology (P=0.001). Cohen's chance corrected agreement was 0.3. 21 out of 28 who underwent laparotomies had positive FAST results indicating accuracy of 75% (95% CI: 57%-87%).	3
29. Matsushima K, Frankel HL. Beyond focused assessment with sonography for trauma: ultrasound creep in the trauma resuscitation area and beyond. *Curr Opin Crit Care* 2011; 17(6):606-612.	Review/Other-Dx	N/A	Review role of FAST in evaluation of the trauma patient.	The indications for FAST and additional US studies in the injured patient continue to evolve. Application of sound clinical evidence will avoid unsubstantiated indications for US to creep into clinical practice.	4

Blunt Chest Trauma
EVIDENCE TABLE

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30. Kirkpatrick AW, Sirois M, Laupland KB, et al. Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). *J Trauma* 2004; 57(2):288-295.	Observational-Dx	225 patients	To evaluate the diagnostic utility of hand-held US identifying OPTXs missed by the anteroposterior supine CXR.	225 eligible patients (207 blunt, 18 penetrating); 17 were excluded from the US examination because of battery failure or a lost probe. 65 PTXs were detected in 52 patients (22% of patients), 41 (63%) being occult to CXR in 33 patients (14.2% whole population, 24.6% of those with a CT). The US and CXR agreed in 186 (89.4%) of patients, Extended FAST was better in 16 (7.7%), and CXR better in 6 (2.9%). Compared with the composite standard, the sensitivity of Extended FAST was 58.9% with a likelihood ratio of a positive test of 69.7% and a specificity of 99.1%. Comparing Extended FAST directly to CXR, by looking at each of 266 lung fields with the benefit of the CT gold standard, the Extended FAST showed higher sensitivity over CXR (48.8% vs 20.9%). Both exams had a very high specificity (99.6% and 98.7%), and very predictive likelihood ratio of a positive test (46.7 and 36.3).	3
31. Soldati G, Testa A, Pignataro G, et al. The ultrasonographic deep sulcus sign in traumatic pneumothorax. *Ultrasound Med Biol* 2006; 32(8):1157-1163.	Observational-Dx	186 patients	To validate the transthoracic US in defining the presence, location and size of traumatic pneumothorax in comparison with anteroposterior supine CXR and CT scan (gold standard) in emergency room.	The prevalence of pneumothorax on CT scan was 56/186 (30.1%). Pneumothorax was proven on radiography in 30/56 cases without false positive results: "radiographic deep sulcus sign" was evident in 3/29 cases, 26/29 cases being occult. The US study demonstrated the presence of pneumothorax in 55/56 patients: one occult pneumothorax was missed and no false positive results were observed. The CT scan differed of +/-2.3 cm (range 1-5 cm) from the US study in evaluating size and location of pneumothorax.	2

Blunt Chest Trauma
EVIDENCE TABLE

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32. Rowan KR, Kirkpatrick AW, Liu D, Forkheim KE, Mayo JR, Nicolaou S. Traumatic pneumothorax detection with thoracic US: correlation with chest radiography and CT--initial experience. *Radiology* 2002; 225(1):210-214.	Observational-Dx	27 patients	To prospectively compare the accuracy of US with that of supine CXR in the detection of traumatic PTX, with CT as the reference standard.	11/27 patients had pneumothorax at CT. All 11 of these PTX were detected at US, and 4 were seen at supine CXR. In the one false-positive US case, the patient was shown to have substantial bullous emphysema at CT. Sensitivity and NPV of US were 100% (11/11 and 15/15 patients, respectively), specificity was 94% (15/16 patients), and PPV was 92% (11/12 patients). CXR had 36% (4/11 patients) sensitivity, 100% (16/16 patients) specificity, a 100% (4/4 patients) PPV, and a 70% (16/23 patients) NPV.	2
33. Wilkerson RG, Stone MB. Sensitivity of bedside ultrasound and supine anteroposterior chest radiographs for the identification of pneumothorax after blunt trauma. *Acad Emerg Med* 2010; 17(1):11-17.	Review/Other-Dx	4 observational studies; 606 patients	Evidence-based review of the medical literature was performed to compare sensitivity of bedside US and anteroposterior CXRs in identifying pneumothorax after blunt trauma.	4 prospective observational studies were identified, with a total of 606 subjects who met the inclusion and exclusion criteria. The sensitivity and specificity of US for the detection of pneumothorax ranged from 86% to 98% and 97% to 100%, respectively. The sensitivity of supine anteroposterior CXRs for the detection of pneumothorax ranged from 28% to 75%. The specificity of supine anteroposterior CXRs was 100% in all included studies.	4
34. Rothlin MA, Naf R, Amgwerd M, Candinas D, Frick T, Trentz O. Ultrasound in blunt abdominal and thoracic trauma. *J Trauma* 1993; 34(4):488-495.	Observational-Dx	312 patients	To examine the value of US in patients with blunt thoracic or abdominal injuries.	The sensitivity for demonstration of intra-abdominal fluid and organ lesions was 98.1% and 41.4%, respectively. The overall sensitivity and specificity of the US examination were 90.0% and 99.5%, respectively.	3
35. Brooks A, Davies B, Smethhurst M, Connolly J. Emergency ultrasound in the acute assessment of haemothorax. *Emerg Med J* 2004; 21(1):44-46.	Observational-Dx	61 patients	To evaluate thoracic US for the detection of hemothorax in patients with thoracic trauma against established investigations.	61 patients, 54 (89%) after blunt trauma, underwent thoracic US evaluation during the study. 12 patients had a hemothorax detected by US and confirmed by CT or by tube thoracostomy. 4 hemothoraces detected on US were not apparent on trauma CXR. There were 12 true positives, 48 true negatives, no false positives, and one false negative scan. The sensitivity of US was 92% and specificity 100% with a PPV of 100% and NPV 98% for the detection of hemothorax after trauma.	3

Blunt Chest Trauma
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
36. Griffith JF, Rainer TH, Ching AS, Law KL, Cocks RA, Metreweli C. Sonography compared with radiography in revealing acute rib fracture. *AJR* 1999; 173(6):1603-1609.	Observational-Dx	50 patients	To compare the sensitivities of US and radiography for revealing acute rib fracture.	At presentation, radiographs revealed 8 rib fractures in 6 (12%) of 50 patients and US revealed 83 rib fractures in 39 (78%) of 50 patients. 74 (89%) of the 83 US detected fractures were located in the rib, 4 (5%) were located at the costochondral junction, and 5 (6%) in the costal cartilage. Repeated US after 3 weeks showed evidence of healing in all reexamined fractures. Combining US at presentation and after 3 weeks, 88% of subjects had sustained a fracture.	3
37. Davis S, Affatato A. Blunt chest trauma: utility of radiological evaluation and effect on treatment patterns. *Am J Emerg Med* 2006; 24(4):482-486.	Observational-Dx	233 patients	To evaluate the accuracy of emergency physicians in interpreting rib radiographs and to determine if that interpretation resulted in any variance in treatment patterns.	The overall chi2 calculation showed no differences between the fractured group and the no fracture group (P=.072). From this, it can be concluded that there were no between group differences in drugs prescribed based on whether a fracture was diagnosed by the emergency department physician. Indicating that the interpretation of the rib series does not influence the physician's treatment plan.	3
38. Malghem J, Vande Berg B, Lecouvet F, Maldague B. Costal cartilage fractures as revealed on CT and sonography. *AJR* 2001; 176(2):429-432.	Review/Other-Dx	8 patients	To describe the CT and US appearance of 15 costal cartilage fractures observed in 8 patients.	On CT, fracture was seen as a low-density area through the costal cartilage, with surrounding calcifications present near old fractures, and gas density within the cleft in some cases. On US, cartilage fracture appeared as an interruption of the smooth anterior aspect of the cartilage.	4
39. Soldati G, Testa A, Silva FR, Carbone L, Portale G, Silveri NG. Chest ultrasonography in lung contusion. *Chest* 2006; 130(2):533-538.	Observational-Dx	121 patients; 109 patients (group 1) and 12 patients (group 2)	To examine the possible clinical applicability of chest US for the diagnosis of lung contusion (LC) in the emergency department in comparison to radiography and CT.	The diagnosis of lung contusion was established by CT scan in 37 patients. If alveolointerstitial syndrome is considered, the sensitivity of US study was 94.6%, specificity was 96.1%, PPV and NPV were 94.6% and 96.1%, respectively, and accuracy was 95.4%. If peripheral parenchymal lesion is alternatively considered, sensitivity and NPVs drop to 18.9% and 63.0%, respectively, but both specificity and PPVs increased to 100%, with an accuracy of 65.9%. Radiography had sensitivity of 27% and specificity of 100%.	3

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40. Bock JS, Benitez RM. Blunt cardiac injury. *Cardiol Clin* 2012; 30(4):545-555.	Review/Other-Dx	N/A	To review some of the most common patterns of blunt cardiac injury.	Blunt chest trauma represents a spectrum of injuries to the heart and aorta that vary markedly in character and severity. The setting, signs, and symptoms of chest trauma are often nonspecific, which represents a challenge to emergency providers. Individuals with suspected blunt chest trauma who have only mild or no symptoms, a normal ECG, and are hemodynamically stable typically have a benign course and rarely require further diagnostic testing or long periods of close observation. Individuals with pain, ECG abnormalities, or hemodynamic instability may require rapid evaluation of the heart by echocardiography and the great vessels by advanced imaging.	4
41. Rojas CA, Cruite DM, Chung JH. Traumatic ventricular septal defect: characterization with electrocardiogram-gated cardiac computed tomography angiography. *J Thorac Imaging* 2012; 27(6):W174-176.	Review/Other-Dx	N/A	To report a case in which a ventricular septal defect caused by blunt chest trauma was characterized with ECG-gated CT angiography and to review the current literature and theories of injury mechanism.	No results stated in abstract.	4
42. Rollins MD, Koehler RP, Stevens MH, et al. Traumatic ventricular septal defect: case report and review of the English literature since 1970. *J Trauma* 2005; 58(1):175-180.	Review/Other-Dx	N/A	No abstract available.	No abstract available.	4
43. Sohn JH, Song JW, Seo JB, et al. Case report: pericardial rupture and cardiac herniation after blunt trauma: a case diagnosed using cardiac MRI. *Br J Radiol* 2005; 78(929):447-449.	Review/Other-Dx	N/A	A case of traumatic herniation of the heart for which a CT scan and MRI made a major contribution to the diagnosis is reported.	No results stated in abstract.	4
44. Malbranque G, Serfaty JM, Himbert D, Steg PG, Laissy JP. Myocardial infarction after blunt chest trauma: usefulness of cardiac ECG-gated CT and MRI for positive and aetiologic diagnosis. *Emerg Radiol* 2011; 18(3):271-274.	Review/Other-Dx	2 patients	To determine usefulness of cardiac ECG-gated CT and MRI for diagnosis of myocardial infarction after blunt chest trauma.	Cardiac CT and MRI were useful to noninvasively explore these lesions.	4
45. Tepe SM, Glockner JF, Julsrud P. MRI demonstration of acute myocardial infarction due to posttraumatic coronary artery dissection. *Int J Cardiovasc Imaging* 2006; 22(1):97-100.	Review/Other-Dx	1 patient	To review MRI of myocardial infarction.	No results stated in abstract.	4

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46. Christensen MD, Nielsen PE, Sleight P. Prior blunt chest trauma may be a cause of single vessel coronary disease; hypothesis and review. *Int J Cardiol* 2006; 108(1):1-5.	Review/Other-Dx	65 articles; 77 patients	To review the relation between blunt chest trauma and angina pectoris, in addition to the relation with myocardial infarction.	Angiography revealed 12 cases with completely normal vessels, which might be due to spasm or recanalisation; 31 cases showed occlusion but no atherosclerosis, which strongly suggested a causal relation between the trauma and subsequent occlusion. Acute myocardial infarction should therefore be considered in patients suffering from chest pain after blunt chest trauma. Because traumatic acute myocardial infarction might often be the result of an intimal tear or dissection, thrombolytic therapy might worsen the situation and acute percutaneous coronary intervention must be considered preferable.	4
47. Grosse A, Grosse C, Steinbach L, Anderson S. MRI findings of prolonged post-traumatic sternal pain. *Skeletal Radiol* 2007; 36(5):423-429.	Review/Other-Dx	5 patients	To characterize the different causes of prolonged sternal pain following thoracic trauma with involvement of the sternum and to define criteria for sternal nonunion diagnosis using MRI.	2 patients revealed a sternal nonunion after sternal fracture. One patient had a sternal fracture with delayed union and minor displacement of the sternal halves. Abnormal signal intensity alterations adjacent to and within the manubrio-sternal joint were evident in 2 patients and considered due to trauma-related changes in the manubrio-sternal joint. The 3 patients who were not included in the study had no abnormalities of the sternum: 1 of them proved to have a well-healed sternal fracture and nonunion of a rib fracture, 1 had subtle Tietze's syndrome, and 1 patient revealed no pathological findings on imaging.	4
48. Subhas N, Kline MJ, Moskal MJ, White LM, Recht MP. MRI evaluation of costal cartilage injuries. *AJR* 2008; 191(1):129-132.	Review/Other-Dx	13 patients with 14 injuries	A report on MRI findings in a series of patients with costal cartilage injuries.	MRI can be a useful technique in the diagnosis of costal cartilage.	4
49. Kwee TC, Takahara T, Niwa T. Diffusion-weighted whole-body imaging with background body signal suppression facilitates detection and evaluation of an anterior rib contusion. *Clin Imaging* 2010; 34(4):298-301.	Review/Other-Dx	1 patient	A report on MRI findings in a 29-year-old woman with anterior chest wall pain following blunt trauma, with special emphasis on the value of diffusion-weighted whole-body imaging with background body signal suppression.	Although a rib contusion could be depicted at (fat-suppressed) T2-weighted MRI, anatomical localization and assessment of lesion extent were superior and more straightforward at diffusion-weighted whole-body imaging with background body signal suppression.	4

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50. Shanmuganathan K, Mirvis SE, White CS, Pomerantz SM. MR imaging evaluation of hemidiaphragms in acute blunt trauma: experience with 16 patients. *AJR* 1996; 167(2):397-402.	Review/Other-Dx	16 patients	To evaluate the usefulness of MRI in excluding or confirming the diagnosis of diaphragmatic injury after blunt trauma.	MRI studies confirmed diaphragmatic injury in 7 patients (44%) and revealed an intact diaphragm in 9 (66%). In 7 patients MRI studies were able to correctly reveal the site of the diaphragmatic tear and the abdominal viscera that herniated into the thoracic cavity. None of the 9 patients with intact diaphragms on MRI studies had delayed presentation of a diaphragmatic rupture on outpatient follow-up.	4
51. Maenza RL, Seaberg D, D'Amico F. A meta-analysis of blunt cardiac trauma: ending myocardial confusion. *Am J Emerg Med* 1996; 14(3):237-241.	Review/Other-Dx	3 separate meta-analyses	To use a meta-analysis of the current literature to identify which patients with blunt cardiac trauma develop complications.	Results of the three meta-analyses were similar. Abnormal ECG and abnormal creatine phosphokinase-MB isoenzyme were found to correlate directly with complications requiring treatment. Conversely, normal ECG and creatine phosphokinase-MB isoenzyme correlated with the lack of clinically significant complications. Radionuclide scans did not correlate with complications. The results for echocardiogram were not congruent between the prospective and retrospective studies. The data support the use of ECG and creatine phosphokinase-MB isoenzyme in the diagnosis of clinically significant myocardial contusion. Radionuclide scanning is not useful in the evaluation of patients with blunt cardiac trauma. Further studies need to define the role of echocardiography.	4
52. Pai M. Diagnosis of myocardial contusion after blunt chest trauma using 18F-FDG positron emission tomography. *Br J Radiol* 2006; 79(939):264-265.	Review/Other-Dx	1 case	To report a case of acute myocardial infarction without coronary artery injuries after a blunt chest trauma, in which myocardial viability status was evaluated by FDG-PET combined with 201Tl perfusion single-photon-emission computed tomography.	FDG-PET helped to identify the contused myocardium as a result of perfusion-metabolism matching defect suggesting non-viable infarcted myocardium. FDG-PET may be useful in early decision making for patients with blunt chest trauma in a case with indistinct laboratory and imaging findings.	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

CCT = Chest computed tomography

CI = Confidence interval

CT = Computed tomography

CXR = Chest radiograph

ECG = Electrocardiogram

FAST = Focused assessment with sonography for trauma

FDG-PET = Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography

MDCT = Multidetector computed tomography

MRI = Magnetic resonance imaging

NPV = Negative predictive value

OPTXs = Occult pneumothoraces

OR = Odds ratio

PPV = Positive predictive value

PTX = Pneumothoraces

SD = Standard deviation

US = Ultrasound