Old Fashion Clinical Judgment in the Era of Protocols: Is Mandatory Chest X-Ray Necessary in Injured Patients?

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Background: **The ATLS® course advocates that injured patients have a chest x-ray (CXR) to identify potential injuries. The purpose of this study was to correlate clinical indications and clinician judgment with CXR results to ascertain if a selective policy would be beneficial.**

Methods: **Patients treated at a Level I trauma center over 12 months were prospectively evaluated. Before obtaining a CXR, signs, symptoms, and history suggestive of thoracic injury were identified. Additionally, a trauma surgeon (TS) recorded whether in his or her judgment a CXR was clinically indicated. These findings were compared with final CXR diagnoses. The sensitivity of individual clinical indicators, combinations of clinical indicators, and TS judgment for CXR abnormalities were calculated with a 95% confidence interval.**

Results: **During the 12-month study period, data were acquired on 772 patients (age 0–102 years). Seventy percent were male and 86.0% were injured by blunt force. Only 29% (N = 222) of the patients manifested one or more of the clinical indicators (signs and symptoms). The negative predictive value for the TS judgment was 98.2% which was superior to the clinical indicators. Reliance on the opinion of the TS to determine the need for a CXR would have eliminated 49.9% of CXRs and avoided hospital and radiologist reading charges totaling $100,078.22.**

Conclusion: **Mandatory CXR for all trauma patients has a low yield for abnormal findings. A selective policy relying on surgical judgment guided by clinical indicators is safe and efficacious while reducing cost and conserving resources.**

Key Words: **injuries, evaluation, adult, pediatric, trauma surgeon, thoracic injury, chest trauma, chest x-ray, selection, ATLS®**

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Recently, a number of diagnostic and treatment modalities have come under scrutiny regarding both their utility in patient care and their cost effectiveness. These include the routine use of anterior-posterior (AP) pelvic, AP chest, and lateral cervical spine radiographs for the screening of all injured patients. There are a number of studies demonstrating that routine radiographs, specifically pelvic and cervical spine x-rays, are not necessary in the awake and alert trauma patient, and may unnecessarily misappropriate hospital resources.[1–9] Several investigators have reported that in the absence of various clinical indicators, elimination of these x-rays does not compromise patient care or lead to an increase in missed injuries or delay in diagnoses. Additional benefits from selective use of x-rays include cost savings to the hospital, facilitation of a more rapid patient evaluation, and protection of the medical staff and patient from unnecessary exposure to ionizing radiation.[10]

Based on data to support the rationality and safety in a selective radiographic screening policy, the American College of Surgeons has recently decreased the emphasis on mandatory cervical spine x-ray and pelvic radiograph for all trauma patients in its ATLS® course.[11] The established guidelines promulgated by the course are generally considered to be the standard of care for the initial evaluation and management of injured patients.

Hospital policies requiring chest x-ray for all routine admissions and before elective surgery have been revised to a more selective policy based on patient age, diagnosis, and co-morbidities. This selective radiographic screening policy has not yet been extended to the injured patient that has relatively minor injuries, but is seen by the trauma surgeon as a result of prehospital triage criteria.

Conventional AP chest x-ray has long been the mainstay in screening for and diagnosing thoracic and select abdominal injuries. It is regarded as a customary initial diagnostic test.[12,13] In recent years, several other imaging techniques have been documented as being superior to chest radiography for the identification of certain thoracic injuries.[14,15] As a result, the necessity of chest radiographs in all blunt trauma patients has been questioned. In many cases of suspected thoracic trauma, chest x-rays do not provide sufficient delin-

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Table 1 **Demographics and Frequency of Abnormal Chest X-Rays**

	Blunt (n = 667)	Penetrating (n = 105)	All (N = 772)
Age (Mean ± SD)	34.4 ± 21.1	26.7 ± 10.0	33.4 ± 20.1
Gender	N (%)	N (%)	N (%)
Male	446 (66.8)	93 (88.4)	539 (69.8)
Female	221 (33.2)	12 (11.6)	233 (30.2)
Abnormal chest X-ray	65 (9.7)	12 (11.4)	77 (10.0)
Rapid deceleration injury	216 (32.4)	—	—

eation of the extent of injury[12] and other imaging modalities such as computed tomography (CT) scan are required.

CT scan is more sensitive and accurate for diagnosing injuries compared with conventional radiography. One study reported that over 50% of the blunt chest trauma patients with normal initial chest radiographs showed multiple injuries on CT scan.[16] Additional studies concluded that CT scan is superior to CXR for diagnosing less obvious pneumothorax, hemothorax, and lung contusion.[14,17–20] CT has also been shown to be especially useful in detecting intrapleural fluid collections, differentiating blood from serous fluid by density measurement, and displaying sternum fractures which are not apparent on physical examination.[12]

In addition to CT, several other adjuncts have been utilized clinically to supplement chest radiographs in diagnosing thoracic trauma. These include MRI, aortography, and ultrasound.[12,13,21] Recent reports suggest that ultrasound may be a more practical and sensitive screening tool for diagnosing traumatic hemopneumothoracies compared with the supine AP chest radiograph.[17,22]

The cost for these procedures, particularly if used as a screening modality, may be prohibitive. A chest CT incurs approximately seven times the cost of a portable AP chest roentgenogram. Data to support a selective policy of chest x-ray that is safe, accurate, cost effective, and which relies on indications generated by clinical acumen, would be beneficial to the patient, staff and health care system.

The purpose of this study was to evaluate the safety, accuracy, and utility of obtaining a CXR based on trauma surgeon judgment incorporating the patient symptoms, physical examination findings, and mechanism of injury. It further attempts to develop evidence-based guidelines for acquisition of CXR or other adjunctive studies in select trauma patients.

MATERIALS AND METHODS

The study was approved by the IRB of Loyola University Medical Center. Patients were enrolled from May 1, 2003, through May 17, 2004. A data form was completed on each patient meeting trauma team activation criteria. Data included: mechanism of injury, history, vital signs, and symptoms suggestive of chest injury. All patient care was consistent with ATLS® protocol, including the primary survey, followed by resuscitation and the secondary survey. Physical examination of the patient was performed by the trauma team, consisting of junior (PGY-1 or PGY-2) and senior (PGY-4) surgical residents qualified by the ATLS® course. If there was a difference in the assessment of the patient, the final interpretation was adjudicated by the chief resident or attending trauma surgeon.

All CXRs were performed using a portable anteroposterior technique. The supine patient was placed in a semi-upright position achieved by tilting the stretcher approximately 30º in the head up position. Before viewing the CXR, the data form was completed. Additionally, the trauma surgeon (either the senior resident or attending) recorded their judgment of the CXRs' clinical indications A board-certified radiologist, unaware of the clinical management, interpreted all CXRs for final diagnoses. Any additional radiographic study completed as a result of findings on the screening AP CXR, and the diagnoses were also recorded. Sensitivity, specificity, and negative predictive value (NPV) were calculated for individual clinical variables, several combinations of clinical variables, and the trauma surgeon's judgment in relation to the specific diagnoses made on the chest x-ray.

Statistics

Sensitivity, specificity, negative, and positive predictive value of any abnormal sign or symptom, history of rapid deceleration injury, and surgeon judgment for a normal chest x-ray were estimated with 95% confidence intervals. Because many (a total of 37) signs and symptoms were ascertained, those accompanied by the greatest negative predictive ability (sensitivity) were identified examining a tree based model[23] guided by clinical relevance.[24] The sensitivity, specificity, and negative predictive value of the parsimonious set of six signs and symptoms were further examined when combined with a rapid deceleration history and then surgeon judgment. Analyses were conducted using SAS (SAS OnlineDoc®, Version 8., SAS Institute Inc, Cary, NC.), S-Plus (Insightful Corporation, Seattle, WA), and Stata Version 8.0 (Stata Corp., College Station, TX).

RESULTS

During the 12-month study period, data sheets were completed on 772 patients (aged 0–102 years) for the study population (Table 1). Patients sustaining blunt trauma predominated in this series (667/772, 86%), as compared with penetrating injuries (105/772, 14%). Seventy percent were male. The majority of all study patients (92.4%) were not intubated at the time of evaluation, and had a mean GCS

Table 2 **Distribution of Variables Indicative of Thoracic Injury (N = 772)**

	n	%		n	%
Mechanism of Injury	309	40.0	Stab	42	5.4
Motor vehicle collision					
Fall > 20 feet	160	20.7	Motorcycle collision	37	4.8
Gunshot wound	71	9.2	Bicyclist	27	3.5
Pedestrian struck	65	8.4	Other	5	0.6
Assault	52	6.7	Crush	4	0.5
Symptoms					
Point tenderness along rib	49	6	Dyspnea	15	2
Chest pain	43	6	Pleuritic pain	8	1
Shortness of breath	20	3			
Signs					
Abrasion	57	7	S_aO_2 < 91%	4	1
Pulse > 110	49	6	Chest wall hematoma	4	1
Ecchymosis	43	6	Flail chest	4	1
Diminished or absent breath sound	32	4	Use of accessory muscles	4	1
Laceration	30	4	Focal neurologic deficit below clavicles	3	—
Contusion	23	3	Respiratory rate > 29	3	—
Systolic BP < 90	20	3	Tracheal deviation	3	—
Shallow respiration	16	2	Sternal instability	2	—
Point tenderness along sternum	15	2	Neck hematoma	2	—
Pulse < 70	13	2	Shoulder belt mark	1	—
Bony crepitus	12	2	Visible sternal defect	—	—
Splinting	12	2	Dullness to percussion	—	—
Respiratory rate < 10	11	1	Hyperresonance to percussion	—	—
Cardiac arrhythmia	7	0.9	Complain of referred pain	—	—
Chest wall instability	5	1	Neck vein distension	—	—
Focal neurologic deficit upper extremity	5	1	Ischemia on EKG	—	—

score of 13.7 ± 0.1. Pediatric patients accounted for 13.9% (n = 107) of the study population. Patients injured by penetrating wounds were younger than the blunt trauma group (27 years versus 34 years).

The most common blunt mechanism of injury was motor vehicle collision, followed by fall from greater than 20 feet (Table 2), accounting for 60.7% of the blunt force mechanisms. Seventy percent of the motor vehicle crashes fit the definition for rapid deceleration (>40 mph). The majority of the penetrating wounds were caused by firearms (62.8%).

Only 29% (N = 222) of the patients manifested one or more of the clinical indicators (signs and symptoms) sought by the data sheet (Table 2). One or more of the five symptoms recorded in this analysis were elicited, in 17.5%—at most—of the study population. All symptoms manifested by each patient were recorded; therefore, one patient could present with more than one symptom. The majority of injured patients (71%) did not have any symptoms of a thoracic injury. The most common symptom encountered was pain.

Thirty-two anatomic or physiologic signs of thoracic injury were evaluated in this study (Table 2). The three most common signs on physical examination were abrasion, ecchymosis, and diminished or absent breath sounds. Pulse rate greater than 110 was the most common physiologic abnormality followed by shock (systolic blood pressure less than 90 mm Hg). None of the patients were found to have dullness or hyperresonance to percussion.

The ability of the TS to evaluate signs and symptoms was compromised in 233 patients by intubation and a GCS less than 14. Fifty-eight patients were transferred to the trauma center intubated, eliminating the opportunity to elicit symptoms. The reliability of detecting signs of a thoracic injury on physical examination was affected by a GCS ≤ 13 in 116 patients. The incidence of an abnormal CXR in the intubated group was 20.7% (n = 12), and for the patients with a head injury 22.4% (n = 26).

Seventy-seven patients (10%) had 159 diagnoses made on the screening AP CXR (Table 3). The most common diagnosis was rib fracture(s), followed by widened mediastinum. There were no diagnoses of pneumomediastinum, pneumoperitoneum, or irregular diaphragm made from the CXR. Although the majority (90%) of CXRs were normal, when an abnormality was identified, the clinician ordered an additional radiologic study in 55% of these cases.

Table 4 contains the NPV, sensitivity, and specificity for the individual clinical variables and various combinations of the following: history of rapid deceleration, the most common signs (abrasion, bony crepitus), symptoms (shortness of breath, chest pain, point tenderness), shock, and the trauma surgeon's judgment. The trauma surgeon's ability to predict that the CXR was normal (NPV) was 98.2% for the entire study population, which was equivalent to the NPV for the trauma surgeon combined with other clinical indicators (Table 4). Similarly, the sensitivity calculation for the judgment

Table 3 **Frequency of Diagnoses Made by Chest X-Ray for Study Population (N = 772) and of All Traumatic Diagnoses (n = 77)**

Diagnosis	#	N = 772	n = 77
Rib fracture(s)	34	5.5	44.2
Widened mediastinum	33	5.4	42.9
Pneumothorax	23	3.7	30.0
Clavicle fracture	18	2.9	23.4
Pulmonary contusion	13	2.1	16.9
Other	9	1.5	11.7
Hemothorax	7	1.1	9.1
Subcutaneous air	6	1.0	7.8
Foreign body (missile)	5	0.8	6.5
Diaphragmatic rupture	4	0.7	5.2
Spine fracture	2	0.3	2.3
Sternal fracture	1	0.2	1.3
Scapular fracture	1	0.2	1.3
Atelectasis	1	0.2	1.3
Pneumomediastinum	—	—	—
Pneumoperitoneum	—	—	—
Irregular diaphragm	—	—	–

of the trauma surgeon was 92.8% (95% CI 85.7, 97.1). Specificity for the clinical variables, individually or in combination, and the trauma surgeon's judgment ranged from 43% to 86%. In an effort to assess the impact of a limited physical examination, the NPV was determined for the study population after excluding patients with one or more of the following criteria: GCS $<$ 13, intubated, and age $<$ 16 years. The trauma surgeon's ability to predict that the CXR was not abnormal (NPV) remained 98.2%, identical to that observed for the entire study group (Table 5).

Using the NPV, estimates were made for elimination of CXR without missing injuries (Table 6). The trauma surgeon's judgment would have eliminated 49.9% (n = 386) of screening radiographs without missing a thoracic injury. The cost for a portable CXR during the study period was $259.27 (hospital technical $217.27+professional $42.00). Eliminating CXR based on trauma surgeon judgment would have avoided hospital and radiologist reading charges totaling $100,078.22.

Table 4 **Comparison of Individual and Combination of Variables For Predicting CXR Without Abnormality (Negative CXR)**

	Blunt (n=667) NPV	Penetrating (n=105) NPV	All (N=772) NPV
Absence of positive sign or symptom	97.3 (94.86,98.74)	98.4 (91.47,99.96)	97.5 (95.38,98.78)
Absence of rapid deceleration injury (Rapid)	89.9 (86.45,92.72)	—	—
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain	94.2 (91.82,96.00)	95.2 (88.12,98.67)	94.3 (92.20,96.02)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid	96.4 (93.90,98.06)	95.1 (87.98,98.66)	96.2 (93.95,97.76)
Surgeon judgment that CXR will be normal	98.2 (96.08,99.33)	98.1 (89.74,99.95)	98.2 (96.29,99.27)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid with Surgeon Judgment	98.4 (95.82,99.55)	100.00 (93.02, 100.00)	98.7 (96.58,99.63)
	Sensitivity	Sensitivity	Sensitivity
Absence of positive sign or symptom	89.0 (80.18,94.86)	93.3 (68.05,99.83)	89.7 (81.86,94.64)
Absence of rapid deceleration injury (Rapid)	48.0 (36.31,59.85)	––	––
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain	62.2 (50.81,72.68)	73.3 (44.90,92.21)	63.9 (53.54,73.42)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid	84.2 (74.42,91.28)	73.3 (44.90,92.21)	82.5 (73.43,89.45)
Surgeon judgment that CXR will be normal	92.7 (84.75,97.27)	93.3 (68.05,99.83)	92.8 (85.70,97.05)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid with Surgeon Judgment	95.1 (87.98,98.66)	100.00 (78.20, 100.00)	95.8 (89.78,98.87)
	Specificity	Specificity	Specificity
Absence of positive sign or symptom	54.7 (50.58,58.81)	69.7 (59.01,78.97)	56.9 (53.06,60.66)
Absence of rapid deceleration injury (Rapid)	65.8 (61.62,69.89)	––	
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain	85.8 (82.66,88.50)	88.8 (80.31,94.48)	86.2 (83.39,88.73)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid	59.5 (55.41,63.53)	87.6 (78.96,93.67)	63.4 (59.65,67.05)
Surgeon judgment that CXR will be normal	55.6 (51.44,59.66)	57.3 (46.37,67.74)	56.0 (52.16,59.79)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid with Surgeon Judgment	40.8 (36.80,44.94)	57.3 (46.37,67.74)	43.3 (39.48,47.09)

(95% Confidence interval).

Table 5 Comparison of Individual and Combination of Variables for Predicting CXR Without Abnormality (Negative CXR) for Patients With a GCS ≥ 13, Not Intubated, and ≥ 16 Years

	Blunt (n = 465) NPV	Penetrating (n = 89) NPV	All (n = 554) NPV
Absence of positive sign or symptom	98.61 (95.99, 99.71)	98.18 (90.28, 99.95)	98.52 (96.26, 99.60)
Absence of rapid deceleration injury (Rapid)	90.27 (85.98, 93.61)	—	—
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain	95.11 (92.38, 97.08)	95.89 (88.46, 99.14)	95.24 (92.81, 97.03)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid	97.87 (95.10, 99.31)	95.89 (88.46, 99.14)	97.40 (94.95, 98.87)
Surgeon judgment that CXR will be normal	97.81 (94.96, 99.28)	100.00 (92.60, 100.00)	98.19 (95.82, 99.41)
Absence of SOB, Bony Crepitus, Point Tenderness, Chest abrasion, BP<90, Chest Pain, or Rapid with Surgeon Judgment	98.10 (94.55, 99.61)	100.00 (92.60, 100.00)	98.54 (95.80, 99.70)

(95% Confidence interval).

DISCUSSION

The Advanced Trauma Life Support (ATLS®) course developed by the American College of Surgeons Committee on Trauma emphasizes the importance of physical examination for prompt diagnosis of life threatening injuries during the primary survey of patient evaluation. The course curriculum also encourages the liberal use of adjunctive tests for the early diagnosis of potentially life threatening thoracic injuries during the secondary survey. These adjunct tests have traditionally included radiographs of the cervical spine, pelvis, and chest. However, clinical data supporting these recommendations are limited. Recent clinical studies have evaluated the reliability of key elements of the incident history and/or physical examination findings used to clinically diagnose various thoracic injuries discovered on CXR in both the adult and pediatric population.[1,8,25–29] These efforts have sought to develop a selective policy for obtaining chest radiographs. No such studies have assessed the ability of the treating physician to select patients having a low probability of thoracic injury, and in whom the CXR is unnecessary.

The present study demonstrates that the judgment of the trauma surgeon can reliably predict that the CXR will be normal, or identify patients with a high probability of having sustained injuries. This study was unique in that it prospectively explored the capacity of trauma surgeon judgment to utilize the complete clinical presentation as an effective evaluation of the necessity for chest radiography. In this study, surgeon opinion that the chest radiograph would be normal and not indicated was able to predict a normal and unnecessary chest x-ray in 98.2% of trauma patients. When surgeon opinion was combined with absence of the following clinical indicators: shortness of breath, bony crepitus, thoracic point tenderness, chest abrasion, hypotension (systolic blood pressure <90), chest pain or a rapid deceleration mechanism of injury, the NPV for CXR was not enhanced compared with the judgment of the trauma surgeon alone.

Other studies have concluded that clinical findings lack sensitivity as a predictor of blunt thoracic injury.[25–27] In contrast, Bokhari et al. prospectively evaluated the ability of specific findings on physical examination to identify hemothorax and pneumothorax in adult patients sustaining blunt trauma before CXR and observed a sensitivity and NPV of 100%.[8] Gittelman et al. developed a clinical prediction rule using abnormal respiratory rate, back abrasions, and chest wall tenderness to identify pediatric patients with subsequent abnormal chest radiograph with a sensitivity of 100%.[28] However, the prediction rule was developed and tested using historical controls, and was not tested in a prospective fashion. In addition to clinical findings, the functional utility of the CXR in the blunt trauma setting has been scrutinized, as routine AP CXR has been shown to miss common trauma injuries compared with computed tomography.[8,14–20,26]

The current study prospectively examined the trauma surgeon's ability to utilize clinical information including

Table 6 Percentage of CXRs Eliminated by Relying on Selected Clinical Variables (N = 772)

	Blunt (%)	Penetrating (%)	All (%)
Absence of positive sign or symptom	49.3	60.6	51.0
Absence of rapid deceleration injury (Rapid)	35.9	—	35.9
Absence of SOB, Bony Crepitus, Point Tenderness, Chest Abrasion, BP < 90, Chest Pain	79.8	79.8	79.9
Absence of SOB, Bony Crepitus, Point Tenderness, Chest Abrasion, BP < 90, Chest Pain, or Rapid	54.1	78.8	57.6
Surgeon judgment that CXR will be normal	49.6	50.0	49.9
Absence of SOB, Bony Crepitus, Point Tenderness, Chest Abrasion, BP < 90, Chest Pain, or Rapid with Surgeon Judgment	36.4	49.0	38.3

mechanism, symptoms, and signs to predict whether a screening AP CXR would assist diagnosing any unsuspected injuries. The surgeon predicted a normal and unnecessary chest x-ray in 98.2% of trauma patients. The NPV was not altered by the mechanism of injury (blunt—98.18, penetrating—98.08). The trauma surgeon's ability to predict when the CXR would be positive for a thoracic injury was superior to the other clinical indicators individually or in combination (sensitivity—92.8, 95% CI 85.7, 97.1).

During the study period, three patients with abnormal chest radiographs were reported as having no clinical indications for chest x-ray by the trauma surgeon. Medical records of these patients revealed that no significant injury was missed by clinical examination. Two patients demonstrated chronic pulmonary changes on the portable chest x-ray unrelated to the trauma (chronic interstitial pattern and segmental atelectasis). Portable chest x-ray of the other patient revealed an enlarged cardiac silhouette with normal mediastinal contour. Follow-up chest CT for this individual was normal, and a two-dimensional echocardiogram demonstrated small amounts of extrapericardial echogenic liquid in the anterior mediastinum. The patient was discharged and lost to follow-up. Thus, using surgeon judgment and clinical indicators appears to be accurate in identifying virtually all patients with CXRs that show no evidence of acute abnormalities related to trauma.

In this study, 100% of abnormal chest radiographs in the penetrating trauma patient population (12/77 patients) were successfully predicted by the trauma surgeon when combined with clinical indicators. Although the penetrating trauma sample size is relatively small, it appears that the ability of the trauma surgeon to accurately predict a normal chest radiograph within this patient population is reliable and safe as well.

In the case of penetrating traumatic injuries, areas of injury are typically obvious and the focus of the subsequent medical investigation can be narrowed. Blunt trauma injuries can present equivocally, resulting in a more liberal use of diagnostic modalities for evaluation. However, we demonstrated that surgeon judgment, assimilating clinical information, was able to accurately identify 98.1% of blunt trauma patients with a normal chest x-ray. This suggests that even in the blunt trauma patient, the clinical examination is reliable and effective in appropriately identifying which patients will benefit from thoracic radiography.

Our data confirm that physical examination is reliable in assisting the treating physician's decision as to whether or not the injured patient needs a CXR. One or more of the 37 signs and symptoms indicative of chest trauma were present in all patients diagnosed with a thoracic injury. However, five clinical indicators were not observed in any of the patients (referred pain, visible sternal defect, neck vein distension, ischemia on EKG, hyperresonance, or dullness to percussion). Possible explanations for these observations are that they were not present at the time of the trauma surgeon's evaluation or they were not identified, or aggressively sought, during the examination of the patient. Complaints of referred pain, observation of neck vein distension, or visible sternal instability may be difficult to discern during the initial evaluation. The absence of dullness or hyperresonance on percussion of the chest raises a question of the importance in recognizing abnormalities in the pleural space, since other signs or symptoms are apparently more common harbingers of a thoracic injury.

This study compared the judgment of the trauma surgeon against various individual clinical indicators or in combination. Although the negative predictive value and sensitivity calculations for the trauma surgeon are better than clinical indicators individually or in combination, the trauma surgeon's performance is enhanced with the addition of specific clinical indicators. This observation supports the concept of a clinical prediction rule as first proposed by Gittelman et al.[28]

There are other indications for obtaining an AP CXR in the management of trauma patients. These include assessment of therapeutic interventions such as position of endotracheal tube and thoracostomy tube placement. It is also necessary to confirm proper placement of a central line catheter and to assess for complications (pneumothorax or hemothorax). One might debate that even any one of these complications might be determined by clinical examination, but that was not the intent of this study.

There are several limitations to this study. First, the study population may be underpowered due to the low incidence of diagnoses made from the screening AP CXR (10%), which may introduce a type II error. However, this low frequency of significant thoracic injuries supports our hypothesis that the trauma surgeon's clinical acumen allows him or her to accurately identify patients at risk for significant chest trauma. Another potential opportunity for error is the lack of control for interobserver variability in interpretation of the physical examination findings. This may have been minimized with all treating physicians holding current qualification for ATLS®. The incidence of variation of interpretation by examining physicians may also have been minimized by the fact that only six chief residents rotated on the trauma service during the study period.

Using trauma surgeon judgment for the basis of an exclusion decision, 49.9% (n = 386) of routine chest radiographs could have been safely eliminated during the 12-month study period. At our institution, by eliminating these radiographs, $100,078.22 in hospital charges could have been eliminated. These charges do not take into account the burden of other unnecessary resource utilization such as increased nursing time in the emergency department, clerical staffing to compile documentation, requisitions, and reports, and increased technician staffing. Extrapolating nationally, it is estimated that 1.6 million injured patients are hospitalized annually and presumably have a CXR at the time of evaluation in the emergency department. By eliminating 50% of these, at an average of $200 per x-ray, the potential for cost

savings is $160 million. This does not take into account the estimated 27 million patients who are treated and released from emergency departments after injury, many of whom may undergo CXR.

In conclusion, this study suggests that clinical examination of the injured patient, when performed by a trained trauma surgeon, is sufficient in determining whether a patient should receive a chest radiograph. Routine AP CXR for screening the injured patient yields little additional information compared with the trauma surgeon's judgment. Using information gleaned from the history, mechanism of injury, symptoms and physical examination, the trauma surgeon is able to quickly determine the probability of a thoracic injury. Specific clinical indicators include: shortness of breath, bony crepitus, point tenderness along a rib, chest abrasion, hypotension (systolic blood pressure < 90), chest wall pain and a history of rapid deceleration injury. By eliminating CXRs in select patients, there is an opportunity to reduce health care cost without compromising patient care. Further studies are warranted to validate these findings.

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DISCUSSION

Dr. Mary-Margaret Brandt (Ann Arbor, MI): *(Dr. Patton has sent these comments.)* A number of studies have called into question the utility and necessity of routine radiographs, particularly the lateral C-spine and pelvic x-ray in the initial evaluation of the injured patient. Today, Dr. Luchette and colleagues have further challenged us to look more closely at the dogmatic indications for routine chest radiographs in this setting. They have prospectively reviewed a series of 772 consecutive patients presenting for trauma team evaluation at their institution. These patients were evaluated for mechanism of injury, a variety of signs and symptoms of thoracic injury, and the results of radiographs.

This study sought to determine whether or not the need for a chest x-ray could be safely determined based on the trauma surgeon's judgment, or was better guided by any constellation of more definable clinical signs or symptoms. Based on results indicating that trauma surgeon judgment

alone was more sensitive in predicting a negative chest x-ray and carried an improved negative predictive value for thoracic injury as demonstrated by chest x-ray, they have concluded that a number of these studies can be eliminated from the workup of these patients. While this conclusion is probably valid, the study population does not appear to be significantly injured. No data regarding injury severity scores or specifically ISS is presented, and a minority of the patients appeared to have had physiologic alterations. Indeed, while it seems intuitive that the least severely injured may be less likely to benefit from routine diagnostic testing, this skewed population may have led to an under-appreciation of the utility of chest x-rays in the more severely injured patients.

Additionally, other authors have reported on the relatively low sensitivity of plain chest x-rays in identifying abnormalities in acutely injured patients. Based on these findings alone, the use of chest x-ray as a screening tool for significant abnormality is questionable, at best. Basing a determination of diagnostic accuracy on such a study is probably unreliable and perhaps misguided. Since only 10% of the chest x-rays in the current study showed an abnormality, a relatively low percentage compared to those previously reported, this point is further exemplified. There are some questions for the authors. The manuscript describes the trauma surgeons as being asked whether or not they believe a chest x-ray was clinically indicated, yet results are based on the lack of findings on chest x-ray. Are not the indications for the study and its results mutually exclusive? How do you reconcile this discrepancy? In other words, isn't the prediction of positive or negative findings inherently different than the assessment of clinical indication?

Considering that 90% of all chest x-rays were interpreted as normal, is this study sufficiently powered to detect significant differences in diagnostic approaches? Would CT scan perhaps have served as a better gold standard by which to judge the accuracy of the various clinical indicators? Do you believe that any specific clinical scenarios, for example, the nonawake, nonalert and/or intubated patient, or the victim of penetrating chest injury, have reason enough to routinely warrant obtaining a chest x-ray?

Remembering that ATLS® recommendations are not necessarily geared to guide the experienced surgeon, but rather are designed to ensure safe and uniform practice, particularly from nonsurgeons and infrequent trauma practitioners, how do your recommendations, based on the clinical judgment afforded by the experienced trauma surgeon, translate to practitioners with less experience who are most frequently called on to initially evaluate the least-severely injured patients?

This is an important, thought-provoking work that warrants further study in order to justify the application of clinical judgment alone in determining the need for diagnostic intervention. As this study suggests, we must continue to strive to separate practice based on dogma from that based on an examination of the evidence. In doing so, I am sure that we will find, much like the emperor of the lateral C-spine and pelvic film, their routine chest x-ray will, indeed, be found lacking of sufficient attire.

Dr. Kimberly K. Nagy (Chicago, Illinois): I do have one concern, and that is for the patient with the potential for thoracic aortic injury. Many of these patients, as you know, may present without any of this clinical symptomatology. The only way that we would know to do any further workup on these patients would be with an abnormality on their chest x-ray. I'm just concerned that you're limiting your screening chest x-ray in patients with a potential for a very serious injury.

Dr. Peter Rhee (Los Angeles, California): As you know negative predictive value is 97%. That would mean that you would miss 3 out of 100, or would be 30 out of 1,000. If you did miss an injury, how many of these types of injury are of clinical relevance, meaning are they thoracic aortic injuries or are the missed injuries just little minor things that did not have much clinical relevance? This is an excellent study because it works on looking at chest x-ray, which we deem as a very cheap and easy study to get in the field or in the emergency department, and as you know, the trend is going towards scanning everybody who has a chest.

Dr. Frederick A. Luchette (Closing): The first comment was in reference to the acuity of the study population. Specifically, we did not include ISS. As you know, ISS is calculated at the time of discharge from the hospital. Thus, when the trauma surgeon is attending the injured patient real time in the trauma bay, ISS is irrelevant. The premise of the study was that the trauma surgeon would be able to use relevant information from the mechanism of injury, the patient's symptoms and signs, and then weigh various clinical indicators to identify which patient is at risk for a thoracic injury. When the trauma surgeon is in the trauma bay with the patient, ISS does not have any significant meaning compared to your clinical acumen. By the way, the mean ISS for patients in this study was 19.

You are correct that other authors have reported the low sensitivity of chest x-ray and recommended using thoracic CT scan because of the better sensitivity for diagnosing chest wall injuries and particularly small asymptomatic pneumothoraces. The minority of our study population had a finding on the screening chest x-ray, but the majority (>50%) of this group went on to have a dynamic helical CT scan. We agree with this observation and our results support the other authors' recommendation that routine chest x-ray should be eliminated in select low risk patients and perhaps replaced with CT scan in patients deemed to be at moderate to high risk for a thoracic injury.

Dr. Patton raises a question about the indication for the study and its results being mutually exclusive. The recommendation that all injured patients need to have screening chest x-ray performed to identify injuries was based on consensus opinion at a time when trauma surgeons and trauma systems were only talked about. The data we present today

are an effort to assess the sensitivity, specificity, and negative predictive value of this diagnostic study and compare them to the opinion of the clinician. I agree with you that CT scan is the ideal gold standard to identify *all* injuries, but it is not clinically practical to suggest that all patients undergo a more expensive imaging study with inherent risk of allergic reaction to contrast or soft tissue injury from extravasation of contrast. I would suggest that the next study needs to identify the clinical indicators that can be used to select patients for CT scan rather than chest x-ray. As demonstrated in our study, only 10% had an abnormal chest x-ray, but 55% had additional radiologic studies. The most common study was thoracic CT scan.

The next question dealt with the use of chest x-ray in the intubated or the head injured patient. We included these patients in this study, but they only totaled approximately 100. The lack of a patient's ability to communicate symptoms did not diminish the utility of physical examination to assist the clinician, who is also able to take into account the mechanistic information in predicting the need for a chest x-ray. For example, a patient who presents with an isolated gun shot wound to the head and is intubated for airway control is at low risk for any thoracic injury, and physical exam will identify a pneumothorax or right mainstem bronchial intubation. A requirement that a chest x-ray be completed in the trauma bay prior to obtaining a CT scan of the head may actually have a negative impact on outcome.

Dr. Patton asked about the translation of our observations to the less experienced. All the trauma surgeons making the determination about the need for a chest x-ray were PGY4's and ATLS providers. Our residents are very good surgeons with a total of 6 months experience on our trauma service. This by no means makes them any more experienced at judging the need for a chest x-ray than a board eligible or certified emergency medicine physician. With further study of the specific clinical indicators, it may be possible to identify which is sensitive for a thoracic injury or able to assist the less experienced clinician in predicting which patient needs additional radiographs without missing significant injuries.

Dr. Nagy makes an excellent point about the asymptomatic patient at risk for thoracic aortic injury. We do not want to suggest that the only clinical indicator of a thoracic injury is the patient's symptoms or signs. Rather, we are suggesting that all the clinical indicators need to be taken into account by the trauma surgeon to safely predict which patient does not need a screening chest x-ray. Certainly, the most important indicator for recognizing the patient at risk for aortic transection is mechanism. Any history of rapid deceleration, lateral impact or even rear-end impact would suggest that the patient needs a chest x-ray to assess the width of the mediastinum. However, other authors have concluded that this patient needs a dynamic helical CT scan to assess the great vessels to minimize the small, but real false negative rate of chest x-ray for missing this injury.

Finally, to Dr. Rhee's question about the negative predictive value of 97%. Phrased another way, what is the clinical relevance of a 3% false negative rate and what type of injuries were not detected by mechanism, symptoms, or signs. There is a detailed discussion of the false negatives in the manuscript. The majority are technically not considered thoracic injuries, but rather truncal injuries such as a clavicle fracture or scapular fracture which should be detected on physical exam. Clearly, a missed injury or delayed diagnosis may be catastrophic or insignificant. In this study, no significant injuries would have been missed had the chest x-ray been eliminated by the trauma surgeon.