Original Article

Evaluating validity of clinical criteria for requesting chest X-rays in trauma patients referred to emergency room

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Abstract

Background: Our goal was to identify the clinical criteria for requesting the chest X-ray in patients with blunt trauma and whether its findings such as clinical signs with a high sensitivity could be used to codify the final criteria.

Materials and Methods: 386 patients with multiple trauma or blunt chest trauma examined by a physician and the injury mechanism, vital signs, O_2 saturation, auscultation findings, abrasions and ecchymosis, crepitation, tenderness on palpation, and pain on lateral compression were noted. The physician's clinical judgment on the necessity of a chest X-ray was also noted in a questionnaire. After taking the X-ray, a digital photo was taken and showed to a radiologist to report any significant chest injury. Data were collected and the positive and negative predictive values, sensitivity and specificity were estimated.

Results: 350 males (90.9%) and 35 females (9.1%) with the mean age of 47.1 ± 15.5 years old were evaluated. Falling down (37.7%) was the major mechanism of injury and chest pain (48%) the first complaint of patients. In 87.3% of the chest X-rays, there was no abnormal finding. Among several pathological findings in the chest X-rays, hemothorax, and rib fracture (each with 3.4% prevalence) had a higher prevalence. Tenderness on palpation with clinical judgment had a higher sensitivity about 95% and higher specificity about 100% in crepitation detected.

Conclusion: Results showed the combination of positive chest pain and tachypnea in the patients could identify a significant chest injury with 100% sensitivity. More studies on this issue are warranted.

Key Words: Chest trauma, chest X-ray, clinical criteria, evaluation

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INTRODUCTION

At present, a Chest X-ray is obtained from all trauma patients having suspicion to chest trauma. Several studies have shown that in only 13% of requested chest X-rays there was positive findings including rib fracture, pulmonary contusion, pneumothorax, hemothorax, clavicle or sternal fracture, or a wide mediastinum and injury to the aorta.[1,2] Therefore, it seems like chest X-rays do not have any benefit for a large proportion of patients with blunt chest trauma.

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Using clinical signs to screen, and requesting chest X-rays in high risk patients can reduce the number of unnecessary chest X-rays. Patients will have less contact with radiation and its complications and also less time and costs will be wasted and the quality of health care services will improve. Past studies on knee, ankle, and vertebral trauma resulted in the codification of clinical protocols like the National Emergency X-Radiography Utilization Study (NEXUS) criteria that were able to identify high risk patients with a great sensitivity.[3-6] Using the protocols mentioned caused a decrease in the number of chest X-rays requested without endangering patients' health. Until now, the clinical criteria for screening patients suspicious to blunt chest trauma have not been defined. So, if clinical signs such as physical examination, vital signs, and oxygen saturation are able to identify high risk patients with suspicion to injury with a high diagnostic sensitivity and accuracy, then the number of chest X-rays requested would be significantly decreased. This study was a pilot study to derive a clinical decision rule that is highly sensitive for detecting intrathoracic injury, which will allow emergency department (ED) physicians to be more selective in use of chest X-ray in trauma patients.

The clinical criteria for requesting a chest X-ray in a patient with blunt trauma and its findings (clinical signs with a high sensitivity) could be used in a larger study to codify the final criteria.

MATERIALS AND METHODS

This cross-sectional and a diagnostic test evaluation study was conducted from October 2009 to March 2010 in department of Emergency Medicine in Imam Khomeini University Hospital (Tehran University of Medical Sciences) and The Ethics Committee of Tehran University of Medical Sciences approved the study protocol.

Designed questionnaire was written by emergency medicine residents in all of the shifts of the emergency department.

Every patient with multiple trauma or blunt chest trauma was examined by a physician and the mechanism of injury, vital signs, O_2 saturation, auscultation findings, abrasions and ecchymosis, crepitation, tenderness on palpation, and pain on lateral compression were noted. The physician's clinical judgment on the necessity of a chest X-ray was also noted in a questionnaire. Excluding criteria were penetrating chest trauma, GCS<15, under 16 years, patients who had expired or had been transferred to the OR before taking a chest X-ray, and the lapse of more than 72 h from the trauma.

After taking the X-ray, a digital photo was taken and showed to a radiologist for a report and whether it showed any kind of significant chest injury including pneumothorax, hemothorax, rib or clavicle or sternal fracture and pulmonary contusion, flail chest, widened mediastinum, cardiomegaly, or injury to the aorta was noted in the form. Data were collected and the positive and negative predictive values and sensitivity and specificity were estimated.

The true positives were patients who had at least one of the above-mentioned clinical signs in their form and at least one of the significant chest injuries in the radiologist's report. Patients who had neither of them were considered as true negative. False positives were those with at least one of the clinical signs but did not show anything significant pathology in their X-ray. False negatives were patients without any clinical signs that had a significant chest injury in their X-ray. Finally, all the data were analyzed using SPSS software, version 17 and the *P value*s <0.05 were considered as significant.

The clinical decision rule was derived using the κ coefficient and logistic regression analysis.

RESULTS

In our study, 385 patients consisting of 350 males (90.9%) and 35 females (9.1%) were evaluated. The mean age of all patients was 47.1 ± 15.5 years. The females' mean age was 37.7 ± 18.7 years and for males it was 37.1 ± 18.6. According to our analysis, the mean ages of males and females were not significantly different (P >0.05).

The mechanism of the trauma was falling down in 145 cases (37.7%), 102 cases were car or motorcycle accidents (26.5%), 131 cases were car or pedestrian accidents (34%), and 7 cases were due to other causes (1.8%). The patients' chief complaints were chest pain in 185 cases (48%) and dyspnea in 89 cases (23%). Chest X-rays were taken in the PA view in 318 cases (82.1%) and the rest were in AP view. Therapeutic procedures were placing a chest tube in 32 cases (8.3%), mechanical ventilation in 5 cases (1.3%), and nasal O_2 for 338 cases (87.8%).

In 87.3% of the chest X-rays, there was no abnormal finding. Among the several pathological findings in the chest X-rays, hemothorax, and rib fracture (each with 3.4% prevalence) had a higher prevalence. Table 1 shows the relative frequency of the abnormal findings in chest X-rays.

The relative frequency of abnormal findings in clinical examination in groups, those with a positive X-ray (abnormal X-ray) and those with negative X-rays (normal X-ray), is shown in Table 2. The most common clinical finding in the positive X-ray group was tenderness on palpation, and tachycardia in the negative X-ray group.

Sensitivity, specificity, positive predictive value, and negative predictive value were measured for each abnormal clinical finding in comparison with the radiologist's report [Table 3].

DISCUSSION

The literature addressing blunt chest trauma and the utility of physical examination to diagnose chest injuries is scant. The indications for such radiographs are not well defined. This results in a large number of unnecessary chest radiographs being obtained. Dubinsky and Low[7] recommended that routine chest radiographs are not necessary in blunt chest trauma because no significant lung injury was detected in their series. McLellan *et al.*[8] retrospectively looked at autopsies of patients with chest trauma and compared the findings to the initial trauma team diagnoses on the basis of chest radiographs and physical examinations. They concluded that physical examination and chest radiographs are not sensitive in diagnosing all serious injuries.

Among our patients, 49 had a significant chest injury including pneumothorax, hemothorax, rib, sternal, or clavicle fracture, pulmonary contusion, flail

Table 1: The relative frequency of abnormal findings in chest X-rays

CXR pathology	Frequency	Percent
Pneumothorax	12	3.1
Hemothorax	13	3.4
Hemothorax and pneumothorax	4	1
Contusion	5	1.3
Contusion and hemothorax	2	0.6
Rib fracture	13	3.4
Rib fracture and pneumothorax	5	1.3
Rib fracture and hemothorax	4	1
Rib fracture and hemothorax and pneumothorax	3	0.7
Clavicle fracture	1	0.3
Sternal fracture	1	0.3
Flail chest	1	0.3
Mediastinal widening	1	0.3
Cardiomegaly	1	0.3
Aorta injury evidence	1	0.3
No pathology	336	87.3
Total	385	100.0

Table 2: The relative frequency of abnormal findings in clinical examination in both abnormal X-ray and normal X-ray groups

Clinical findings	Frequency of abnormal CXR (%)	Frequency of normal CXR (%)
Abrasion	9 (2.3)	14 (3.6)
Chest pain	45 (11)	140 (36)
Crepitaton	13 (3.3)	0
Decreased breath sounds	18 (4.6)	17 (4.4)
Ecchymosis	23 (5.9)	10 (2.5)
Hypotension	8 (2)	12 (3.1)
Hypoxia	12 (3.1)	4 (1)
Other auscultation abnormality	13 (3.3)	33 (8.5)
Pain on lateral compression	45 (11.6)	142 (36.8)
Respiratory distress	22 (5.7)	67 (17.4)
Tachycardia	44 (11.4)	162 (42)
Tachypnea	45 (11.6)	157 (40.7)
Tenderness on palpation	47 (12.2)	144 (37.4)

Table 3: Sensitivity, specificity, positive, and negative predictive values for each abnormal clinical finding

Criteria	Sensitivity: True positive (95% CI)	Specifity: True negative (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)
Abrasion	18 (8–29)	95 (93–97)	39 (19–59)	88 (85–92)
Chest pain	91 (84–99)	58 (53–63)	24 (18–30)	98 (96–99)
Crepitance	26 (14–38)	100 (98–100)	100 (75–100)	90 (87–93)
Decreased breath sounds	36 (23–50)	95 (92–97)	51 (34–67)	91 (88–94)
Ecchymosis	46 (32–60)	97 (95–98)	69 (54–85)	92 (89–95)
Hypotension	16 (5–26)	96 (94–98)	40 (18–61)	88 (85–92)
Hypoxia	24 (12–36)	98 (97–99)	75 (53–96)	89 (86–93)
Other auscultation abnormalities	26 (14–38)	90 (87–93)	28 (15–41)	89 (86–92)
Pain on lateral compression	91 (84-99)	57 (52-63)	24 (17-30)	97 (96-99)
Respiratory distress	44 (30–58)	80 (75–84)	24 (15–33)	90 (87–94)
Tachycardia	89 (81–98)	51 (46–57)	21 (15–26)	97 (94–99)
Tachypnea	91 (84–99)	53 (47–58)	22 (16–28)	97 (95–99)
Tenderness on palpation	95 (90–100)	57 (51–62)	24 (18–30)	98 (97–100)
Clinical judgment	95 (90–100)	48 (43–54)	21 (16–26)	98 (97–100)

chest, evidence of a wide mediastinum and injury to the aorta, or a combination of them according to the radiologist's report. Therefore, there was no significant injury in the X-rays of 336 patients. Chest tenderness and lateral compression tenderness each had a sensitivity of 95%, and chest pain had a sensitivity of 91%. The physician's clinical judgment alone also had a sensitivity of 95%. In this study, crepitation and hypoxia had a specificity of 100% and 98%, respectively. Chest pain, tenderness, and the physician's clinical judgment had a negative predictive value of 98%. In studies designed to evaluate the sensitivity and specificity of screening tests, we can combine two diagnostic criteria so that either one or both would be positive, then we would have a higher sensitivity and specificity than using only one criteria. In this study, after evaluating the forms obtained, we found out that by combining chest pain and tachypnea so that each one would be positive in the patient, we could identify every patient with a significant chest injury with a sensitivity of 100%. On the other hand, using these two criteria caused a 48% decrease in the number of chest X-rays.

Compared with similar studies on blunt chest trauma done in 2003 by Rodriguez *et al.*[9] at the University of San Francisco, the study had 507 patients. In 6.3% of the patients, the radiologist reported a significant chest injury. Tenderness and chest pain each had a sensitivity of 90% in diagnosing the above injury. Hypoxia had the highest specificity (97%). The combination of tenderness on palpation and hypoxia had a sensitivity of 100% and a specificity of 50% in diagnosing injury. Meanwhile, the positive and negative predictive values were 2% and 100% for tenderness on palpation and hypoxia, respectively. By using these two criteria, the number of chest X-rays requested would be decreased by 46%. In a similar study conducted by Holmes *et al.* in 2002,[10] blunt chest trauma in children (under 16 years) was evaluated. In that study, multiple logistic regressions showed that the following are commonly associated with chest injury: Low systolic blood pressure, tachypnea, auscultation findings, chest inspection, tenderness on palpation, femur fracture, and a GCS<15.

In another study in 2000, Bokhari *et al.*[1] showed the significance of physical examination in diagnosing hemopneumothorax in 676 trauma patients. Patients were evaluated according to tenderness, tachypnea, and chest pain and both lungs were auscultated. All patients were hemodynamically stable and chest X-ray was done for all of them. Five hundred twenty three patients had blunt of trauma which 7 of them (1.3%) had hemopneumothorax. The positive predictive value in these patients for auscultation, chest pain or tenderness on palpation, and tachypnea were 50%, 25%, and 32%, respectively. The negative predictive values for them were all below 91%, at the end, the authors concluded that patients with blunt trauma who are hemodynamically stable and have a normal physical examination do not need a chest X-ray. On the other hand, all patients with a penetrating trauma need a chest X-ray, since they might have hemopneumothorax despite of having a normal physical examination.

Benjamin Sears *et al.*[11] showed the relation between clinical judgment and chest X-ray findings in trauma patients in a study conducted in 2005. In that study, the signs and symptoms and history of patients were documented during a period of 12 months and a surgeon would declare his opinion on the necessity of a chest X-ray. These data were compared with chest X-ray findings. The sensitivity of each criterion alone and in combination with other clinical criteria and the surgeon's clinical judgment were measured. The negative predictive value of the surgeon's judgment was 98.2% that was higher than the clinical criteria and caused a 49.9% decrease in requested chest X-rays, and was significant economically and time-wise. Therefore, they recommended that a surgeon's clinical judgment according to clinical signs is a safer and more efficient method for decreasing the number of chest X-rays requested.

It seems that in larger studies by using a combination of the criteria above, we could find the diagnostic criteria for very low risk patients (considering significant chest injury) and thus prevent unnecessary X-rays.

CONCLUSIONS

Our results showed that by combining chest pain and tachypnea so that each one would be positive in the patient, we could identify every patient with a significant chest injury with a sensitivity of 100%. Larger studies by using a combination of the criteria are warranted.

Since some patients may have symptoms so minor that they do not seek medical care or their presentation does not suggest the possibility of the thoracic injury, it is impossible to identify every patient with a potential injury. Such patients cannot be identified by this or any other criteria. The question we wished to response was whether some of the many patients who are currently considered candidates for chest x -ray can be safely classified as having such a low probability of injury on clinical background that radiography need

not be performed, it is obvious the consequence is cost savings and medical benefits for the patients.

Finally, this study confirms the validity of a decision rule based on two clinical criteria for identifying, with a high degree of sensitivity, patients with thoracic trauma who have an extremely low probability of having sustained injury to the chest. The sensitivity of this set of criteria approaches 100% for clinically important injuries, and its general application should result in both clinical and economic benefit. As with any other clinical criteria, it should be used with great care. There may be compelling reasons to order chest X-ray in traumatic patients, even if all the criteria for a low probability of injury are met.

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