Role of Routine Chest Radiographs in the Evaluation of Patients with Stable Blunt Chest Trauma – A Prospective Analysis

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ABSTRACT

Objective: *The study sought to assess the test performance characteristics of clinical judgement in the evaluation of stable blunt chest trauma patients compared with chest radiography (CXR) in the determination of significant intra-thoracic injury.*

Methods: *We prospectively enrolled all adult patients (older than 16 years) who were considered to have stable blunt chest trauma over a six-month period (May 1−October 31, 2009). We defined the latter as patients who were unintubated, normotensive (systolic blood pressure > 90 mm Hg) and without hypoxia (oxygen saturation > 95% at room air). Patients eligible for the study were sent for anteroposterior (AP) CXRs which were then interpreted by the same consultant radiologist throughout the study period. Both test (clinical judgement) and disease status (CXR) were assigned and correlated as binary measures. We compared the test performance characteristics such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic likelihood ratios of clinical judgement to CXR findings in the determination of significant intra-thoracic injury.*

Results: *During the six-month period, data were collected from 77 eligible stable blunt chest trauma patients (age over 16 years). Fifty-nine patients (76.6%) were male. Nine patients (11.7%) were radiologically confirmed to have significant blunt chest injuries including rib fractures, pneumothorax and an isolated case of pulmonary contusion. All nine (11.7%) patients had a positive (abnormal) radiograph for rib fractures. In addition, three (3.9%) of them also had both rib fracture and pneumothoraces and one (1.3%) had both a rib fracture and pulmonary contusion. Clinical judgement for the diagnosis of significant blunt chest injuries matched with the CXR finding with 95% confidence intervals (CIs): sensitivity 100% (95% CI 66.4, 100), specificity 32.4% (95% CI 21.5, 44.8), prevalence 11.7%, PPV 16.4% (95% CI 7.77, 28.8), NPV 100% (95% CI 84.6, 100), DLR^+ 1.48 (95% CI 1.25, 1.74).*

Conclusion: *The majority of patients who sustained blunt chest injuries and were assessed as stable patients do not require CXR routinely. This study revealed that physicians in the local Emergency Department may be over-utilizing CXR for patients who have stable blunt chest trauma.*

Keywords: Routine chest radiograph, stable blunt chest trauma

Papel de las Radiografías de Tórax Rutinarias en la Evaluación de Pacientes con Traumas Contundentes estables del Tórax - Análisis Prospectivo

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RESUMEN

Objetivo: *Este estudio se propuso evaluar las características de rendimiento de test del juicio clínico, a la hora de evaluar pacientes con traumatismos contundentes torácicos estables, en comparación con la radiografía de tórax al determinar lesiones intra-torácicas significativas.*

Métodos: *De forma prospectiva, fueron enrolados todos los pacientes adultos (mayores de 16 años) de quiénes se consideraba que habían tenido un trauma contundente torácico estable por un período de más de seis meses (1ero de mayo al 31 de octubre, 2009). Definimos a estos últimos como pacientes no*

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entubados, normotensos (tensión arterial sistólica > 90 mm Hg) y sin hipoxia (saturación de oxígeno > 95% en el aire de la habitación). Los pacientes elegibles para el estudio fueron enviados a hacerse una radiografía torácica anteroposterior (AP), la cual fue entonces interpretada por el mismo radiólogo consultante a cargo de ese análisis durante todo el periodo de estudio. Tanto el test (juicio clínico) como el estatus de la enfermedad (rayos X del tórax) fueron asignados y correlacionados como medidas binarias. Se compararon las características de rendimiento del test, tales como la sensibilidad, la especificidad, el valor predictivo positivo, el valor predictivo negativo, las tasas de probabilidad diagnóstica del juicio clínico, con los hallazgos de los rayos X de tórax para la determinación de la lesión intra-torácica significativa.

Resultados: *Durante el periodo de seis meses, se recogieron datos de 77 pacientes elegibles con traumatismos contundentes estables de tórax (mayores de 16 años). Cincuenta y nueve pacientes (76.6%) eran varones. En nueve pacientes (11.7%) se habían confirmado radiológicamente lesiones de tórax significativas, incluyendo fracturas de las costillas, pneumotórax, y un caso aislado de contusión pulmonar. Los nueve (11.7%) pacientes todos tenían una radiografía positiva (anormal) de las fracturas de las costillas. Además, tres de ellos (3.9%) tenían fractura de la costilla y además pneumotórax, en tanto que uno (1.3%) presentaba fractura de las costillas y contusión pulmonar también. El juicio clínico para el diagnóstico de lesiones contundentes estables de tórax significativas se correspondía con los hallazgos de las radiografías torácicas, como lo muestran los siguientes resultados de la prueba, con intervalos de confianza (ICs) de 95%: sensibilidad 100% (95% IC 66.4, 100), especificidad 32.4% (95% IC 21.5, 44.8), prevalencia, 11.7%, PPV 16.4% (95% IC 7.77, 28.8), NPV 100% (95% IC 84.6, 100), DLR^{+} 1.48 (95% IC 1.25, 1.74).*

Conclusión: *La mayoría de los pacientes que han sufrido traumatismos contundentes de tórax, y fueron evaluados como pacientes estables no requieren rayos C de tórax rutinariamente. Este estudio reveló que los médicos en el Departamento de Emergencias local pueden estar haciendo un uso excesivo de las radiografías torácicas en el caso de pacientes con traumas torácicos contundentes estables.*

Palabras claves: Radiografía torácica de rutina, trauma torácico contundente estable

West Indian Med J 2012; 61 (1): 65

INTRODUCTION

Guiding principles for trauma care have been promulgated by the American College of Surgeons Committee on trauma through the Advanced Trauma Life Support (ATLS) course. The ATLS curriculum advocates routine radiographs for all multiple trauma patients regardless of the physical presentation of the patient in the Emergency Department [ED] (1). These include anteroposterior (AP) pelvic, chest and lateral cervical spine radiographs for screening purposes. According to a number of studies, the routine radiographs, particularly pelvic and cervical spine X-rays, are unnecessary in the awake and alert trauma patient and can be over-utilized (2−7). In the absence of specific clinical indicators, elimination of these X-rays does not compromise patient care or lead to an increase in missed injuries or delay in diagnosis (8). The American College of Surgeons has decreased the emphasis on compulsory cervical spine and pelvic X-rays on all trauma patients in its ATLS course based on data that support the rationality and safety of the selective radiographic screening policy (9).

Anteroposterior chest X-ray (CXR) has been the mainstay in screening and detecting thoracic injuries as a traditional initial diagnostic test (10). Non-life-threatening or stable blunt chest trauma is a very common injury reported in the ED. The primary aetiologies of these injuries are falls, sports injuries and motor vehicle accidents (11). Performing routine CXR in the emergency room following blunt chest trauma can result in a large number of unnecessary X-rays (7). This issue is particularly relevant to the practice of emergency medicine at the University Hospital of the West Indies (UHWI) where trauma accounts for approximately 40% of the workload in both the Accident and Emergency Unit and Surgical Wards (12) and furthermore, there are limited resources in the institution.

A careful history taking and physical examination may be able to offer the same information much more expeditiously than a CXR in stable patients (7). Rodriguez *et al*, in a pilot study to derive clinical variables for selective chest radiography in blunt trauma patients, the combination of palpation tenderness and hypoxia (oxygen saturation > 95% at room air), identified all significant thoracic injury with the screening performance of sensitivity 100% (95% CI 91, 100), specificity 50% (95% CI 45, 54), positive predictive value 12% (95% CI 9, 17) and negative predictive value 100% (95% CI 99, 100). Based on these findings, the authors in the above report concluded that the combination of chest tenderness as well as the presence of hypoxia identified all blunt trauma patients with significant intra-thoracic injury while potentially eliminating the need for 46% of chest radiographs (13).

The above reports support the hypothesis that CXR in the stable patient with blunt chest injury in the absence of certain specific signs on clinical examination is unnecessary. However, as there is often inter-observer variability in assessing subjective clinical signs across physicians, these findings will need to be replicated in our emergency setting before it could be implemented as policy. In other words, the test performance characteristics of clinical judgement of emergency medicine residents of UHWI compared with CXR in assessing stable blunt chest trauma patients would need to be determined. Therefore, in this study, we aimed to determine the sensitivity, specificity, likelihood ratios and predictive values of clinical judgement based on the emergency medicine residents integrating information from the patient's history, physical examination findings and mechanism of injury compared with CXR in diagnosing significant intra-thoracic injury. We hypothesized that blunt chest trauma patients who were stable with a normal physical examination did not require a chest radiograph routinely.

STUDY OBJECTIVES

Aim

* To assess the test performance characteristics of clinical judgement in the evaluation of stable blunt chest trauma patients.

Specific Aim

* To measure the sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio of clinical judgement compared with the chest radiograph as the gold standard.

SUBJECTS AND METHODS

This was a prospective observational study of patients with stable blunt chest trauma attending the ED of UHWI during the period May 1 – October 31, 2009. The UHWI is a teaching hospital in Kingston, Jamaica, that serves a predominantly urban population. Approximately 53 000 patients are seen in the ED annually with a considerable number of patients presenting with trauma. The stable patients were defined as unintubated, normotensive (systolic blood pressure > 90 mm Hg) and without hypoxia (oxygen saturation > 95% at room air). Patient eligibility for the study inclusion was based on the following criteria.

Inclusion criteria

* Patients with stable blunt chest trauma who were assessed to need chest radiographs

Exclusion criteria

* Age less than 16 years
* Pregnant women
* Primary trauma that occurred more than 24 hours before presentation
* Penetrating trauma
* Haemoptysis
* Patients who were in shock (pulse > 100 beats/min +/- systolic blood pressure < 90 mmHg)
* Oxygen saturation less than 95% at room air
* Glasgow Coma Scale score less than 15
* Patients with endotracheal intubation
* Patients who underwent needle or tube thoracostomy
* Patients who were transferred from another institution
* Prior enrolment in our study

Study protocol

This study was approved by The University of the West Indies Ethics Committee. Screening of patients was continuous throughout the study period of six months. Patients attending to UHWI with blunt chest trauma who met the eligibility requirements were approached for study participation and a written informed consent was obtained prior to study enrolment. Patients who declined to participate received standard care. Eligible patients were seen by the on duty emergency medical team consisting of senior house officers (SHOs), junior and senior residents in conjunction with a consultant emergency physician. A data sheet was used to collect the information. Patients age, gender, registration number and clinical diagnosis were recorded in the data sheet. Blunt mechanisms included fall from heights, motor vehicle collisions or motor vehicle *versus* pedestrian collisions, sports related injury and assaults either by objects or by fists and/or feet. Emergency medicine doctors then assessed the patients for the following criteria in order to establish a diagnosis:

* Pain in the chest
* Shortness of breath
* Injury of the chest wall (abrasion, laceration, contusion, ecchymosis, seatbelt sign)
* Chest wall tenderness on palpation
* Pain on lateral chest compression
* Palpable crepitus
* Abnormal chest auscultation

Clinical diagnosis was recorded before obtaining the CXR. The CXR was performed on each patient using the anteroposterior technique.

Outcome measure

For the purposes of this study, significant acute blunt thoracic injury was defined as rib fractures, sternal fracture, sternoclavicular dislocation, scapular fracture and scapulothoracic dissociation, pneumothorax, haemothorax, haemopneumothorax, pulmonary contusion and pulmonary laceration. All chest radiographs were interpreted by the same consultant radiologist who was blinded to the study. As CXR is not a screening test for cardiac contusion and haemopericardium, they were not included as significant intra-thoracic injury identifiable by CXR. In addition, no such diagnosis was identified or discovered at any time during the study.

Statistics

Both test measure (clinical judgement) and disease status measure (CXR) were binary measures. Thus, we defined the classification of tests results by disease status as shown in Table 1.

Table 1: Classification of tests results by disease status

	Disease Positive	**Disease Negative**
Test Positive	True Positive (TP)	False Positive (FP)
Test Negative	False Negative (FN)	True Negative (TN)

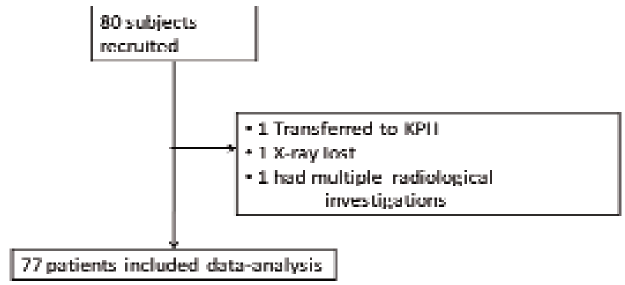

Fig. 1: Diagram showing the distribution of participants

We measured test performance by defining the following variables:

1) Sensitivity = True Positive Fraction = $\text{TPF} = \frac{TP}{Disease\ Negative} = \frac{TP}{TP + FN}$

2) False positive fraction = $\text{FPF} = \frac{TP}{Disease\ Negative} = \frac{TP}{TN + FP}$

3) Specificity = 1-False positive fraction = $\frac{TN}{TN + FP}$

4) Prevalence of disease = $\frac{Disease\ Positive}{Disease\ Positive + Disease\ Negative} = \frac{FN + TP}{FN + TP + TN + FP}$

5) Positive predictive values = $\text{PPV} = \frac{TN}{TN + FP}$

6) Negative predictive values = $\text{NPV} = \frac{TN}{TN + FN}$

7) Diagnostic likelihood ratio positive = $\text{DLR}^{+} = \frac{TPF}{FPF}$

8) Diagnostic likelihood ratio negative = $\text{DLR}^{-} = \frac{1 - TPF}{1 - FPF}$

To determine the sample size, it was assumed that the clinical test was 95% specific and 90% sensitive. It was, however, desirous for the test to be at least 80% specific and 75% sensitive to be recommended. It was shown that for the study to have 90% power then the number of cases required was ~ 80.

RESULTS

During the six-month study period, eighty study participants were recruited. Seventy-seven patients were eligible for the study and three patients were excluded (Fig. 1). Of these 77 patients, 59 (76.6%) were male and 18 (23.4%) were female. The age distribution of the study population is shown in Fig. 2. The mean age of the study participants was 37.9 years (SD ± 15.9). The combination of the demographics is shown in Table 2.

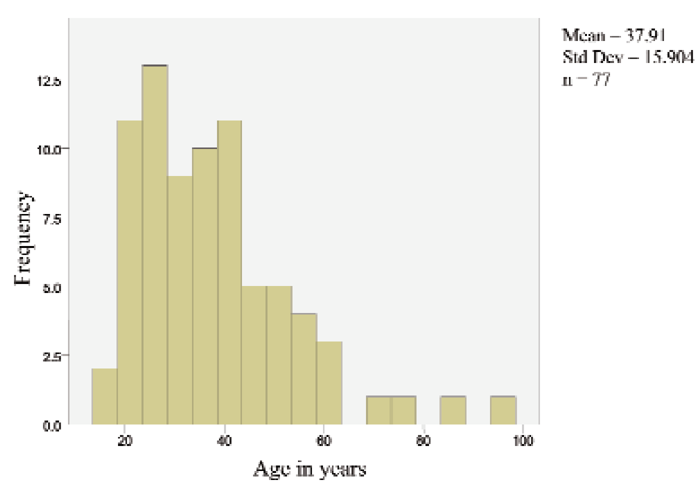

Fig. 2: Age distribution of study population

Table 2: Demographic and distribution

Demographic	Distribution
Age (Mean ± SD)	37.9 ± 15.9
Gender	n (%)
Male	59 (76.6%)
Female	18 (23.4%)

The interpretation of the consultant radiologist was used to identify any of the assigned injuries or diseases such as rib fracture, pneumothorax and pulmonary contusion. The final radiological diagnoses of the study participants are represented in Table 3.

Table 3: The radiological diagnoses of the study participants

Disease	Positive for findings n (%)	Negative for findings n (%)	Total n (%)
All injuries	9 (11.9%)	68 (88.3%)	77 (100%)
Rib fractures	9 (11.9%)	68 (88.3%)	77 (100%)
Pneumothorax	3 (3.9%)	74 (96.1%)	77 (100%)
Pulmonary contusion	1 (1.3%)	76 (98.7%)	77 (100%)

Table 4 shows the performance results of clinical acumen for all diagnoses against the final radiological diagnosis (taken as the gold standard in this study). For all cases (diseases) studied, the clinical diagnosis was positive and matched the radiological diagnosis in nine cases but was falsely positive in 46 cases. The clinical diagnosis was negative and matched the radiological diagnosis in 22 cases but there was no falsely negative case.

Table 4: Clinical diagnosis and radiological diagnosis cross-tabulation (all diseases)

	Radiological diagnosis POSITIVE	Radiological diagnosis NEGATIVE	TOTAL
Clinical diagnosis POSITIVE	9	46	55
Clinical diagnosis NEGATIVE	0	22	22
TOTAL	**9**	**68**	**77**

The test performance characteristics variables of clinical judgement for all diagnoses are shown in Table 5. The variables are sensitivity, specificity, prevalence, positive predictive value (PPV), negative predictive value (NPV) and diagnostic likelihood ratio positive (DLR^+).

Table 5: Test performance characteristics variables of clinical judgement for all diagnoses with 95% Confidence Interval (CI)

		Lower 95% CI	Upper 95% CI
Sensitivity	100%	66.4%	100%
Specificity	32.4%	21.5%	44.8%
Likelihood ratio (+)	1.48	1.25	1.74
Positive predictive value	16.4%	7.77%	28.8%
Negative predictive value	100%	84.6%	100%

The test performance characteristics variables of clinical judgement for all diagnoses and each diagnosis such as rib fracture, pneumothorax and pulmonary contusion are compared (Table 6).

Crosstabs for senior residents only

Twenty-nine patients were seen by senior residents. For all cases (diseases) seen by senior residents, the clinical diagnosis was positive and matched the radiological diagnosis in three cases but was falsely positive in 18 cases. The clinical diagnosis was negative and matched the radiological diagnosis in eight cases but there was no falsely negative case (Table 7).

The test performance characteristics variables of clinical judgement of senior residents for all diagnoses and each diagnosis such as rib fracture, pneumothorax and pulmonary contusion are compared (Table 8). The variables are sensitivity, false positive fraction, specificity, prevalence, positive predictive value (PPV) and negative predictive value (NPV).

Crosstabs for junior residents only

Thirty-six patients were seen by junior residents. For all cases (diseases) seen by junior residents, the clinical diagnosis was

Table 6: Comparison of the test performance characteristics variables of all diagnoses and each diagnosis

Performance defining variables	All diagnoses	Rib fracture	Pneumothorax	Pulmonary contusion
Sensitivity	100%	100%	33.3%	0%
Specificity	32.4%	35.3%	97.3%	98.7%
Prevalence	11.7%	11.7%	3.8%	1.2%
PPV	16%	16.9%	33.3%	0%
NPV	100%	100%	97.3%	98.7%

PPV− positive predictive value, NPV− negative predictive value

Table 7: Clinical diagnosis and radiological diagnosis cross-tabulation (all diseases) − senior residents

	Radiological diagnosis POSITIVE	Radiological diagnosis NEGATIVE	TOTAL
Clinical diagnosis POSITIVE	3	18	21
Clinical diagnosis NEGATIVE	0	8	8
TOTAL	**3**	**26**	**29**

Sensitivity = True positive fraction = 100%
False positive fraction = 0.69
Specificity = 1- False positive fraction = 31% (1− 0.69)
Prevalence of disease = 10.3%
PPV = 14.3%
NPV = 100%

Table 9: Clinical diagnosis and radiological diagnosis cross-tabulation (all diseases) − junior residents

	Radiological diagnosis POSITIVE	Radiological diagnosis NEGATIVE	TOTAL
Clinical diagnosis POSITIVE	5	18	23
Clinical diagnosis NEGATIVE	0	13	13
TOTAL	**5**	**31**	**36**

Sensitivity = True positive fraction = 100%
False positive fraction = 0.58
Specificity = 1- False positive fraction = 42% (1− 0.58)
Prevalence of disease = 13.9%
PPV = 21.7%
NPV = 100%

Table 8: The test performance characteristics variables of clinical judgement by senior residents for all diagnoses and each diagnosis

Performance defining variables	All diagnoses	Rib fracture	Pneumothorax	Pulmonary contusion
Sensitivity	100%	100%	0%	0%
FPF	0.69	0.61	0.036	0 .036
Specificity	31%	39%	96.4%	96.4%
Prevalence	10.3%	10.3%	3.4%	3.4%
PPV	14.3%	15.8%	0%	0%
NPV	100%	100%	96.4%	96.4%

FPF – false positive fraction, PPV− positive predictive value, NPV− negative predictive value

positive and matched the radiological diagnosis in five cases but was falsely positive in 18 cases. The clinical diagnosis was negative and matched the radiological diagnosis in 13 cases but there was no falsely negative case (Table 9).

The test performance characteristics variables of clinical judgment of junior residents for all diagnoses and each diagnosis such as rib fracture, pneumothorax and pulmonary contusion are compared (Table 10). The variables are sensitivity, false positive fraction, specificity, prevalence, PPV and NPV.

Crosstabs for SHOs only

Twelve patients were seen by SHOs. For all cases (diseases) seen by senior house officers, the clinical diagnosis was positive and matched the radiological diagnosis in one case but was falsely positive in 10 cases. The clinical diagnosis was negative and matched the radiological diagnosis in one case but there was no falsely negative case (Table 11).

The test performance characteristics variables of clinical judgement of SHOs for all diagnoses and each diagnosis such as rib fracture, pneumothorax and pulmonary contusion

Table 10: The test performance characteristics variables of clinical judgement by junior residents for all diagnoses and each diagnosis

Performance defining variables	All diagnoses	Rib fracture	Pneumothorax	Pulmonary contusion
Sensitivity	100%	100%	50%	
FPF	0.58	0.58	0.029	
Specificity	42%	42%	97.1%	
Prevalence	13.9%	13.9%	5.6%	
PPV	21.7%	21.7%	50%	
NPV	100%	100%	97.1%	100%

Table 11: Clinical diagnosis and radiological diagnosis cross-tabulation (all diseases) − senior house officers

	Radiological diagnosis POSITIVE	**Radiological diagnosis NEGATIVE**	**TOTAL**
Clinical diagnosis POSITIVE	1	10	11
Clinical diagnosis NEGATIVE	0	1	1
TOTAL	**1**	**11**	**12**

Sensitivity = True positive fraction = 100%
False positive fraction = 0.91
Specificity = 1 – False positive fraction = 9.1% (1− 0.91)
Prevalence of disease = 8.3%
PPV = 9.1%
NPV = 100%

are compared (Table 12). The variables are sensitivity, false positive fraction, specificity, prevalence, PPV and NPV.

Table 12: The test performance characteristics variables of clinical judgement by senior house officers for all diagnoses and each diagnosis

Performance defining variables	**All diagnoses**	**Rib fracture**	**Pneumothorax**	**Pulmonary contusion**
Sensitivity	100%	100%		
FPF	0.91	0.91		
Specificity	9.1%	9.1%		
Prevalence	8.3%	8.3%		
PPV	9.1%	9.1%		
NPV	100%	100%	100%	100%

FPF – false positive fraction, PPV− positive predictive value, NPV− negative predictive value

The relationship between the various predictors and positive radiological outcome was explored with a logistic regression model. In this model, the predictors offered included age of subject, the training status of physician and gender of subject (Table 13).

Table 13: The association of clinical training status of emergency physician, age of patients and risk of positive radiological findings

Radiological disease status	**Odds ratio**	***p*-value**	**Lower 95% CI**	**Upper 95% CI**
Junior resident*	1.14	0.8	0.22	5.94
Senior house officer*	0.98	1.0	0.09	11.23
Age in year	1.05	0.024	1.01	1.09
Male	3.03	0.3	0.31	29.68

*Compared to senior resident

DISCUSSION

Patients with blunt chest trauma are commonly seen in EDs and these injuries can be either life-threatening or non-life-threatening (11, 14). In a stable patient with non-life-threatening blunt chest injury, the appropriate investigations are not well defined (11). In this study, we sought to determine the test performance characteristics of clinical acumen in the evaluation of patients with blunt chest trauma.

Theoretically, a CXR might reveal rib fractures, pneumothorax, haemothorax, pulmonary contusion, consolidation or atelectasis (11). In a study of combined blunt and penetrating trauma done by Sears *et al*, 65 (9.7%) out of 667 patients who sustained blunt chest trauma were correctly diagnosed by the trauma surgeons (9). The most common diagnosis in that study was rib fractures presenting in 34 (5.1%) patients with blunt chest trauma (9). In another study of blunt chest trauma done by Rodriguez *et al*, 31 (6.3%) out of 492 patients had significant intra-thoracic injuries confirmed by CXR (13). The most common diagnosis again was rib fractures (more than 2 ribs) presenting in 20 (4.1%) patients (13).

In the present study of stable blunt chest trauma, nine (11.7%) out of 77 patients were confirmed to have abnormal radiological findings including rib fracture, pneumothorax and pulmonary contusion. All nine (11.7%) patients had a positive radiograph for rib fracture; in addition, three (3.9%) of them also had both rib fracture and pneumothoraxes and one (1.3%) had both a rib fracture and pulmonary contusion diagnosed radiologically.

In the study earlier reported, Sears *et al* evaluated the accuracy of obtaining an abnormal finding on a CXR based on the trauma surgeon's judgement incorporating the patient's symptoms, physical examination finding and the mechanism of the injury (9). In 667 patients who had blunt chest trauma, the sensitivity of the trauma surgeon's judgement that the CXR would be normal was 92.7% (95% CI 84.75, 97.27), the specificity of the trauma surgeon's judgement that CXR would be normal was 55.6% (95% CI 51.44, 59.66), the NPV of the trauma surgeon's judgement that CXR would be normal was 98.2% [95% CI 96.08, 99.33] (9). Also in the study by Rodriguez *et al*, the authors concluded that the combination of tenderness and hypoxia together identified all significant acute intra-thoracic injury with the sensitivity of 100% (95% CI 91, 100), the specificity of 50% (95% CI 45, 54), the PPV of 12% (95% CI 9, 17) and NPV 100% [95% CI 99, 100] (13).

In the present study, we measured the sensitivity, specificity, PPV, NPV, positive likelihood ratio and negative likelihood ratio of clinical judgement for the diagnosis of significant blunt chest trauma including rib fractures, pneumothorax and pulmonary contusion compared with the CXR results as gold standard. The sensitivity was 100% (95% CI 66.4, 100) meaning that the clinicians were able to diagnose correctly for all the cases of significant blunt injuries but there were 46 false positive cases. This data suggested that the clinical judgement for the diagnosis was sensitive because an excess number of CXRs were requested. The specificity was 32.4% (95% CI 21.5, 44.8) meaning that the clinicians were not consistent in excluding patients without any significant blunt chest injuries. This was also due to the excess number of false positive patients who totalled 46. The PPV was 16.4% (95% CI 7.77, 28.8) stating that the patients who were diagnosed clinically as significant blunt chest injuries actually had positive radiological diagnosis in only 16.4% of cases. This result was not surprising as the study population that was stable had low prevalence (11.7%) of significant blunt chest injuries. At the same time, the low specificity of the clinical judgement caused poor PPV. The NPV was 100% (95% CI 84.6, 100) meaning that all the patients who did not have significant chest injuries clinically were not positive for the radiological diagnosis of thoracic injury. Both positive and negative predictive values are dependent upon the prevalence of the disease. In this study, the sample was assumed to be a cohort and the prevalence ratio calculated accordingly. The extent to which the sample prevalence differs from the population prevalence will affect the PPV and NPV.

The likelihood ratio positive (LR+) is the likelihood that a given test result would be expected in a patient with the target disorder compared to the likelihood that that same result would be expected in a patient without the target disorder. Likelihood ratio has the advantage of being independent of the prevalence of the disease as well as it can be used to calculate the post-test probability of disease. In this study, the LR+ for clinical acumen in diagnosing significant chest pathology was 1.48. The value greater than 1 obtained for the LR+ implies that the post-test probability of significant chest pathology will be higher than the pre-test probability. In other words, the outcome of the clinical examination improves the diagnosis of chest pathology, albeit modestly.

Rib fractures are the most common type of chest trauma (15). Studies have shown that the majority of rib fractures were due to motor vehicle accidents (15). In the present study, the prevalence of rib fracture in stable blunt chest trauma was 11.7%. Rib fractures are seldom isolated (15). In a study of 7147 patients, Zieglar *et al* found that 711 (10%) had rib fractures (16). Among these patients with rib fractures, 274 (32%) had haemothorax and pneumothorax and 187 (26%) had pulmonary contusion (16). In the present study, pneumothorax and pulmonary contusion were associated with the rib fractures in three (33.3%) patients and one (11.1%) patient respectively. It can be reasoned that the physician's clinical suspicion of a rib fracture (localized tenderness) should alert him or her to the possibility of other associated injuries such as pneumothorax and pulmonary contusion as was borne out in this small study.

A pneumothorax is the abnormal accumulation of air within the pleural cavity (15). These injuries have been described in 20% of patients surviving major trauma (15). In the present study, the prevalence of pneumothorax was 3.8%. The typical presentation of pneumothorax is dyspnoea and pleuritic type chest pain (17). These symptoms are present in 80% to 90% of patients, although up to 10% of patients will be asymptomatic (17). The chest pain is usually on the same side and may radiate to the shoulder, neck and back (17). Dry cough is not uncommon (17). On physical examination, tachycardia, tachpnoea, asymmetrical chest wall expansion, hyperresonance on percussion and diminished breath sounds may be present (17).

Pulmonary contusion is the most frequent parenchymal injury of the lungs in severe blunt chest trauma (15, 18). In a study done by Cohn, pulmonary contusion was present in 17% of patients with multiple injuries secondary to blunt trauma (18). The prevalence of pulmonary contusion in stable blunt chest trauma was only 1.2% in the present study. Pulmonary contusions can occur when the chest wall is compressed against the lung tissue at the time of impact and patients who sustain blunt chest wall trauma should be assessed for developing this complication (15, 19). Emergency physicians should suspect pulmonary contusion in the presence of dyspnoea, tachypnoea and hypoxia (15). In the present study, the presence of hypoxia was one of the exclusion criteria. According to our data, although we could assume that pulmonary contusion might occur in the absence of hypoxia, our sample size and the prevalence of the disease was too small to prove this. The presence of rib fracture should raise the suspicion of pulmonary contusion and the CXR is the basis of the diagnosis (15). In our study, only one case of pulmonary contusion was associated with rib fracture. Pulmonary contusion is still possible even in the absence of rib fracture (20).

The sensitivity of CXR is not too high for the diagnosis of pulmonary contusion in the early part of the presentation (15). Studies have shown that only 64% of patients diagnosed with pulmonary contusion have a positive initial CXR, usually taken within six hours of injury, whereas 11% have a delayed radiographic presentation (15). In the present study, we were not able to follow-up patients to detect the natural history of the progression of pulmonary contusion.

In our study, the clinical evaluations were done by three classifications of staff members: senior residents, junior residents and senior house officers. We found out that there was no statistical significant difference in the odds of detecting significant injury based on clinical training (Table 13). This was mostly due to the small sample size.

LIMITATIONS

There were several limitations to our study. Besides the small sample size, the study population was underpowered due to the low incidence of blunt chest trauma in the patients who were clinically stable and this might have been as a result of selectivity (stable, blunt chest trauma). Trauma patients who would have otherwise been more likely to have clinical and radiological abnormalities might have triaged away from our population. Nevertheless, it was borne out that even in this non-alert category, overuse of chest radiography was detected.

Another drawback in this study was the lack of control for inter-observer variability in the interpretation of clinical findings and diagnosis among the different levels of clinicians. Furthermore, the wide heterogenicity of the patient's profile compounded this issue of objective and tangible clinical findings.

The general problem is that of evaluating the properties of a diagnostic test when the gold standard was measured with error. The use of more than one rater will not necessarily improve the accuracy of the gold standard and the statistic proposed, the kappa, is the measure of reliability, not accuracy. In truth, the assumptions that were made in the analysis of the data were that the gold standard was measured with error and the diagnostic test was independent of the disease outcome. We accept that test characteristics so produced are biased. However, the techniques required to adjust for the bias inherent in our approach are complex and beyond the scope of this paper.

In order to overcome these limitations, a multi-centre study may be needed to accumulate larger numbers to gain statistical significance. The consideration of a diagnostic protocol geared towards this group of patients may offer more efficient care. Certainly, cost factor and over-exposure to radiation are serious considerations to revisit the overuse of the radiography and this warrants further studies locally.

CONCLUSION

This study suggests that stable blunt chest trauma patients without significant clinical diagnosis do not require CXR routinely. The patients without any significant blunt chest injuries on clinical examination had direct correlation with normal radiographic findings in the study population. At the same time, the clinicians were not consistent in excluding patients without any significant blunt chest injuries, resulting in an excess number of unnecessary CXRs being requested. This study also revealed that physicians in the local ED may be over-utilizing the CXR for patients who had stable blunt chest trauma. This was a pilot study and it needs to be repeated as a multi-centre trial.

REFERENCES

1. Dillard E, Luchette FA, Sears BW, Norton J, Schermer CR, Reed RL et al. Clinician *vs* mathematical statistical models: which is better at predicting an abnormal chest radiograph finding in injured patients? Am J Emerg Med 2007; **25:** 823−30.
2. DeLuca SA, Rhea JT, O'Malley TO. Radiographic evaluation of rib fractures. AJR Am J Roentgenol 1982; **138:** 91−2.
3. Hoffman JR, Schriger DL, Mower W, Luo JS, Zucker M. Low-risk criteria for cervical-spine radiography in blunt trauma: a prospective study. Ann Emerg Med 1992; **21:** 1454−60.
4. Salvino CK, Esposito TJ, Smith D, Dries D, Marshall W, Flisak M et al. Routine pelvic x-ray studies in awake blunt trauma patients: a sensible policy? J Trauma 1992; **33:** 413−6.
5. Gonzalez RP, Fried PQ, Bukhalo M. The utility of clinical examination in screening for pelvic fractures in blunt trauma. J Am Coll Surg 2002; **194:** 121−5.
6. Duane TM, Tan BB, Golay D, Cole FJ Jr, Weireter LJ Jr, Britt LD. Blunt trauma and the role of routine pelvic radiographs: a prospective analysis. J Trauma 2002; **53:** 463−8.
7. Bokhari F, Brakenridge S, Nagy K, Robers R, Smith R, Joseph K et al. Prospective evaluation of the sensitivity of physical examination in chest trauma. J Trauma 2002; **53:** 1135−8.
8. Ersoy G, Karcioglu O, Enginbas Y, Eray O, Ayrik C. Are cervical spine X-rays mandatory in all blunt trauma patients? Eur J Emerg Med 1995; **2:** 191−5.
9. Sears BW, Luchette FA, Esposito TJ, Dickson EL, Grant M, Santaniello JM et al. Old fashion clinical judgment in the era of protocols: is mandatory chest X-ray necessary in injured patients? J Trauma 2005; **59:** 324−30; discussion 30–2.
10. Reuter M. Trauma of the chest. Eur Radiol 1996; **6:** 707−16.
11. Dubinsky I, Low A. Non-life-threatening blunt chest trauma: appropriate investigation and treatment. Am J Emerg Med 1997; **15:** 240−3.
12. McDonald A, Duncan ND, Mitchell DI, Fletcher PR. Trauma aetiology and cost in the Accident and Emergency Unit of the University Hospital of the West Indies. West Indian Med J 1999; **48:** 141−2.
13. Rodriguez RM, Hendey GW, Marek G, Dery RA, Bjoring A. A pilot study to derive clinical variables for selective chest radiography in blunt trauma patients. Ann Emerg Med 2006; **47:** 415−8.
14. McGillicuddy D, Rosen P. Diagnostic dilemmas and current controversies in blunt chest trauma. Emerg Med Clin North Am 2007; **25:** 695−711.
15. Ullman EA, Donley LP, Brady WJ. Pulmonary trauma emergency department evaluation and management. Emerg Med Clin North Am 2003; **21:** 291−313.
16. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma 1994; **37:** 975−9.
17. Putukian M. Pneumothorax and pneumomediastinum. Clin Sports Med 2004; **23:** 443−54.
18. Cohn SM. Pulmonary contusion: review of the clinical entity. J Trauma 1997; **42:** 973−9.
19. Miller LA. Chest wall, lung, and pleural space trauma. Radiol Clin North Am 2006; **44:** 213−24.
20. Wanek S, Mayberry JC. Blunt thoracic trauma: flail chest, pulmonary contusion, and blast injury. Crit Care Clin 2004; **20:** 71−81.