

Delayed pneumothorax after stab wound to thorax and upper abdomen: Truth or myth?

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ABSTRACT

Background: Stab wounds to the thorax and upper abdomen have the potential to cause pneumothorax (PTX). When a CXR (CXR) obtained during initial resuscitation is negative, a second CXR (CXR-2) is commonly performed with the goal of identifying delayed PTX.

Objectives: To assess the diagnostic yield of the CXR-2 in identifying delayed PTX.

Methods: Prospective observational study of patients (age ≥ 13 years) with stab wounds to the thorax (chest/back) and upper abdomen with suspected PTX, in a level 1 trauma centre. Patients were included if they had a negative initial CXR followed by a repeat CXR 3–6 h after the initial one. Exclusion criteria: patients who died, were transferred out of the ED, or received chest tubes before the second CXR. The outcome of interest was delayed PTX. All CXR were read by an attending radiologist. To test the inter-observer agreement, another blinded radiologist reviewed 20% of CXR. Continuous data is presented as mean \pm standard deviation and categorical data as percentages with 95% confidence interval (CI). Kappa statistics were used to measure the inter-observer agreement between radiologists.

Results: Between January 2003 and December 2006 a total of 185 patients qualified for the enrollment (mean age: 28 ± 10 years, age range: 13–65, 94% male). Only 2 patients (1.1%, 95% CI, 0.4–4.1%) had PTX on the CXR-2. Both patients received chest tubes. The inter-observer agreement for radiology reports was high (kappa: 0.79).

Conclusion: Occurrence of delayed PTX in patients with stab wounds to the thorax and upper abdomen and negative triage CXR is rare.

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Introduction

Penetrating thoracic trauma is associated with a wide spectrum of injuries, ranging from clinically non-significant to life-threatening. Interestingly, most of our knowledge of penetrating thoracic trauma originates from combat casualties during World War II and the wars in South East Asia, where the mortality for such injuries exceeded 50%.¹¹

Among different types of penetrating thoracic injuries, stab wounds typically create a challenge to clinicians since the size, track and nature of the wounds are often not clearly visualised. The standard for initial management of these injuries is assessment with

a portable CXR (CXR). Patients who remain asymptomatic and have a normal initial CXR are typically observed, and after a period of 3–6 h, are reassessed by another CXR. Results of previous studies indicate that if delayed sequelae do develop, they tend to do so within the first few hours following the initial insult.¹⁵ The existing literature suggests that these delayed findings are due to a variety of mechanisms. One commonly held belief regarding the development of pneumothorax over time is that a linear stab wound may form a subcutaneous seal around the pleural wound, creating a flap and valve mechanism. This flap may subsequently stretch and permit air entry into the pleural space, creating a pneumothorax.⁸ Other authors suggest that the delayed presentation of pneumothorax and haemothorax may be the result of thrombus or adhesion of the pleura which may eventually be lost as the patient strains or coughs.¹⁰

The purpose of our study was to assess the rate of delayed pneumothorax in patients who presented with stab wounds to the thorax and upper abdomen who had a negative radiological evaluation at triage.

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Methods

Study design

This was a prospective observational study investigating the yield of 3–6 h repeat CXR for identifying delayed pneumothorax after stab wound to the thorax or upper abdomen. On designated shifts when research assistants were available, all trauma patients older than 13 years of age (the age cut-off for adult trauma patients in our institution) who presented with stab wounds were considered for enrollment. Research assistants are medical student or undergraduate students trained in data collection for specific studies. Training for this study included a 2 h session of introductory explanation of the project and two additional clinical sessions directly training the assistants how to enroll or exclude the subjects and how to obtain the necessary information.

Study setting

This study was conducted from January 2003 to December 2006. Our institution is an academic level 1 trauma centre with approximately 150,000 Emergency Department (ED) visits and 1800 trauma admissions annually. The study was approved by the institutional review board and waiver of consent was granted.

Selection of participants

We enrolled a convenience sample of trauma patients with stab wounds to the thorax and upper abdomen, where the suspicion of pneumothorax was a concern. We define the sample as 'convenience' due to lack of 24 h research assistant staffing, however during staffed time blocks a consecutive sample was sought and achieved.

Boundaries used to define the chest included anteriorly from the supraclavicular junction to the xiphoid tip and costal margins. Lateral borders included the deltopectoral groove to the posterior tips of the inferior scapula. Boundaries of the back included posteriorly from the base of the neck to the posterior axillary line and the entire area inferiorly to the posterior superior iliac spines. We also included stab wounds to the upper abdomen (area above a line connecting the lowest points of rib cage anteriorly) which included the epigastric area and most of the upper left and right abdominal quadrants.

All patients received an anteroposterior portable CXR immediately upon arrival. If the CXR was negative, the patient was observed in the ED and another CXR was obtained 3–6 h after triage. Patients with abnormal triage CXR findings related to the stab wound (e.g., haemothorax, pneumothorax, pulmonary contusion, pericardial effusion, etc) were excluded. We also excluded patients who required immediate surgical intervention (including tube thoracostomy), those who died or were transferred out of the ED prior to repeat CXR.

Research assistants recorded demographic data, vital signs, location of stab wounds, concomitant injuries, the results of imaging studies (first and second CXR) and all other diagnostic procedures.

Outcome measures

The prevalence of delayed pneumothorax, defined as pneumothorax (of any size) not evident on initial CXR but apparent on the repeat CXR after 3–6 h, was the primary outcome. Agreement was assessed using kappa statistics. In order to ensure the accuracy of the radiology readings and to differentiate "missed" pneumothoraces from "delayed" ones, we randomly selected 20% of first

CXR and 20% of repeat CXR for review by an independent radiologist blinded to the subject of the study and unaware of the readings by previous radiologists. We used a random number generator to choose the CXRs for second readings.

Data analysis

Descriptive data are reported as mean \pm standard deviation for continuous variables and proportions with 95% confidence intervals (CI) for categorical data.

Power calculation was done with the aim of achieving a width of the 95% confidence interval (95%CI) that would be 5% of the calculated proportion value. Using the previously reported rate of delayed pneumothorax of 6% (reported rate of 0% to 12%) for "p" the approximate confidence interval width was quantified as $CI = x6Z \times [p \times 12p/n]^{1/2}$, with 1.96 as the standard value for Z for a 95%CI. This would require a minimum of 90 subjects.

Results

During the study period, 348 patients were considered for enrollment. After excluding patients with no initial CXR and those with positive findings on initial CXR, data analysis was performed on 185 patients (Fig. 1). All these patients sustained stab wounds to the thorax and upper abdomen, were suspected of having pneumothorax, and had negative triage CXR. The sample population consisted of 174 males (94%) and 11 females (6%). The mean age was 28 ± 10 years (range: 13–65 years). Anatomical location of stab wounds consisted of upper abdomen (13%), chest (38%), and back (56%). Fifty-one patients (28%) had multiple stab wounds. Baseline characteristics of the study subjects are presented in Table 1.

After 3–6 h of observation, 2 CXR revealed pneumothoraces not evident on the triage CXR (1.1%, 95% CI, 0.04–4.1%). Both subjects underwent tube thoracostomy. The first patient's delayed CXR demonstrated a 15% pneumothorax after a stab wound to the left second intercostal space. The tube was removed at day 5 and the patient was discharged home. The subject had no complications after 2 months of outpatient follow-up. The second subject suffered a stab wound to the posterior thorax 2 cm from midline at the level of the inferior tip of the right scapula. Repeat CXR revealed a small apical pneumothorax. A right sided chest tube was inserted by the admitting trauma team. The patient had an uncomplicated hospital course and up to 1 month clinic follow-up.

Two patients had small pneumothoraces detected by CT approximately 1 h after arriving to the ED. Both patients had negative 6 h CXR despite the CT findings. Both patients were managed by observation in the hospital (no tube thoracostomy) and discharged on day 3. Since the objective of our study was to assess the yield of repeat CXR and both of these patients had negative repeat CXR and did not require tube thoracostomy, we did not consider them as delayed pneumothorax. Had we counted these two cases, the prevalence of delayed pneumothorax would have been 2.2% (95% CI, 0.7–5.6%).

Inter-observer agreement in the interpretation of 68 chest radiographs (33 initial and 34 repeat) demonstrated a concordance rate between the first and second radiologists' readings of 98% and a kappa of 0.79. No pneumothoraces were missed on the initial or repeat CXR readings.

Discussion

The objective of our study was to examine the prevalence of delayed pneumothorax after stab wounds to the thorax and upper abdomen. It is a common practice to obtain an initial CXR in such patients and if negative, to follow-up at 3–6 h with a repeat CXR to

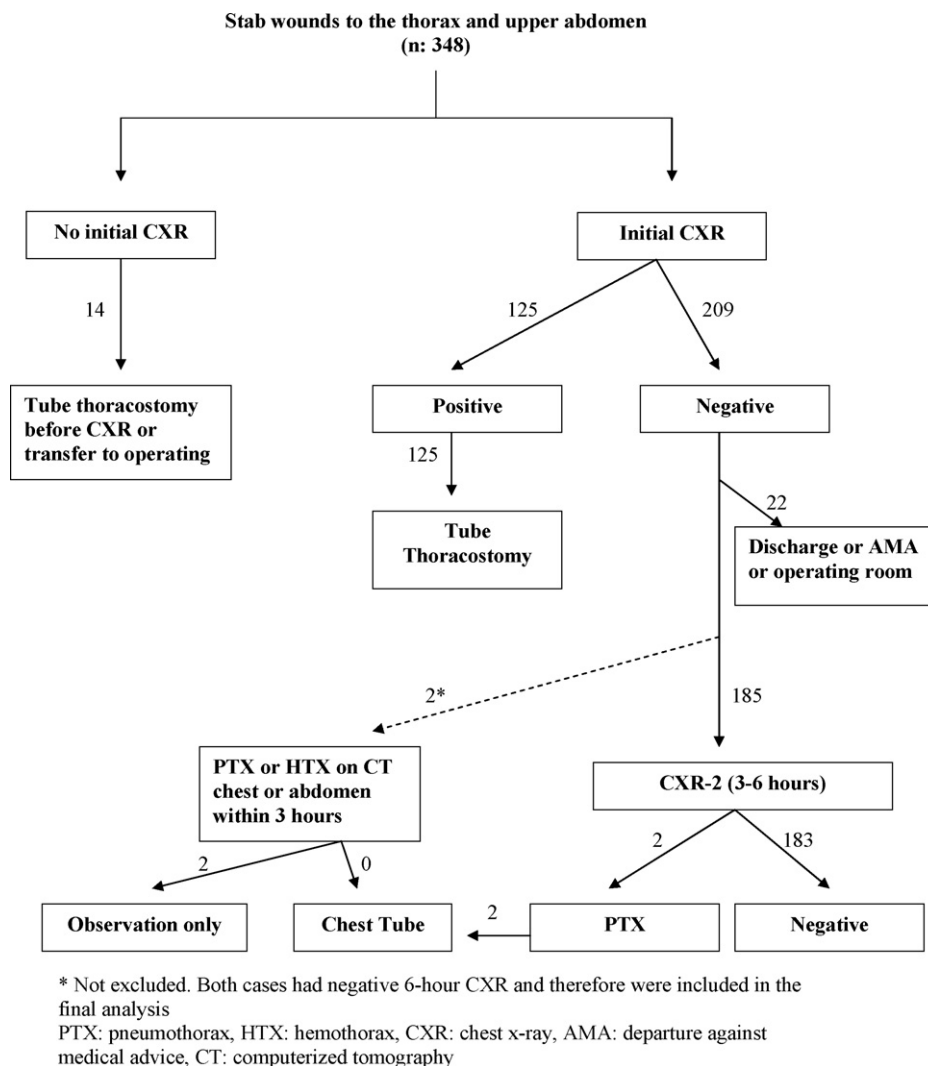


Fig. 1. Flow chart representing the inclusion/exclusion process.

detect delayed pneumothoraces. Different studies have reported a wide range for the prevalence of delayed pneumothorax (0–12%).^{7,8,12,15} In our study, we found delayed pneumothorax in only 1.1% (2/187) of the subjects.

This wide range could be due to the possibility of mislabeling “missed” cases as newly developed delayed pneumothoraces. Most of the studies reporting this prevalence are relatively old, when electronic radiographic imaging was not available. Digital chest radiography has been proven to be superior to analog film-screen systems.¹⁴ Another possibility for higher risk of missed cases is the use of portable anteroposterior views instead of posteroanterior

upright chest views in most studies. Compared to upright posteroanterior views, supine anteroposterior views have limited sensitivity in revealing pneumothoraces.^{1,2} In our study the majority of the initial CXR were portable as well. However, to alleviate the risk of missed pneumothoraces, we had 20% of the initial CXR and 20% of repeat CXR reviewed by a second radiologist who was blinded to the study objectives and patient information. We found that the inter-observer agreement for radiological interpretations in our study was very high (kappa: 0.79).

Finally, among the studies that reported the prevalence of delayed pneumothorax, one study comes across as an outlier with the highest reported rate of 12%¹² while the remaining literature report a rate generally below 4%.^{6,7,8,15}

Reviewing the studies that investigated the rate of delayed pneumothorax reveals that these pneumothoraces are small in nature in the majority of cases. In our study both pneumothoraces were less than 20%. Recently, several studies have proposed managing small pneumothoraces with observation alone instead of tube thoracostomy.^{4,17} These prospective trials have demonstrated that an occult pneumothorax in a haemodynamically stable trauma patient can be safely managed with simple observation. Tube thoracostomy is not benign; it has been associated with complications in as many as 21% of cases (e.g., pain, vascular injury, improper positioning, longer hospital stay, infections, etc.).⁵ This

Table 1
Baseline characteristics of the study subjects (n = 185).

Age (years)	28 ± 10
Gender	94% Male
Ethnicity	93% African American/Caribbean
Anatomical location	Chest: 38%
	Back: 56%
	Upper abdomen: 13%
Single versus multiple stab wounds	28% multiple
Mean systolic blood pressure (mmHg)	129 ± 18
Mean diastolic blood pressure (mmHg)	74 ± 10
Mean heart rate (bpm)	85 ± 19
Hypoxia (pulse-oxyetry < 95%)	2%

strategy has been associated with minimal complications (~1% thoracostomy placement), even in patients who require mechanical ventilation.³

Computed tomography (CT) has been suggested as a very sensitive diagnostic tool for identifying pneumothorax in stab wound patients.⁹ However, detecting small pneumothoraces not apparent on CXR by CT may not change patient management. In addition, CT is associated with a higher dose of radiation and higher cost. These limitations together with lack of availability in some centres make CT less attractive for this purpose.

Another approach could be combining the initial CXR with an ED ultrasound. This practice may create more certainty for the clinicians and further decrease the likelihood of pneumothorax. Ultrasound has good sensitivity and specificity for detecting pneumothorax following blunt and penetrating chest trauma.^{13,16} Low prevalence of delayed pneumothorax, the use of ED ultrasound as a diagnostic adjunct, and successful resolution of small pneumothoraces with observation alone may ultimately alleviate the practice of chasing this entity with 3–6 h CXRs.

Limitations

This study analysed a convenience sample of patients with stab wounds to the thorax and upper abdomen. Although there was no restriction on patient enrollment other than the exclusions mentioned in Methods, our data represent only a portion of our institution's trauma patients with such injuries. Additionally, due to the small number of patients with delayed pneumothorax, we were not able to compare the clinical management (observation versus tube thoracostomy) and outcomes (admission versus discharge) of patients with such injuries.

Conclusion

We found a very low rate of delayed pneumothorax in patients with stab wound to the thorax and upper abdomen. Emergency physicians should determine on an individual basis the level of probability and risk at which, they are comfortable not to pursue such diagnosis. In our opinion, even when a delayed pneumothorax is present, the evidence weighs against any intervention in most instances. The majority of these pneumothoraces are small and clinically asymptomatic and resolve without complications. Clinicians may also consider complementing the initial chest X-ray with a bedside thoracic ultrasound and even further decrease the probability of a pneumothorax.

Conflict of interest statement

There is no conflict of interest involving any of the authors.

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