

Occult pneumothoraces in patients with penetrating trauma: Does mechanism matter?

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Accepted for publication
 Nov. 2, 2009

This manuscript was presented at the Southwestern Surgical Congress 60th Annual Meeting, Acapulco, Mexico, Apr. 1, 2008.

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Background: Supine anteroposterior (AP) chest radiography is an insensitive test for detecting posttraumatic pneumothoraces (PTXs). Computed tomography (CT) often identifies occult pneumothoraces (OPTXs) not diagnosed by chest radiography. All previous literature describes the epidemiology of OPTX in patients with blunt poly-trauma. Our goal was to identify the frequency of OPTXs in patients with penetrating trauma.

Methods: All patients with penetrating trauma admitted over a 10-year period to Grady Memorial Hospital with a PTX were identified. We reviewed patients' thoracoabdominal CT scans and corresponding chest radiographs.

Results: Records for 1121 (20%) patients with a PTX (penetrating mechanism) were audited; CT imaging was available for 146 (13%) patients. Of these, 127 (87%) had undergone upright chest radiography. The remainder (19 patients) had a supine AP chest radiograph. Fifteen (79%) of the PTXs detected on supine AP chest radiographs were occult. Only 10 (8%) were occult when an upright chest radiograph was used ($p < 0.001$). Posttraumatic PTXs were occult on chest radiographs in 17% (25/146) of patients. Fourteen (56%) patients with OPTXs underwent tube thoracostomy, compared with 95% (115/121) of patients with overt PTXs ($p < 0.001$).

Conclusion: Up to 17% of all PTXs in patients injured by penetrating mechanisms will be missed by standard trauma chest radiographs. This increases to nearly 80% with supine AP chest radiographs. Upright chest radiography detects 92% of all PTXs and is available to most patients without spinal trauma. The frequency of tube thoracostomy use in patients with overt PTXs is significantly higher than for OPTXs in blunt and penetrating trauma.

Contexte : La radiographie pulmonaire antéropostérieure en position couchée constitue un moyen non sensible de détecter le pneumothorax (PTX) post-traumatique. La tomodynamométrie (TDM) détecte souvent un pneumothorax occulte (PTXO) non diagnostiqué par une radiographie pulmonaire. Toutes les publications antérieures décrivent l'épidémiologie du PTXO chez les patients qui ont subi un poly-traumatisme contondant. Nous voulions déterminer la fréquence du PTXO chez les patients victimes d'un traumatisme perforant.

Méthodes : Tous les patients victimes d'un traumatisme perforant admis au cours d'une période de 10 ans à l'Hôpital commémoratif Grady qui avaient un PTX ont été identifiés. Nous avons étudié les TDM thoracoabdominales des patients et les radiographies pulmonaires correspondantes.

Résultats : Nous avons vérifié les dossiers de 1121 (20 %) patients victimes d'un PTX (mécanisme perforant). L'imagerie par TDM était disponible pour 146 (13 %) des patients. De ce total, 127 (87 %) avaient eu une radiographie pulmonaire en position debout. Les autres (19 patients) avaient eu une radiographie pulmonaire antéropostérieure en position couchée. Quinze (79 %) des PTX détectés par des radiographies pulmonaires antéropostérieure en position couchée étaient occultes. Seulement 10 (8 %) étaient occultes lorsqu'on a utilisé la radiographie pulmonaire en position debout ($p < 0,001$). Le PTX post-traumatique était occulte dans les radiographies pulmonaires de 17 % (25/146) des patients. Quatorze (56 %) des patients qui avaient un PTXO ont subi une thoracostomie comparativement à 95 % (115/121) des patients qui avaient un PTX évident ($p < 0,001$).

Conclusion : La radiographie pulmonaire habituelle des traumatisés rate jusqu'à 17 % du total des PTX chez les patients traumatisés par un mécanisme perforant. Ce pourcentage atteint presque 80 % pour les radiographies pulmonaires antéropostérieures en position couchée. La radiographie pulmonaire en position debout détecte 92 % des PTX

et est disponible pour la plupart des patients qui n'ont pas de traumatisme rachidien. La fréquence du recours à la thoracostomie chez les patients qui ont un PTX évident est beaucoup plus élevée que chez ceux qui ont un PTXO dans les cas de traumatisme contondant et perforant.

Occult pneumothorax (OPTX) is a pneumothorax (PTX) diagnosed by computed tomography (CT) that had not been previously identified by a supine anteroposterior (AP) chest radiograph.¹⁻⁷ With the increasing use of thoracoabdominal CT imaging in modern trauma care, the incidence and study of OPTXs has increased dramatically. Because PTXs are the most common manifestation of blunt intrathoracic injury,^{1,3,8-20} OPTXs have been described almost exclusively following motor vehicle collisions and falls. As a result, the frequency and treatment of patients with OPTXs from penetrating trauma is unknown.

The incidence of OPTXs among patients with blunt injury has been reported to be as high as 64% in intubated, polytrauma patients with a mean injury severity score of 30.²¹ The primary risk factor for the presence of an OPTX in this setting is subcutaneous emphysema.¹⁷ The use of tube thoracostomy as treatment for OPTXs varies considerably depending on the need for mechanical ventilation. Whereas most nonventilated patients with OPTXs do not require insertion of a chest tube, most patients requiring positive pressure ventilation undergo tube thoracostomy.^{17,18} Patients with overt PTXs detected by supine chest radiography also have a higher rate of chest tube insertion than those with OPTXs, despite evidence showing that they are similar in size and distribution.^{17,22} The pattern of chest tube use in penetrating trauma is unclear.

Owing to the more common use of upright chest radiography in patients not suspected of having spinal column injuries, the incidence of OPTXs in penetrating trauma is presumed to be significantly lower than in blunt injury. However, a small number of patients with penetrating injuries are still initially limited to supine AP chest radiography. These patients are clearly at risk for an OPTX. Although the frequency of OPTXs in penetrating trauma has been estimated to be 5%,¹⁸ these data are extremely limited. Unlike the impressive diagnostic utility of upright chest radiography,²³ supine AP chest radiography is the least sensitive of all plain radiographic techniques for detecting PTX.²⁴⁻²⁶ Scenarios in which supine chest radiography is used for penetrating trauma include concurrent blunt injury with concern for spinal trauma, inability to properly position the patient for upright chest radiography and an error in diagnostic judgment on the part of the clinician.

Our primary goal was to identify the frequency of OPTXs in patients with penetrating trauma. Our secondary goal was to describe the use of tube thoracostomy in these patients.

METHODS

Using the trauma registry, we identified all patients with a penetrating injury admitted over a 10-year period to Grady Memorial Hospital with a PTX. Patients who underwent initial upright or supine AP chest radiography and either a chest and/or abdominal CT scanning were selected. We excluded patients with pre-existing thoracic drainage at the time of arrival and those who did not undergo CT scanning following the initial supine AP chest radiograph. We reviewed the original dictated reports by board-certified radiologists experienced in trauma imaging to determine if the PTX had been identified on the initial supine AP chest radiograph (overt PTX) or whether it was first detected by CT scanning (OPTX).

We obtained data about patient demographics, penetrating injuries and treatment from the trauma registry. These data included patient age, sex, hemodynamic stability at presentation (heart rate, systolic blood pressure and Glasgow coma scale), discharge status (alive or dead), type of CT scan (chest and/or abdomen) and mechanism of injury (stab or gun shot). Outcomes of interest included chest tube placement, length of hospital stay and length of stay in the intensive care unit.

We performed data analyses using Stata version 8.0 (Stata Corp.). Normally or near-normally distributed variables are reported as means. We compared means using the Student *t* test, and we assessed differences in proportions among categorical data using the Fischer exact test. We considered *p* values less than 0.05 to be statistically significant for all comparisons.

RESULTS

In all, 5552 patients with a penetrating injury were admitted by the trauma service over the 10-year study period (hospital stay > 23 h). We audited the records of all 1121 (20%) patients diagnosed with a PTX via a penetrating mechanism. In all, 146 (13%) of these patients had a paired CT scan and chest radiograph. Of these, 127 (87%) underwent upright chest radiography. The remainder (19 patients) underwent supine AP chest radiography. The study group was 91% male (Table 1).

Fifteen (79%) of the PTXs detected on supine AP chest radiographs were occult when interpreted by a board-certified radiologist (Table 2). Only 10 (8%) were occult when an upright chest radiograph was used (*p* < 0.001; Table 2). Pneumothoraces were occult on chest radiographs in 17% (25/146) of patients. Age, sex, mechanism,

mortality, presenting vital signs and length of stay were similar between the overt and occult PTX groups, as well as across the type of imaging (Table 1).

Fourteen (56%) patients with OPTXs via a penetrating mechanism underwent tube thoracostomy (Table 2). Ninety-five percent (115/121) of patients with overt PTXs underwent chest tube insertion ($p < 0.001$). This was consistent across imaging type (Table 2).

DISCUSSION

The aim of this study was to determine the incidence of OPTXs in patients with penetrating trauma. In patients with blunt injuries, the incidence has been reported to be between 3.7% in injured children presenting to an emergency department²⁰ and 64% in intubated, multitrauma patients with an average injury severity score of 30.²¹ Although this range is broad, the overall incidence in most trauma registries is between 1.8% and 6%.^{1,3,11,19} In our study, 17% of all PTXs in patients with penetrating trauma were occult. Whereas the proportion of PTXs that are occult in blunt trauma patients ranges from 29% to 72%,^{1,2,4-7,11,12,14,20,21,24,27,28} this rate typically exceeds 50%.¹⁷ We believe the much lower incidence of OPTXs among patients with penetrating injuries is a direct result of the improved sensitivity and diagnostic utility of upright chest radiography over supine AP radiography. Upright chest radiographs had an OPTX rate of only 8%, whereas 79% of OPTXs were occult on supine AP chest radiographs. This further supports the contention that supine AP chest radiography is not only a poor diagnostic test for detecting PTXs but that is also the least sensitive of all plain radiographic techniques used for this purpose.^{24-26,29}

Clinical equipoise still exists regarding the optimal treatment of various-sized OPTXs.^{3,7,12-16,20,21,24,30-35} Whereas the literature supports the close observation of many OPTXs in nonventilated patients with blunt polytrauma, the actual practice pattern of tube thoracostomy insertion is more complex.¹⁷ Virtually all (95%) penetrating trauma patients with an overt PTX, whether detected in the upright or supine position, underwent chest tube insertion, compared with only 56% of patients with OPTXs. This difference in

insertion choice is consistent with previously published data in blunt polytrauma patients outlining tube thoracostomy rates of 80% and 47% for overt and occult PTXs, respectively.¹⁷ Given that both overt and occult PTXs are statistically similar in size and distribution,²² it is unclear why clinicians tend to insert chest tubes differentially among these 2 groups. This pattern clearly extends beyond blunt injury to penetrating trauma. We suspect that it relates to the antiquated notion that OPTXs “must be smaller” than overt PTXs. The concept of overtreatment is particularly important with tube thoracostomy because it is associated with a 22% rate of major complications.^{1,2,30-32,36,37} It must be restated, however, that the debate surrounding the need for chest tube insertion is intended for patients with stable cardiorespiratory status only. If a seriously injured patient exhibits respiratory distress or has a “large” OPTX, a chest tube should be immediately inserted.

The role of supine AP chest radiography in patients with penetrating trauma is limited. As previously noted, this orientation is inferior for detecting PTXs compared with the upright orientation.²³ Eighty-seven percent of all chest radiographs in our patient cohort were performed in the erect position. A minority of patients (13%) underwent supine AP chest radiography in a few limited scenarios. These included the inability of a patient to tolerate the upright position, concurrent blunt injury with concern for spinal trauma and failure to select the appropriate orientation on the part of the clinician. The poor test performance of supine AP chest radiography reiterates the importance of positioning the patient in the erect position for radiography after any penetrating trauma where spinal precautions are not necessary. Although the vast majority of OPTXs occurred with supine imaging, 8% were still occult on upright chest radiographs. This highlights the limitations and imperfections in all plain radiographic techniques. It also supports the notion that, if it is absolutely essential to rule out a PTX, CT imaging is the gold standard.

Another diagnostic option for detecting PTXs, based on its impressive test characteristics, is bedside ultrasonography. Because OPTXs are typically located in the anterior thorax,²² the apical pleural line that most nonradiologists use to identify a PTX on an upright chest radiograph is absent.^{38,39} This deficit is contrasted by the 98% and 99%

Table 1. Patient characteristics by type of pneumothorax

Characteristic	Overt PTX, <i>n</i> = 121	Occult PTX, <i>n</i> = 25
Mean age, yr	30.9	29.4
Male sex, no. of patients	111	22
Mechanism, no. of patients		
Gun shot	73	16
Stab	48	9
Length of hospital stay, mean, d	7.5	7.9
Length of ICU stay, mean, d	2.8	3.3

ICU = intensive care unit; PTX = pneumothorax.

Table 2. Treatment by type of imaging and pneumothorax

No. (%) of patients	Upright chest radiograph, <i>n</i> = 127		Supine chest radiograph, <i>n</i> = 19	
	Overt PTX	Occult PTX	Overt PTX	Occult PTX
Total	117 (92)	10 (8)	4 (21)	15 (79)
Received tube thoracostomy	111 (95)	6 (60)	4 (100)	8 (53)

PTX = pneumothorax.

sensitivity and specificity, respectively, for diagnosing PTXs by thoracic ultrasonography.⁴⁰ At our centres, both upright chest radiographs and bedside thoracic ultrasonography are used for all patients.

This study has several limitations. First, it is retrospective and, therefore, the possibility of bias cannot be eliminated. Second, although most patients (83%) underwent chest CT scanning, some imaging was limited to the abdomen only. This restricts investigation of the upper lung fields. In light of the evidence that up to 12% of blunt-injured patients with OPTXs are diagnosed based solely on selected images from thoracic CT, we cannot exclude that some OPTXs may have been missed.²²

In summary, up to 17% of all PTXs in patients injured by a penetrating mechanism may be missed by standard trauma chest radiography. This may increase to nearly 80% when supine AP chest radiography is used. Fortunately, upright chest radiography, which detected 92% of all PTXs, is available to most patients without spinal trauma. The frequency of tube thoracostomy use in patients with overt PTXs is significantly higher than for OPTXs in blunt trauma, as well as in penetrating trauma.

Competing interests: None declared.

Contributors: Drs. Ball, Dente, Rajani, Wyrzykowski, Vercruyse, Rozycki, Nicholas, Salomone and Feliciano and Mr. Shah helped design the study. Drs. Ball and Rajani and Mr. Shah acquired the data, which Drs. Ball, Dente, Kirkpatrick, Rajani and Feliciano analyzed. Drs. Ball and Rajani and Mr. Shah wrote the article, which Drs. Ball, Dente, Kirkpatrick, Rajani, Wyrzykowski, Vercruyse, Rozycki, Nicholas, Salomone and Feliciano reviewed. All authors approved the version submitted for publication.

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