



Original article

The utility of serial chest X-rays for detection of delayed pneumothorax, haemothorax or haemopneumothorax following penetrating thoracic injury

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ABSTRACT

Introduction: Penetrating thoracic injuries are a common presentation in Emergency Departments in South Africa with pneumothorax, haemothorax and haemopneumothorax (PTX/HTX/HPTX) a cause of morbidity and mortality. Serial chest X-rays (CXRs) are used to assess patients with penetrating thoracic injury without PTX/HTX/HPTX on initial CXR in order to increase sensitivity and thus detection of PTX/HTX/HPTX. This study aimed to assess the utility of serial CXRs to detect a delayed presentation of PTX/HTX/HPTX following penetrating thoracic injury.

Methods: This retrospective observational study analysed data from Helen Joseph Hospital Emergency Department, Johannesburg, South Africa for patients presenting with penetrating thoracic injury over a 2-year period for whom the initial CXR was negative for a PTX/HTX/HPTX to determine the utility of serial CXRs for detection of a delayed presentation of PTX/HTX/HPTX.

Results: 118 patients, the majority of which had penetrating trauma secondary to a stab wound, were included in the study. Eight (7%) had a PTX/HTX/HPTX detected on subsequent investigation. Three (3%) patients with normal initial CXRs and three (3%) patients with abnormal initial CXRs had a PTX/HTX/HPTX detected on serial CXRs. Two (2%) delayed presentations of PTX/HTX/HPTX were noted on computerised tomography (CT) scan only. Six patients had an intercostal drain (ICD) inserted and were admitted; 2 patients (those with PTX/HTX/HPTX noted on CT only) were managed conservatively. Three patients (3%) had an ICD inserted to manage a delayed presentation of PTX/HTX/HPTX with a normal initial CXR.

Discussion: Only 3% of patients with normal initial CXRs required intervention.

Conclusions: It is recommended that patients for whom the presentation CXR shows an abnormality undergo serial CXRs. Given the low incidence of PTX/HTX/HPTX in patients with a normal presentation CXR, along with the resource implications of serial CXRs, it may be prudent to discharge patients with thorough counselling and advice to return for review if warranted.

African relevance

- Penetrating injuries to the thorax are a common presentation in Emergency Departments in South Africa with pneumothorax, haemothorax and haemopneumothorax (PTX/HTX/HPTX) a cause of morbidity and mortality.
- There is no uniformity of practice within South Africa regarding whether penetrating injuries to the thorax with a chest X-ray (CXR) initially negative for PTX/HTX/HPTX require serial CXRs.
- In a resource limited setting, serial CXRs incur both financial costs and contribute to Emergency Department overcrowding.
- This study describes the utility of serial CXRs with consideration to a cost-benefit analysis in a resource limited African setting.

Background

Penetrating injuries to the thorax are a common presentation in Emergency Departments (EDs) in South Africa. Stab wounds were the major mechanism of penetrating trauma in the 1970s and 1980s, however there was a shift in the mid 1980s, continuing into the 1990s, to gunshot wounds (GSWs) as the major mechanism of penetrating trauma. In recent years GSWs have declined with a resurgence of stab wounds as the major mechanism of penetrating trauma, despite an increase of violent crime [1].

Pneumothorax, haemothorax and haemopneumothorax (PTX/HTX/HPTX) are a cause of morbidity and mortality following penetrating injuries to the thorax. Numerous studies have noted that the supine

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chest X-ray (CXR) is an insensitive test for the detection of posttraumatic pneumothorax [2–4]. Computerised Tomography (CT) is more sensitive than conventional chest radiography for detection of pneumothorax, however CT is not routinely used for the detection of a pneumothorax in the acute trauma situation [3]. Certainly, in a low-middle income country such as South Africa, routine thoracic CT would not be financially prudent.

Studies have shown that the diagnostic accuracy from point of care chest ultrasonography, typically as part of the extended focused sonography in trauma (EFAST) examination, for PTX/HTX/HPTX is significantly higher than that from CXR [4]. However, diagnostic yield of the EFAST examination for PTX/HTX/HPTX in the setting of trauma is dependent on operator training and expertise. The Emergency Medicine Society of South Africa maintains a reference list of practitioners who are level 1 ultrasound accredited (accredited to perform the EFAST examination). This list currently notes that approximately 200 practitioners throughout South Africa are level 1 ultrasound accredited in total. Whilst this list may not be comprehensive, it does suggest that the number of practitioners within South Africa is limited [5].

Serial CXRs are used to assess patients with penetrating injury to the thorax without PTX/HTX/HPTX on initial CXR in many EDs within South Africa, in order to increase sensitivity and thus detection of either occult or delayed PTX/HTX/HPTX. The suggested time interval for performing serial CXRs is variable in the existing literature, ranging from 3 to 48 h [6]. It is anticipated that the practice of performing serial CXRs in the Emergency Department may prolong the assessment and management of patients with penetrating injury to the thorax without PTX/HTX/HPTX thus potentially delaying a disposition decision and contributing to Emergency Department overcrowding. The practice of performing serial CXRs is not uniform amongst all EDs within South Africa, with some EDs making a disposition decision on a single CXR following penetrating chest trauma.

This study aimed to assess the value of serial CXRs in the ED to detect a delayed presentation of PTX/HTX/HPTX following penetrating injury to the thorax at an urban, tertiary level hospital ED. We aimed to describe the demographics of patients presenting to a tertiary urban hospital with penetrating thoracic trauma and a CXR that is negative for PTX/HTX/HPTX on presentation. We described the time interval between penetrating injury and initial presentation to the emergency department for these patients and assessed the incidence of delayed PTX/HTX/HPTX resulting from penetrating injuries to the thorax detected by serial CXRs. In addition, we described the initial CXR in those patients found to have a delayed PTX/HTX/HPTX to assess for any radiographic abnormalities that may have been present other than PTX/HTX/HPTX on the initial CXR. We described the management of those patients with delayed PTX/HTX/HPTX.

Methods

Our study analysed data from Helen Joseph Hospital ED, a government public hospital within Johannesburg, Gauteng, South Africa that provides tertiary health care services to an urban population of approximately 1 million people [7]. Retrospective data were collected from 01-11-2017 to 31-10-2019 inclusive. The ED of Helen Joseph Hospital attends to approximately 60,000 patients annually, of which the vast majority are adults. The ED is responsible for the assessment of

all major injuries presenting to the hospital including all penetrating thoracic trauma.

This retrospective observational study interrogated the clinical files for patients presenting with penetrating thoracic trauma over a 2-year period to review whether an initial CXR was performed and whether a PTX/HTX/HPTX was detected on presentation. Those patients for whom the initial CXR was negative for a PTX/HTX/HPTX were included in the study sample. Patients whose records were not available for review and paediatric patients (age < 18 years) were excluded.

Data extracted included age, gender, mechanism of injury, time from injury to presentation at the ED and first CXR, time from first CXR to repeat (or serial) CXR, findings on initial and repeat (or serial) CXR as assessed by both the attending doctor and reviewed by a qualified Emergency Medicine Consultant, management and disposition. Statistical analysis was performed using SPSS V25 (Statistical Packages for the Social Sciences) IBM®.

Ethics approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (Medical), Clearance Certificate No M191136.

Results

A total of 118 patients were included in the study. Their demographics were as follows: 110 (93%) were male and 8 (7%) were female. The median age was 28 (interquartile range IQR 24–36).

The majority of patients sustained penetrating thoracic trauma secondary to stab wounds (117 99%), with only one patient presenting with penetrating injury secondary to falling onto sharp rocks.

The median time from initial injury to presentation at the ED and first CXR was 143 min (IQR 90–210 min). The median time from first CXR to repeat CXR was 330 min (IQR 255–370.5 min). No patients were noted to have had deterioration of clinical symptoms necessitating urgent repeat CXR outside of standard hospital protocol.

CXRs were interpreted by the attending doctor in the Emergency Department and reviewed by a qualified Emergency Medicine Consultant. As is standard practice in many government, public hospitals in South Africa, no formal report was sought from the radiology department for CXRs. Thoracic CT scans were reviewed by a qualified Radiology Consultant.

Of the 118 patients, 8 (7%) had a PTX/HTX/HPTX on a subsequent investigation. A delayed presentation of PTX/HTX/HPTX were noted for 6 (5%) patients on serial CXR whereas 2 (2%) were noted on thoracic CT which was undertaken as an investigation for vascular injury due to proximity of the penetrating injury to great vessels.

Three patients had abnormal initial CXRs but no PTX/HTX or HPTX noted. The findings are documented in Table 1.

Five patients had a delayed presentation of PTX/HTX/HPTX with an initial CXR that was completely within normal limits. Of these, 3 delayed presentations of PTX/HTX/HPTX were detected by serial CXR with 2 only detectable on thoracic CT and not noted on serial CXR. Only 3 patients with normal initial CXRs developed PTX/HTX/HPTX on subsequent CXRs.

The difference in the time between injury to presentation for patients without PTX/HTX/HPTX on subsequent CXR (median = 135 min, IQR = 114.8 min) and patients with PTX/HTX/HPTX on subsequent imaging, be that CXR or thoracic CT,

Table 1
Initial and serial CXR findings of CXRs for which initial CXR was not within normal limits.

Patient	1	2	3
Age	41	43	74
Gender	Male	Male	Male
Mechanism of Injury	Stab	Stab	Fall onto sharp rocks
Initial CXR findings	Right sided blunting costophrenic angle	Left sided surgical emphysema	Left sided increased opacification and slight blunting costophrenic angle
Serial CXR findings	Right sided haemothorax	Left sided pneumothorax	Left sided haemothorax

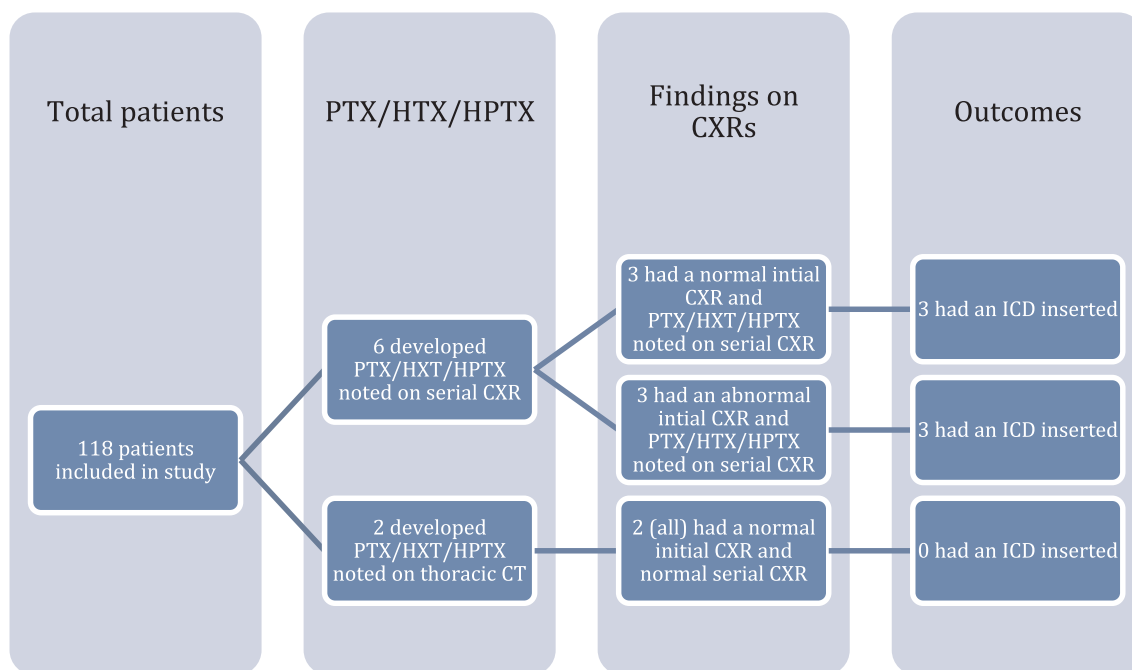


Fig. 1. Summary of pertinent study findings.

(median = 100 min, IQR 90.0 min) was not statistically significant ($U = 313.0, p = 0.17$).

Eight patients had a delayed presentation of PTX/HTX/HPTX. Six had an intercostal drain (ICD) inserted in the ED and were admitted, whereas 2 were managed conservatively without insertion of an ICD, with admission and observation. The patients who were managed conservatively had both their initial CXR and serial CXR documented as displaying no evidence of a PTX/HTX/HPTX; as they were detectable only on thoracic CT imaging.

Three patients (3%) had an ICD inserted to manage a delayed presentation of PTX/HTX/HPTX with an initial CXR that was within normal limits (Fig. 1).

Discussion

Trauma is a major public health concern in South Africa with interpersonal violence in young adult males a major contributor to this trauma burden in our study. Penetrating thoracic injury secondary to stabbing was the main form of trauma in our study. This high proportion of stabbing injuries is likely multifactorial. It is anticipated that GSWs would result in significant breach of the pleura with resultant PTX/HTX/HPTX noted on initial CXR whereas low velocity penetrating thoracic injury, such as secondary to stabbing, is more likely to result in subtle, difficult to detect or delayed presentations of PTX/HTX/HPTX.

The time from injury to presentation was 143 min (IQR 90–210 min). This variation in time from injury to presentation is thought to be related to both the drainage area of the hospital and the varied means by which patients access the hospital. Helen Joseph Hospital drains regions of the City of Johannesburg Metropolitan Municipality extending up to 40 km from the hospital. Thus, patients often travel considerable distances in order to access health care at Helen Joseph Hospital and do so via a variety of means including provincial and private ambulance services, private vehicles or public transport.

There was no statistically significant difference with reference to time from injury to presentation for patients without PTX/HTX/HPTX on subsequent CXR and patients with PTX/HTX/HPTX on subsequent imaging. This excluded the hypothesis that patients with a delayed presentation of PTX/HTX/HPTX may have presented to the ED too

expeditiously following their injury for a PTX/HPTX/HPTX to be detectable on initial CXR.

Time from initial CXR to repeat CXR was 330 min (IQR 255–370.5 min). The current protocol within the Helen Joseph Hospital ED is that a patient with penetrating thoracic trauma for whom the initial CXR is negative for PTX/HTX/HPTX should receive a repeat CXR after 6 h, which was reflected by these data.

The incidence of delayed presentation of PTX/HTX/HPTX was 7% (8/118). Only 3% of patients with normal initial CXRs required intervention. This reflects the findings of other international studies that demonstrated an incidence rate for delayed presentation of PTX/HTX/HPTX varying between 2.5 and 12% [6,8–11] at either 3 hour or 6 hour post initial CXR depending on local protocols. It is of note that all of these previous studies have had similar sample sizes ranging from 100 to 131, which again is comparable to our study with a sample size of 118. Of these previous studies, only 1 has been undertaken in a low-middle-income country (Columbia, South America) showing an incidence rate of delayed presentation of PTX/HTX/HPTX of 11% at 6 hour follow up. The Colombian study noted that 6% of patients with initially negative CXRs for pneumothorax or haemothorax required an intervention following subsequent CXRs [10].

A recent study by Moodley et al. assessed the cost of a CXR using either a picture archiving and communications system (PACS system) or conventional radiography in two private hospitals in South Africa and found the cost of a CXR to be approximately R84 and R60 per CXR respectively [12]. There are no comparative studies of the cost of a CXR in the public sector in South Africa.

A recent study published in the South African Health Review by Day et al. from 2013 [13] has shown that the cost per patient day equivalent for admission to hospital to be approximately R2237 based on the most recent public sector data in 2010/2011. Whilst we acknowledge that the patients in our study are not admitted and managed as in-patients, their stay in the ED of 6 h is not without incurring financial costs. Possibly more concerning is the contribution of the prolonged assessment and management of these patients within the ED to ED overcrowding, exceeding the physical and/or staffing capacity of the department. Overcrowding in the ED impedes the functioning of the ED and constitutes one of the greatest threats to quality emergency care as it is associated with increased risk of errors, delayed time-critical care,

increased morbidity and excess deaths [14]. Improved throughput within the ED, by limiting patients that require prolonged assessment and management whilst in the department, would do much to alleviate this strain.

A reasonable approach, in a low-middle income setting, may be to subject patients to serial CXRs if the original presentation CXR showed an abnormality, despite not requiring intervention, as all of the patients in this group in our study subsequently underwent ICD insertion. Due to the low incidence of delayed presentation of PTX/HTX/PHTX in patients with a normal initial CXR, it may be prudent to discharge patients with thorough counselling and advice to return for review if warranted.

This study was limited by the accuracy of the storage and maintenance of clinical files in order to review clinical notes at hospital records. Data required for the study may not have been present in the files.

Conclusions

PTX/HTX/HPTX are major complications and a cause of morbidity and mortality following penetrating injuries to the thorax. Numerous studies have noted that the supine CXR is an insensitive test for the detection of posttraumatic pneumothorax and thus serial CXRs are used to assess patients with penetrating injury to the thorax without PTX/HTX/HPTX on initial CXR in many EDs within South Africa. Our study demonstrated an incidence rate of 3% for delayed presentation of PTX/HTX/HPTX in patients with a normal presentation CXR, that subsequently required intervention within the ED.

In a low-middle income setting, it would be reasonable to recommend that patients for whom the presentation CXR shows an abnormality undergo serial CXRs. Given the low incidence of new PTX/HTX/HPTX in patients with a normal presentation CXR, along with the resource implications of serial CXRs, it would be reasonable to make a disposition decision to discharge these patients on the basis of a single CXR following thorough counselling and advice to return for review if warranted.

It is noted, however, that the majority of the patients included in our study sustained penetrating injury secondary to a stab wound and thus our findings may not have validity should penetrating injury occur secondary to an alternative mechanism. This observation may warrant further investigation.

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Declaration of competing interest

The authors declare no conflicts of interest.

Dissemination of results

Results from this study were shared with staff members at the data collection site through an informal presentation.

Authors' contributions

Authors contributed as follow to the conception and design of the work; the acquisition, analysis and interpretation of the data for the work; and drafting the work and revising it critically for important intellectual content: CL contributed 70% and DLS contributed 30%. Both authors approved the version to be published and agreed to be accountable for all aspects of the work.

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