

Open pneumothorax: the spectrum and outcome of management based on Advanced Trauma Life Support recommendations

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Abstract

Introduction The current management of open pneumothorax (OPTX) is based on Advanced Trauma Life Support (ATLS) recommendations and consists of the application of a three-way occlusive dressing, followed by intercostal chest drain insertion. Very little is known regarding the spectrum and outcome of this approach, especially in the civilian setting.

Materials and methods We conducted a retrospective review of 58 consecutive patients with OPTX over a four-year period managed in a high volume metropolitan trauma service in South Africa.

Results Of the 58 patients included, 95 % (55/58) were male, and the mean age for all patients was 21 years. Ninety-seven percent of all injuries were inflicted by knives and the remaining 3 % (2/58) of injuries were inflicted by unknown weapons. 59 % of injuries were left sided. In six patients (10 %) a protocol violation was present in their management. Five of the six patients (83 %) in whom protocol violation occurred developed a life-threatening event

(tension PTX) compared to none amongst those where the protocol was followed ($p < 0.001$). There was no mortality as a direct result of management of OPTX following ATLS recommendations.

Conclusions ATLS recommendations for OPTX are safe and effective. Any deviation from this standard practice is associated with avoidable morbidity and potential mortality.

Keywords Open pneumothorax · Penetrating injuries · Management

Introduction

Traumatic pneumothoraces (PTXs) are common, and they are estimated to be present in up to 30 % of all patients with thoracic trauma [1]. Open pneumothoraces (OPTX) refer to a specific subgroup of traumatic pneumothoraces that are commonly referred to as "sucking chest wounds" [2]. Typically a chest wall defect is present which directly communicates with the parietal pleura. This leads to ventilatory insufficiency and rapid respiratory decompensation [3, 4]. The initial management recommended by Advanced Trauma Life Support (ATLS) is a 'three-way' occlusive dressing to achieve a 'flutter-valve' mechanism to prevent further respiratory compromise [3]. This should then be followed by intercostal chest drain (ICD) insertion, and repair of the chest wall defect [3]. While the recommendations from ATLS are well known, there is a relative paucity of the literature on this topic in the civilian setting. The objective of this study was to describe the spectrum of OPTX managed at a high volume metropolitan trauma service in South Africa.

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Materials and methods

This was a retrospective study undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. Our prospectively maintained regional trauma registry was retrospectively reviewed over a period of 4 years from January 2010 to December 2013. Ethics approval for the maintenance of the registry was granted by the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu Natal. The ethics reference number is BE 207/09. The PMTS provides definitive trauma care for the western part of the KwaZulu Natal province. Its catchment area includes the city of Pietermaritzburg and the surrounding rural areas, with a combined catchment population of over three million people. It also serves as the definitive trauma referral service for 19 other district hospitals within the province. A high volume of penetrating trauma is managed by our service, which is a direct reflection of the high incidence of interpersonal violence and crime experienced throughout the region.

Our unit policy for the management of OPTX follows the recommendations from ATLS. All patients who sustain thoracic trauma are initially assessed by the duty trauma residents, under the supervision of a group of specialist trauma surgeons. Decision making is based heavily on clinical criteria. Patients with OPTX are immediately treated with an occlusive dressing, taped on three sides to the chest wall to create a 'flutter-valve' mechanism that allows the maintenance of ventilation. As there is a theoretical risk of subsequent development of tension pneumothorax following sealing of the chest wall defect, we routinely insert an ICD immediately following application of the occlusive dressing without obtaining a chest radiograph (CXR). A CXR is only taken after an ICD is inserted. All ICDs are inserted under local anaesthesia in the fifth intercostal space with an aseptic technique in accordance with ATLS recommendations. ICD insertion is performed via a separate incision and not through the same chest wall defect. Once the patient is stabilised, wound exploration is performed and the chest wall defect is sutured close. All patients with OPTX are admitted to a designated trauma ward for on-going clinical observation.

Data collection for this study included the following: basic demographics, mechanism of injury and side of injury. These data were extracted from the registry onto a Microsoft EXCEL[®] spread sheet for processing. Detailed information was sought on the adherence to protocol and the clinical outcome from the management instituted. The specific association between protocol violation and whether a life-threatening event (e.g. tension PTX) occurred was tested statistically using the Fisher's exact test. This was performed using Stata 12.0 SE. (StataCorp, Stata Statistical Software: Release 13. College Station, TX: StataCorp LP, 2013).

Results

Demographics

During the 4-year study period, a total of 992 patients with penetrating thoracic trauma were managed by the PMTS. Fifty-eight (6 %) of these patients had a clinically apparent OPTX and were included in this study. Ninety-five percent were males and the mean age for all patients was 21 years.

Pattern of injury

All 58 patients sustained an OPTX as a result of stab injuries by sharp objects. Of these, 97 % (56/58) were inflicted by knives and the remaining 3 % (2/58) by an unknown weapon. Eighty-three percent (48/58) of all patients sustained a single stab injury, and the remaining 17 % (10/58) sustained multiple stab injuries. Fifty-nine percent (34/58) of injuries were left sided, and 41 % were right sided.

Protocol violations

In six patients (10 %) a protocol violation occurred. Three of these patients had their wounds sutured and were then sent for CXRs. They subsequently developed massive subcutaneous emphysema and a tension PTX, which required needle decompression and ICD insertions. All three of these patients survived. Two patients had occlusive dressings incorrectly applied (non-ventilating where all sides were sealed, with further compression bandaging circumferentially across the chest). One of these patients was sent for CXR and developed severe respiratory distress thought to be due to tension PTX and had needle decompression in the radiology suite. The remaining patient also developed severe respiratory distress and had an ICD inserted immediately without further imaging. A single patient had an ICD inserted thorough the stab wound, this was promptly removed and a new ICD was inserted at another site. He did not develop any infection-related complications. Table 1 summarises the protocol violations in all six patients and their respective outcome.

Morbidity and mortality

Five patients developed superficial wound sepsis and required intravenous antibiotics. The protocols were followed in these five patients. Five of the six patients (83 %) in whom protocol violation occurred developed a life-threatening event (tension PTX) compared to none amongst those in whom the protocol was followed. This finding was highly statistically significant (Fisher's exact, $p < 0.001$).

Table 1 Outcomes of patients in which protocol violation occurred

Age	Gender	Side	Protocol violation	Progress	Outcome
30	M	L	Wound sutured, no ICD	Tension PTX	Survived
21	M	L	Wound sutured, no ICD	Tension PTX	Survived
28	M	L	Wound sutured, no ICD	Tension PTX	Survived
23	M	R	Incorrect occlusive dressing, no ICD	Tension PTX	Survived
24	M	L	Incorrect occlusive dressing, no ICD	Tension PTX	Survived
36	M	L	ICD inserted through same hole	Delayed recognition	Survived

Table 2 The association between protocol violation and development of life-threatening events

	Life-threatening event	No life-threatening event	Total	<i>p</i> value ⁱ
Protocol followed (%)	0 (0)	52 (100)	52	<0.001
Protocol not followed (%)	5 (83)	1 (17)	6	

ⁱ Fisher's exact test

Table 2 summarises the association between protocol violation and the development of life-threatening event.

There was no mortality in our series.

Discussions

Thoracic trauma is common and pneumothoraces (PTXs) are estimated to be present in up to 40 % of all patients with major thoracic trauma [1, 5]. The true incidence of OPTX is unknown, but it is likely to be relatively less common than other forms of trauma related thoracic pathology such as simple PTX or haemothorax [2, 5, 6]. Most literature to date is confined to the military setting and very little is known about the entity in the civilian population [4]. An OPTX occurs when injury to the chest wall results in a direct communication with the parietal pleura [3, 4, 7]. Following the equilibration of atmospheric and intra-pleural pressure, air will continue to flow along the path of least resistance. If the size of the chest wall defect is over two-third of the diameter of the trachea, air will preferentially pass through the chest wall defect. With each breathe, this process will eventually lead to rapid deterioration of ventilation and severe respiratory compromise [3, 8].

Despite OPTX being a potentially fatal condition that requires careful early management, there is surprisingly little literature on this topic. West et al. [9] in 1939 reported a 33 % overall mortality in patients with OPTX. In a recent review on general thoracic trauma, Dubose et al. [10] noted that the early description of the management of OPTX during World War I was of 'primary closure', without any specific discussion of the need for thoracic drainage. Even after World War II, reports continued to focus on closure of the chest wall defect, rather than the treatment and outcome following closure [11]. Snyder et al. [12] were amongst the

first to report the development of life-threatening tension PTX following closure of chest wound in OPTX. Haynes also emphasised the potentially fatal hazard of converting OPTX to a tension PTX. [13]. While there have been many suggestions regarding the best method of initial management of OPTX [4], there is relatively little evidence supporting the effectiveness of these algorithms. Opinion continues to differ regarding the appropriateness of occlusive dressing [13], the type of dressing (ventilating or non-ventilating type) [14], or whether specific commercially available types are more effective [15]. In an animal study by Ruiz et al. [16], it was suggested that dressings with either total occlusion or flutter-valve occlusion achieved the same outcome. Most authors, however, recommend the use of a 'three-way' occlusive dressing [3, 4, 16, 17]. ATLS continues to recommend that the immediate management should be the application of an occlusive dressing, tapped on three sides to create a 'flutter-valve'-like mechanism [3]. It also suggests that an ICD should then be inserted followed by repair of the chest wall defect [3]. This emphasises the importance of accurate clinical examination prior to obtaining a CXR [18]. Inappropriately applied occlusive dressings appear to be as dangerous as inaccurate clinical examination. ATLS has formed the basis of trauma training over the past three decades worldwide, and our study emphasises that when the ATLS protocol is followed, all patients could be successfully managed with simple ICD insertion. In cases of protocol violation, significant morbidity was encountered.

Conclusions

OPTX is a potentially fatal condition and current management recommended by ATLS should continue to be based

on accurate clinical diagnosis, early use of a ‘three-way’ occlusive dressing, followed by ICD insertion. Deviation from this standard practice is associated with potentially avoidable morbidity and even mortality.

Conflict of interest V. Y. Kong, M. Liu, B. Sartorius, and D. L. Clarke declare that there are no conflicts of interest. There are no financial and personal relationships with other people or organisations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and Grants or other funding.

Ethical standards I, Victor Kong, the corresponding author, confirm that this study was formally approved by the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu Natal (UKZN), The study’s ethical approval reference number is BE 207/09. All parts of the study conform to the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. It was a retrospective study and all data were anonymised prior to inclusion, and no patient-identifiable information was used.

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