Traumatic pneumothorax: a review of current practices

Traumatic pneumothoraces are a common presentation to any emergency department. This article explores the evidence behind thoracostomy drain insertion, and the necessity for the procedure on all patients.

Trauma is the leading cause of death in patients under 40 years of age and the third commonest cause of death worldwide (Shorr et al, 1987; Chan and Hiorns, 1996). Current estimates of thoracic trauma suggest an incidence of 12 persons per million of population per day (Fitzgerald et al, 2008). This amounts to some 10–15% of all traumas; and they are significant contributors to death (Lee et al, 2007). Indeed they are the cause of death in 25% of all fatalities caused by trauma (Shorr et al, 1987; Sirmali et al, 2003; Rezende-Neto et al, 2010), and a major contributor in 50% (Baumann and Noppen, 2004; Fitzgerald et al, 2008).

In the UK trauma management has been described as being poor and at least 30% of polytrauma patient deaths are thought to be preventable (Anderson et al, 1988; Chan and Hiorns, 1996).

Chest injuries themselves occur in 60% of all polytraumatised patients and are 2–3 times as common as intra-abdominal visceral injuries (Chan and Hiorns, 1996). These injuries are associated with a high morbidity rate of 36% and a mortality rate of 15–25% (Shorr et al, 1987; Stafford et al, 2006).

About 70% of thoracic traumas are blunt and the remaining are penetrating injuries (Sirmali et al, 2003; Fitzgerald et al, 2008). Blunt chest injuries are more common mainly because of the increasing incidence of motor vehicle accidents (Shorr et al, 1987; Liman et al, 2003; Fitzgerald et al, 2008).

Definition

The pathophysiology of pneumothorax was described in 1747 by Combulsier, who recognized that the decrease in pulmonary function was a result of lung compression caused by air in the pleural space (Sadikot et al, 1997). Itard first coined the term pneumothorax in 1803, and Laennec described the clinical features in 1819 (Sadikot et al, 1997). Pneumothorax is most simply defined as the presence of air in the pleural space (Noppen and De Keukeleire, 2008).

Annually, more than 50 000 trauma-related pneumothoraces occur in the USA (Baumann and Noppen, 2004). Pneumothorax ranks second only to rib fracture as the most common sign of chest injury (Enderson et al, 1993; Wolfman et al, 1998; Baumann and Noppen, 2004) and can be seen in 30–39% of chest trauma patients (Shorr et al, 1987; Cai et al, 2009).

Insertion of intercostal tube drainage is an effective treatment (Huber-Wagner et al, 2007).

Problems with drains

Percutaneous tube thoracostomy remains the most widely performed procedure to manage blunt and penetrating chest trauma (Deneuville, 2002), and is often a life-saving manoeuvre (Mattox and Allen, 1986; Aylwin et al, 2008). Prospectively gathered trauma registry data have reported that tube thoracostomy is required in 25% of patients presenting with major trauma (Heng et al, 2004; Fitzgerald et al, 2008). However, although generally considered a simple, minor procedure, it is often performed sub-optimally and placing of a chest tube is associated with numerous complications (Helling et al, 1989; Martino et al, 1999; Bailey, 2000; Deneuville, 2002; Heng et al, 2004).

Other sources report that fewer than 10% of blunt chest injuries and 15–30% of penetrating chest injuries require thoracotomy (Bailey, 2000). Thus recently, the need for chest drain insertion for a proportion of traumatic pneumothoraces has been challenged (Johnson, 1996; Bailey, 2000). The justification for this proposed change is the high morbidity and complication rate associated with tube thoracostomy (Helling et al, 1989; Chan et al, 1997; Bailey, 2000; Deneuville, 2002; Fitzgerald et al, 2008).

Infection rates, including empyema, of up to 25% have been reported in the literature (Helling et al, 1989; Chan et al, 1997; Rashid and Acker, 1998), and an overall complication rate as high as 36% has been reported in trauma patients (Helling et al, 1989; Deneuville, 2002; Stafford et al, 2006; Huber-Wagner et al, 2007; Fitzgerald et al, 2008). For the puncture in the mid-axillary line some rare complications are reported in case reports (Waydhas and Sauerland, 2007): laceration of intercostal arteries (Carney and Ravin, 1979), perforation of the lung (Fraser, 1988), perforation of the right atrium (Casillas and de la Fuente, 1983), perforation of the right (Rashid and Acker, 1998) and left ventricle (de la Fuente et al, 1994), obstruction of the subclavian artery (Moskal et al, 1997), Horner's syndrome (Campbell et al, 1989), intra-abdominal placement (Foresti et al, 1992), intra-

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hepatic placement (Rashid and Acker, 1998), intra-bowel placement (Zieren et al, 1999), laceration of the subclavian vein and perforation of the inferior vena cava (Eriksson, 1982). After insertion of chest tubes in the mid-clavicular line an arteriovenous fistula (Cox et al, 1967) and myocardial perforation (Dominguez et al, 1995) have been reported. Furthermore, perforation of the oesophagus (Resnick 1993), of the mediastinum (Rashid et al, 1998) with contralateral pneumothorax (Bailey, 2000), perforation of a major artery (van Kralingen et al, 1991) and injury to the phrenic nerve are known (Waydhas and Sauerland, 2007). There are also reports of sudden death secondary to vagus nerve irritation (Ward and Hughes, 1994) and necrotizing fasciitis (Chen et al, 1992).

The most frequent complication encountered, however, is that of recurrent pneumothorax following tube thoracostomy removal, occurring in 24% of patients with blunt trauma (Helling et al, 1989).

The majority of trauma patients requiring chest decompression have it performed during the initial phase of reception at the receiving hospital (Heng et al, 2004; Fitzgerald et al, 2008). The literature reports that tube thoracostomies performed in the emergency department are often done under hurried, unexpected and less controlled circumstances, and therefore the rate of subsequent pleural infection and other complications may be increased (Chan et al, 1997).

One study found that 31% of chest tubes placed in the emergency department were positioned suboptimally and 17% required repositioning (Aylwin et al, 2008).

Need for a drain

There are currently no recognized local, regional, national or international guidelines regarding the management of traumatic pneumothoraces (Baumann and Noppen, 2004). The only advice available is that of Advanced Trauma Life Support (American College of Surgeons, 2012) which states that: 'Any pneumothorax is best treated with a chest tube', but then proceeds to state that: 'Observation and aspiration of an asymptomatic [simple] pneumothorax may be appropriate'. These recommendations are therefore not definitive, and ultimately leave the decision in the hands of the treating physician.

From the literature it is clear that most surgeons and emergency physicians will place a chest tube in traumatic pneumothoraces (Enderson et al, 1993; Johnson, 1996). However, it is also becoming apparent that chest tube placement may not be required in all traumatic pneumothoraces (Knottenbelt and van der Spuy, 1990; Collins et al, 1992; Enderson et al, 1993; Johnson, 1996; Baumann and Noppen, 2004). Studies suggest that carefully selected patients may be treated conservatively ultimately requiring chest tube placement in only about 10% of cases (Knottenbelt and van der Spuy, 1990; Enderson et al, 1993; Johnson, 1996; Baumann and Noppen, 2004; Noppen and De Keukeleire, 2008).

Discussion

Blunt chest injuries are seen very frequently, the major reasons for this being traffic accidents with an incidence of 70–80% (Liman et al, 2003). The mortality rate varies between 15 and 25% in different studies and usually occurs within 24 hours of the trauma (Ceran et al, 2002).

The rationale for using tube thoracostomy in the treatment of many chest injuries is well established (Bailey, 2000). It is a potentially life-saving procedure and offers definitive treatment for most penetrating wounds to the chest. In particular Advanced Trauma Life Support recommends that all traumatic pneumothoraces be treated by tube thoracostomy on the basis that any simple pneumothorax left untreated could convert into a life-threatening tension pneumothorax (Bailey, 2000).

Although tube thoracostomy is often thought to be a 'simple' treatment and may be delegated to less experienced doctors, previous studies have shown a significant morbidity associated with this procedure (Johnson, 1996; Bailey, 2000). The overall mortality rate attributable to tube thoracostomy failure ranges from 0.4 to 3.4% (Helling et al, 1989; Deneuville, 2002).

Percutaneous tube thoracostomy also carries a significant morbidity related to both iatrogenic injuries and a 25% failure rate unrelated to technical errors. Those failures comprise mainly post-removal air leaks (Helling et al, 1989; Martino et al, 1999; Deneuville, 2002), residual fluid collection (Helling et al, 1989; Deneuville, 2002) and empyema (Helling et al, 1989; Deneuville, 2002). Other well-known complications include recurrent or residual pneumothorax, and incorrect placement (range of 11–30%) (Chan et al, 1997; Huber-Wagner et al, 2007). In one study, these resulted in a two-fold increased median length of stay (Deneuville, 2002). The literature states that the risk may be increased in procedures done under urgent or emergent conditions commonly found in the emergency department (Chan et al, 1997).

Owing to these complications the need for tube thoracostomy for small or moderate sized traumatic pneumothoraces has been challenged (Johnson, 1996; Bailey, 2000).

When pneumothorax is encountered, it has been suggested that size, symptoms and presence of underlying lung disease may guide therapeutic intervention (Sirmali et al, 2003). Those patients with minimal, transient symptoms, and a pneumothorax <20–25% without evidence of an increase in the pneumothorax over several hours may be observed (Sirmali et al, 2003; Yiadom et al, 2008).

Although current evidence indicates that observation of small pneumothoraces without tube thoracostomy in trauma patients not receiving mechanical ventilation is likely safe (Enderson et al, 1993; Misthos et al, 2004; Ball et al, 2005; de Moya et al, 2007), actual clinical practice remains varied (Ball et al, 2003). A case review by Ball et al (2005), although looking at a small number of patients, highlighted some important points; mainly

that the method of treatment was clearly not standardized. Perhaps this is because the literature does not definitively identify which subset of patients receiving mechanical ventilation can safely avoid tube thoracostomy. This likely explains the variation in rates of chest tube insertion, as well as in opinion, among clinicians (Ball et al, 2003).

One suggested list of indications for drainage of traumatic pneumothoraces (Westaby and Brayley, 1990) includes:

- If pneumothorax >1.5 cm (at level of third costochondral junction) whether intermittent positive pressure ventilation is required or not
- If pneumothorax <1.5 cm but intermittent positive pressure ventilation is required for surgery as there are bilateral pneumothoraces
- If pneumothorax <1.5 cm in patients with chronic obstructive pulmonary disease, restrictive lung and chest wall disease, high spinal cord injury, or contralateral lung resection
- All tension pneumothoraces.

In summary, placement of a chest tube in traumatic pneumothorax patients is a reasonable initial approach in the majority of patients (Baumann and Noppen, 2004). However, carefully selected patients may be closely monitored without chest tube placement (Symington and McGugan, 2008). A pneumothorax in spontaneously breathing, stable patients can be treated expectantly with serial examination and chest X-ray (Collins et al, 1992; Misthos et al, 2004) even if moderately sized (Enderson et al, 1993; Fitzgerald et al, 2008). Approximately 10% of these patients eventually require a chest tube (Baumann and Noppen, 2004).

The institution of positive pressure ventilation should prompt strong consideration for chest tube placement in all non-iatrogenic traumatic pneumothorax patients (Baumann and Noppen, 2004). Given the potential need to drain both blood and air, and the potential for a significant air leak if the patient is mechanically ventilated, a larger bore tube (28–36 Fr) should be considered (Baumann and Noppen, 2004).

Conclusions

Despite the relative persistence in the presentation, and the relative comfort of practitioners in dealing with said patients, there is a wide variation in current practice. In the author's experience, this is true of all emergency departments in the north east and probably the UK as a whole.

KEY POINTS

- Traumatic pneumothorax is a common presentation.
- Tube thoracostomy may not be required in selected cases.
- There is a lack of definitive evidence regarding small pneumothoraces.

This variation may come from the fact that there are at present no known guidelines regarding the management of this condition, and there is not a definitive paper outlining best practice. This is clearly an area where further research is needed. What does need to happen is some degree of agreement as to the best management of a patient presenting with a traumatic pneumothorax. Perhaps the British Thoracic Society's guidelines for spontaneous pneumothorax should be adopted and applied to traumatic pneumothoraces as well? The most important underlying factor has to be the care of the patients, and anything which can help expedite the management of a patient in an appropriate manner, which is safe and evidence based, is undoubtedly the way forwards. **BJHM**

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