Tension pneumothorax: are prehospital guidelines safe and what are the alternatives?

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Abstract

Tension pneumothorax is a life threatening complication of chest injury. It can cause rapid physiological decompensation, cardiac arrest and death. The Joint Royal Colleges Ambulance Liaison Committee (JRCALC) provide guidelines on the prehospital diagnosis and treatment of this condition. The aim of this article is to ask whether or not these guidelines are effective and if there are feasible alternatives to the management of tension pneumothoraces in the prehospital environment.

Key words
- Decompression
- Pneumothorax
- Thoracocentesis
- Thoracostomy

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This article discusses recent literature regarding the prehospital treatment of tension pneumothorax. The obstacles involved in diagnosing the condition are considered, along with the techniques to treat it. Is current paramedic practice in dealing with the condition providing safe and effective care for patients and are there feasible prehospital alternatives?

Background

Tension pneumothorax (TPNX) is an immediately life threatening thoracic injury (Leigh-Smith and Davies, 2003). It occurs when a one way valve is created between the lung and the pleura. This leads to a build up of air in the pleural cavity during each respiratory cycle resulting in an increase in intrathoracic pressure. Eventually the lung on the injured side collapses and the mediastinum is displaced towards the opposite side. Venous return is compromised and cardiac arrest can follow (Watts and Howell, 2001). The JRCALC (2006) guidelines emphasize the possible need for rapid therapeutie action, with Leigh-Smith and Davies (2003) in agreement that if the clinical signs suggest a TPNX, then rapid treatment is required.

How do we know if it is a tension pneumothorax?

In order to diagnose and therefore treat a TPNX in the prehospital field, an assessment of the clinical signs needs to be made. Chest injuries, however, can be difficult to assess adequately in these environments, with the additional problem that the ‘classical’ clinical signs of life threatening chest injury are often absent (Lee et al, 2007). According to Leigh-Smith and Davies (2003), current standard texts list a variety of signs that are variably present to make a diagnosis, with JRCALC (2006) listing respiratory distress, ipsilateral chest hypomobility and hyperexpansion, reduced or absent air entry on the affected side and distended neck veins as signs of a TPNX.

Further signs are tracheal deviation, tachycardia and hypotension (JRCALC, 2006). Leigh-Smith and Davies (2003) argue that just two signs, namely respiratory distress and tachycardia, are accepted as being universally present in this condition, with tracheal deviation often absent and at best an inconsistent or late finding.

There is also potential for confusion as regards to chest hyperexpansion. This is a late sign of TPNX as early on there will be hypoexpansion due to collapse of the lung (Leigh-Smith and Davies, 2003). Nevertheless, Lee et al (2007) argue for vigilance for chest hyperexpansion which they state is suggestive of TPNX.

Decreased air entry on the affected side of the chest has been shown to be absent even in an advanced state of the condition (Leigh-Smith and Davies 2003). Furthermore, venous engorgement is an inconsistent sign and will only be visible if the cervical collar (if fitted) is removed to expose the patient’s neck (Lee et al, 2007).
How easy is it to diagnose?
Leigh-Smith and Davies (2003) point towards the unreliability of doctors in recognizing chest signs, let alone paramedics. Lee et al (2007) make the point that auscultation, used to assess decreased or absent breath sounds and strongly advocated by JRCALC (2006) is often difficult due to location and noise—a problem exacerbated in the prehospital environment.

Standard trauma teaching tends to illustrate patients in a critical state and assume that the clinical diagnosis is straightforward; however this is not always the case (Leigh-Smith and Harris 2005). Diagnostic difficulty can occur because of the absence of the ‘classic’ signs listed by JRCALC (2006). As an example, 108 cases of suspected TPNX treated by paramedics were studied with tracheal deviation absent in all of them (Cullinane et al, 2001). Furthermore, decreased blood pressure and cardiac output are not common in awake patients and when found are likely to be as a result of other pathology or TPNX in its pre-terminal stage (Leigh-Smith and Harris, 2005).

This is not made clear in the JRCALC (2006) guidelines which state that findings of these signs confirm the diagnosis of TPNX. Leigh-Smith and Harris (2005) go so far as to argue that tracheal deviation and neck vein distension should be de-emphasized, if not abandoned altogether, as signs of the condition.

Recognizing the signs of TPNX, even if they are present, is difficult (McRoberts et al, 2005). Emergency doctors have been shown to miss 50% of cases of tracheal displacement (Leigh-Smith and Harris, 2005) and cases of unrecognized and untreated TPNX by paramedics suggest that prehospital diagnosis on clinical criteria alone may be difficult (Heng et al, 2004). These authors report on 13 patients out of a total of 173 (8%) in whom the finding of tension pneumothoraces went unrecognized and untreated until their arrival at a trauma centre.

How do we treat it?
JRCALC (2006) states that TPNX must be decompressed rapidly by needle thoracocentesis. This has the goal of decompressing the increased intra-pleural pressure of TPNX, quickly reversing the severe haemodynamic deficit by relieving mediastinal shift and increasing venous return to the heart (Netto et al, 2008). While immediate action does need to be taken for patients showing signs of pre-terminal decompensation (McRoberts et al, 2005), this guideline does not take into account the management of lower risk cases of possible TPNX where needle decompression may not be a necessary immediate step (Chan, 2009).

In spontaneously breathing patients, the predominant feature during decompensation is progressive respiratory failure and the time course of deterioration may be longer than is suggested by UK guidelines, especially if the initial hypoxaemia is correctable with oxygen. In short, chronic forms of TPNX can occur (Chan, 2009). In this author's opinion, UK guidelines appear a little too ‘black and white’ and this could lead to cases of unnecessary needle decompression. Cullinane et al (2001) report numerous cases of unwarranted prehospital decompressions, with Leigh-Smith (2007) also arguing that thoracocentesis is often performed in the absence of a true TPNX. Indeed, many authors feel that the number of prehospital needle decompressions far exceeds the incidence of TPNX and should be limited. In contrast, Netto et al (2008) found that paramedics had a clear understanding of the indications for performing needle decompressions.

Many experts agree that where there is seriously impaired respiratory and circulatory function immediate decompression is necessary and that even transport to a nearby hospital without decompression represents an unacceptable delay (Waydhas and Sauerland, 2007). Leigh-Smith and Harris (2005) agree that emergency
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Figure 2. Overall needle decompression often appears to be an effective, easy to use and relatively safe method to treat tension pneumothorax.

needle decompression is widely advocated and has proved safe and effective in the prehospital environment. The American College of Surgeons Committee on Trauma also recommends that needle decompression be performed as the first step in treating TPNX (Netto et al, 2008).

Bartolomeo et al (2001) make the point that there is little evidence supporting the practice of prehospital decompression, but that the same can be said for every advanced life support procedure in trauma prehospital care. However, becoming more prevalent is the view that the minimal disadvantage of spending a little time in performing needle decompression should never outweigh the risk of transporting an unstable patient with an injury that is potentially life threatening and relatively easily treatable (Bartolomeo et al, 2001).

Prehospital needle decompression can be performed rapidly and may be a life saving intervention; however it is not a benign procedure and injury to intrathoracic structures may occur—for example, cardiac tamponade and injury to the underlying lung and intercostal vessels (Butler et al, 2003) Furthermore, failure to penetrate the pleural space should be an additional consideration in larger patients (Barton et al, 1995).

It is widely accepted that needle decompression is a safe and effective, if only temporising, method of treating tension pneumothorax.

Techniques and equipment

Current UK guidelines make no mention of how to actually perform the treatment they recommend (JRCALC, 2006), despite the fact that the technique of needle thoracocentesis is critical (Cullinane et al, 2001). The first choice of site for the procedure, and the one that is generally taught to paramedics in the UK, is the second intercostal space in the mid-clavicular line (Lee et al, 2007). However, this entails penetration of pectoral muscles and a variable quantity of subcutaneous tissue (Leigh-Smith and Harris, 2005). The danger is that the standard cannulas used for the procedure may not be long enough to penetrate the pleural cavity (Cullinane et al, 2001). Britten and Palmer (1996) advocate the use of a longer cannula as a temporising measure, but this is associated with the risk of intrapulmonary placement and damage to the lung of those patients without pneumothoraces (Cullinane et al, 2001).

Other problems with needle decompression are failure to drain and poor retention or dislodgement of the cannulas (Barton, 1999). Jones and Hollingsworth (2002) point to the nature of the devices predisposing them to kinking and so propose the use of a rigid device similar to an intraosseous needle. Cullinane et al (2001), on the other hand, argue that it may be better to keep the needle within the catheter in situ, to prevent it from kinking. To combat the dislodging of the inserted cannula, Allison et al (2002) report on the use of the Asherman chest seal as a stabilization device. They argue that it can easily be placed over the barrel of the cannula and permits a more robust, easy and readily available stabilization device than tapes and syringe barrels which are currently suggested.

A recent study from the UK concluded that lateral needle aspiration in the fifth intercostal space at the anterior axillary line is technically easy and maybe a potentially safer option (Heng et al, 2004). Leigh-Smith and Harris (2005) agree that this approach may be safer and that this area contains less fat and avoids large muscles; however damage to the lung may be more likely in the supine patient as air collects at the highest point. Further complications of lateral needle placement could be an increased likelihood of dislodgement and damage to the axillary artery and vein (Heng et al, 2004). Yet another alternative site for decompression is lateral to the nipple line which should avoid mediastinal structures, and also avoids having to identify the mid clavicular line in sub-optimal field conditions, something that paramedics are prone to doing (Heng et al, 2004).

Waydhas and Sauerland (2007) report a study
where, after needle decompression, air was released through the needle in 47% of cases, and in 32% of patients an improvement in vital signs was noted. Insufficient needle length was a problem in 4.1% of patients, with dislocation of the needle occurring in 2.4% of cases. Conversely Massarutti et al (2006) report on a study which showed that of 108 needle decompressions performed by paramedics only 5% of the patients showed improvement in vital signs. Many authors agree, however, that overall needle decompression often appears to be an effective, easy to use and relatively safe method to treat TPNX (Waydhas and Sauerland, 2007); however other procedures may be an option for the prehospital practitioner.

**Alternative prehospital treatment**

Current UK guidelines are clear that needle decompression may fail (JRCALC, 2006) and Jones and Hollingsworth (2002) agree with the guidelines that if the procedure has failed and the paramedic strongly suspects a TPNX is present a further attempt at needle thoracocentesis is a reasonable action. Even if the procedure is successful it is not the definitive treatment for a TPNX, although it is an adequate temporising measure until a formal tube thoracostomy can be performed (Butler et al, 2003). This entails the insertion of a chest tube into the pleural cavity to drain air allowing continuous large volume drainage (Shlamovitz, 2009). There is the question, however, of whether or not prehospital thoracostomy can be safely and effectively carried out.

Many experts would bypass the step of needle decompression if the capability to perform tube thoracostomy (TT) was immediately available (Chan, 2009). Much controversy surrounds this procedure in the prehospital setting however, and data from recent studies suggest that patients are at increased risk for complications after prehospital TT placement (Schmidt et al, 1998). The role that the qualifications and experience of the medical personnel on scene (emergency nurse, paramedic or emergency doctor) may play would seem to be an important issue with such a skilled procedure; however this has not generally been studied (Waydhas and Sauerland, 2007).

Lee et al (2007) emphasize that thoracostomy is a specialized technique which should be practiced only by appropriately trained practitioners and go on to argue that evidence of benefit is poor with comparison to needle decompression lacking.

While Schmidt et al (1998) submit that complications after prehospital TT such as injury to organs are documented, with proper techniques they consider it a safe procedure. The success rate of prehospital chest tubes is reported to range between 79 and 95% (Waydhas and Sauerland, 2007), seemingly higher than that of needle decompression. However, as well as injury to organs, intrapleural infection after chest tube placement is a common long-term complication and must be considered when TT procedures are performed in non-sterile environments (Barton et al, 1995).

While this success rate is encouraging, applying this procedure to current emergency medical systems in the UK would be problematic as paramedics in the UK do not have the experience of doctors (Deakin, 1998). Simple thoracostomy (ST), however, is essentially a modified thoracostomy without chest tube placement (Barton, 1999). No tube is necessary as following the incision through the chest wall positive intrathoracic pressure on inhalation expels air (Deakin, 1998).

Massarutti et al (2006) report on a helicopter emergency medical service that has adopted ST for the treatment of TPNX. They describe it as a safe and effective technique in the early prehospital phase that is simpler and faster when compared to TT. Both Deakin (1998) and Barton (1999) found that scene time is shortened using this procedure and it did not necessitate the skill needed for chest tube insertion.

Lockey et al (2008) emphasise that prehospital ST is not a novel procedure. They argue that it is an effective intervention in severely injured patients and simplifies treatment in the prehospital phase, allowing for the insertion of a chest tube after arrival at hospital.
Conclusion

There is evidence supporting current UK guidelines in the treatment of tension pneumothorax, and it is widely accepted that needle decompression is a safe and effective, if only temporising, method of treating TPNX. While doubts are documented as to its effectiveness in the field with regard to indications for the procedure and the procedure itself, paramedics can and do save lives through its use. Alternative treatments are advocated and used successfully, however their use demands the presence of differently skilled prehospital practitioners at severe trauma events.

Key points

- Needle thoracentesis is a safe and effective treatment for tension pneumothorax
- It is a temporising measure pending definitive treatment
- It can be difficult to recognise with the often taught ‘classic signs’ frequently absent from the clinical picture
- Prehospital tube thoracostomy and simple thoracostomy have been shown to be safe and effective treatments although they require skills currently beyond the scope of practice of most UK paramedics

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