



Brief Report

Are needle decompressions for tension pneumothoraces being performed appropriately for appropriate indications?

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1. Introduction

Thoracic injuries are a leading cause of mortality in trauma patients [1]. Even so, many life-threatening thoracic injuries can be managed nonoperatively by simple therapeutic procedures [2]. One example is needle decompression of tension pneumothoraces. Left untreated, a tension pneumothorax results in the continuous accumulation of air in the pleural space, which impairs both ventilation and venous return to the heart resulting in intractable shock [3].

Generally, needle decompressions (NDs) are performed by physicians and highly trained prehospital paramedics. Previous studies have shown that performing ND in the prehospital setting results in few complications and may improve trauma outcomes [4–7]. Even so, these investigators have also underscored the importance of training and quality improvement initiatives to minimize complications associated with this procedure; in particular, they felt that

more attention should be focused on teaching the appropriate indications and anatomical landmarks for performing ND [7,8]. The purpose of this study is to evaluate the prehospital performance of needle decompression by experienced paramedics.

2. Material and methods

A prospective study was undertaken of all trauma patients assessed at our institution (a level I equivalent adult trauma center) from December 1, 2005, to December 30, 2006. All adult patients (16–90 years old) with either blunt or penetrating mechanisms of injury were included if they received needle decompression in the prehospital setting for a presumed tension pneumothorax. Patients referred from other hospitals or who sustained burns were excluded.

Emergency medical services in our catchment area are provided by municipal paramedics. At present, only advanced care and critical care paramedics are allowed to perform ND. They receive approximately 1 hour of

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didactic training followed by 1 hour of laboratory training. Generally, these paramedics will have refresher training on ND through self-directed continuing medical education programs on an annual basis but receive a mandatory refresher every 2 years.

Within our trauma system, prehospital ND can be performed on patients who present with obvious thoracic trauma, who are 12 years of age or older and who are 40 kg or more in mass. Paramedics may perform ND without contacting their base station if procedure indications are fulfilled. Indications for prehospital ND require all the following conditions to be present: severe and worsening shortness of breath or respiratory distress, absent or markedly decreased breath sounds on affected side, and systolic blood pressure of 90 mm Hg or lower.

Our paramedic ND protocol is as follows: before performing the procedure, 100% oxygen is applied. The procedure then consists of locating the second intercostal space on the anterior chest wall in the midclavicular line on the affected side and prepping the area quickly. The 14- or 16-gauge catheter (over a needle and attached to a syringe) is then inserted along the upper border of the third rib. The needle-catheter combination is advanced approximately 2 in. while aspirating for free air. Once in the pleural cavity, the needle and syringe are removed, and the catheter is secured in place and a flutter valve is placed over the catheter.

Trauma patients who received prehospital ND during the study period were further studied. Patient demographics, injury data, and outcomes were prospectively recorded by our institutional trauma registry staff. The medical charts of study patients were then prospectively reviewed by our trauma fellow (FN) with particular attention focused on the prehospital record. Prehospital physiologic status (including blood pressure, heart rate, oxygen saturation) and any clinical signs or symptoms of chest trauma (respiratory distress, absent breath sounds, and the presence of penetrating chest injury, bruising, or crepitus) were noted. Any changes in prehospital physiologic status that accompanied needle decompression were also noted. From the trauma room record, we determined whether tube thoracostomy (TT) was performed immediately in the trauma room or whether it followed plain chest radiography or chest computed tomographic (CT) examination. Findings on all thoracic diagnostic imaging were also reviewed.

The primary outcome of the study was whether or not ND was being performed in the correct anatomical location. One author (FN) assessed each study patient at the time of presentation in the trauma room or the next morning. He determined the location of the midclavicular line for each patient and analyzed each ND with relation to these landmarks. He did not analyze ND with relation to the second intercostal space as we felt the potential for major hemorrhagic complications would be related more to medial deviation of ND from accepted landmarks. There-

fore, potential primary outcomes were “at the midclavicular line,” or either “medial” or “lateral” to the midclavicular line. Needle decompression was considered “at the midclavicular line” if it was within 1 cm of the determined landmark.

We also determined if ND was “within the cardiac box” or “lateral to the cardiac box.” Nagy et al [9] studied 121 penetrating injuries in proximity to the heart (within the cardiac box) and found that 12 caused cardiac injury. The cardiac box is bound superiorly by the clavicles, laterally by the nipple lines, and inferiorly by the costal margins (Fig. 1). Other primary outcome for each ND was “within the cardiac box” or “lateral to the cardiac box.”

Secondary outcomes included any complications of needle decompression. In addition, we reviewed the prehospital records to determine if ND was “indicated,” “potentially indicated,” or “not indicated.” The procedure was judged to be “indicated” only if performed for physiologic instability (hemodynamic or hypoxia) and if local signs/symptoms of chest trauma were evident (auscultatory findings, respiratory distress, and evidence of chest trauma). The procedure was considered “potentially indicated” if performed for either physiologic instability or associated signs of chest trauma. Needle decompression was judged as being “not indicated” if neither criterion was fulfilled.

Descriptive statistics are presented (means+SD). Statistical analysis was performed using SAS version

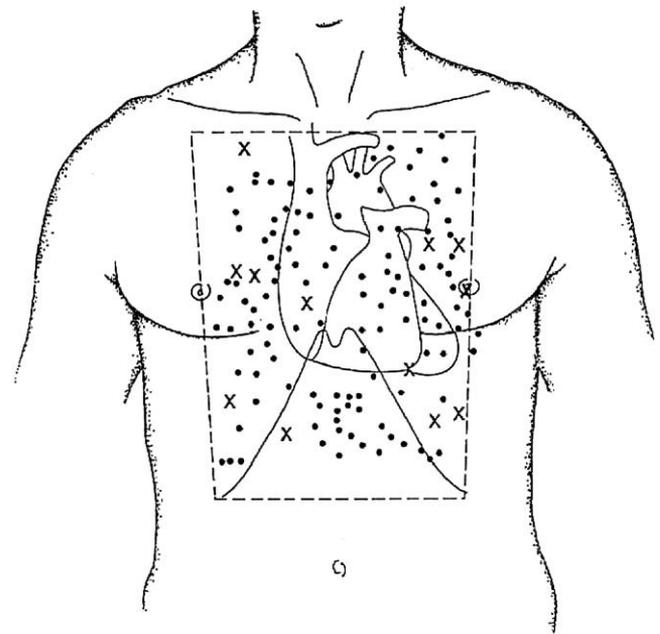


Fig. 1 “Cardiac Box” defining location of proximity wounds to the heart. (Reproduced with permission from *J Trauma* 1995;38:859. X indicates wounds that produced cardiac injuries in that study.)

Table 1 Baseline characteristics of the study group

Characteristic	Total no. of trauma patients (n = 1135)	Received needle decompression (n = 17)
Age (y)	40 ± 14	32 ± 14
Male sex	861 (76%)	14 (82%)
Mechanism (blunt)	939 (83%)	10 (59%)
ISS	22 ± 13	33 ± 18
Air transport (yes)	286 (25%)	7 (41%)
Died	110 (10%)	5 (29%)

Means ± SD are presented for continuous variables; counts and percentages are presented for categorical variables. ISS, injury severity score.

8.02 (SAS Institute, Cary, NC). This study was reviewed and approved by the research and ethics board of our institution.

3. Results

During the 1-year study period, 1135 severely injured trauma patients were evaluated by the trauma service at our institution. Seventeen of these patients received 18 needle decompressions by prehospital personnel. Patients receiving ND were younger than the average trauma patient and were more seriously injured. Likely, the difference for the observation was mostly secondary to the fact that patients receiving ND were more likely to have suffered penetrating injuries (Table 1).

Ninety-four percent (17/18) of all NDs were performed within the cardiac box. Forty-four percent (n = 8) were performed medial to the midclavicular line. No major complications were noted to have arisen from the needle decompressions; however, in some cases, ND was performed

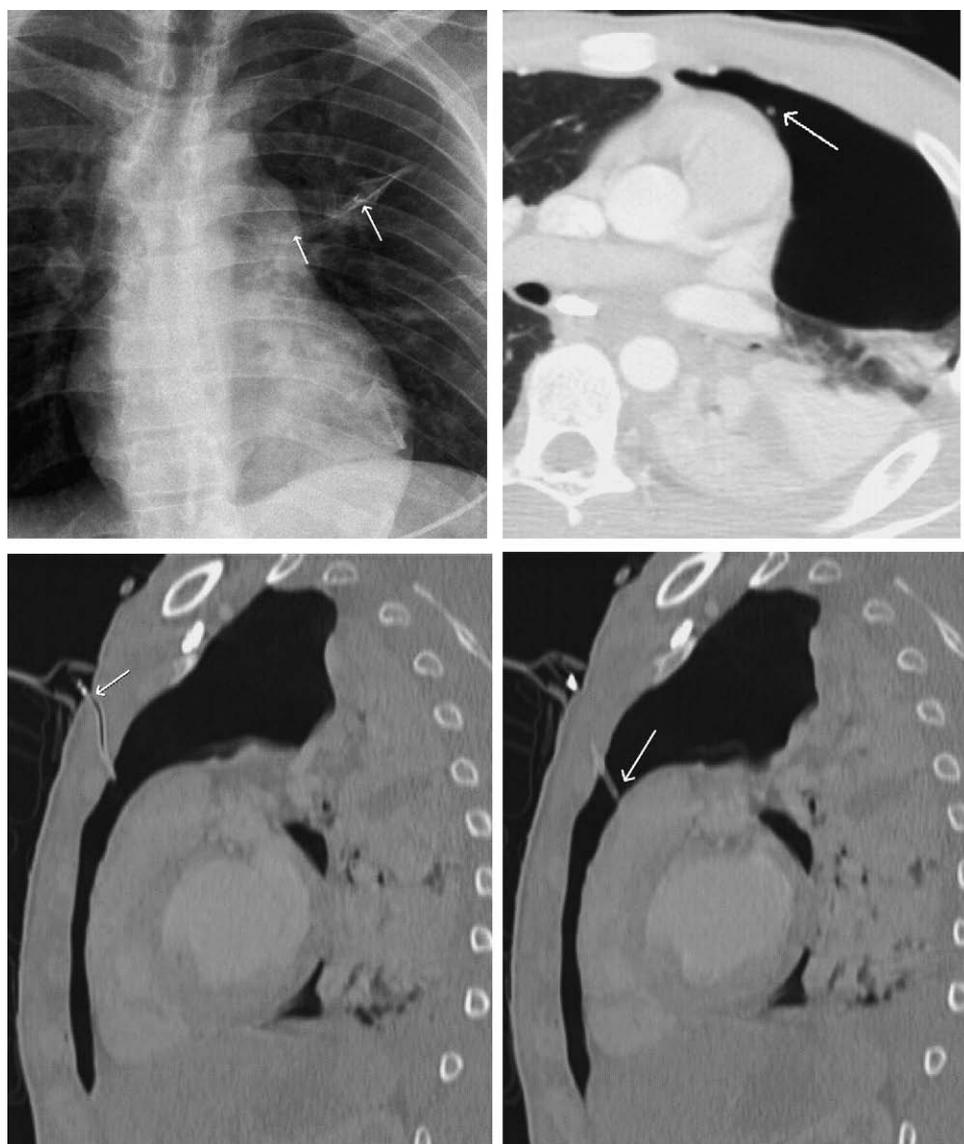


Fig. 2 Chest x-ray shows a catheter medially oriented. The axial CT view (top right) shows the relationship of the catheter to the heart. The CT sagittal views (bottom) show the relationship of catheter to the mediastinal structures.

Table 2 Indications for needle decompression and outcomes

Patient	Mechanism	PH instability	PH chest findings	TT placement	Chest findings	Death
1	Stab	Y	Y	After CXR	Pneumothorax	N
2	GSW	Y	Y	Immediate	Hemothorax	N
3	GSW	Y	Y	ED thoracotomy	Massive hemothorax	Y
4	MVC	Y	Y	Immediate	Bilateral hemo/pneumothorax	Y
5	Stab	Y	Y	ED thoracotomy	Massive hemothorax	Y
6	Motorcycle	Y	Y	Immediate	Flail and hemo/pneumothorax	N
7	GSW	Y	Y	DOA/not done	Unknown	Y
8	MVC	Y	Y	Immediate	Contusions + pneumothorax	N
9	MVC	Y	Y	Immediate	Contusions + pneumothorax	N
10	Fall	Y	Y	Immediate	Pneumothorax	Y
11	GSW	Y	Y	Immediate	Hemothorax	N
12	MVC	N	Y	Immediate	Hemothorax and diaphragm	N
13	MVC	Y	N	Immediate	Pneumothorax	N
14	Bicycle	N	Y	After CXR	Pneumothorax	N
15	MVC	N	Y	After CXR	Pneumothorax	N
16	Pedestrian vs car	Y	N	None	No pneumo-/hemothorax	N
17	GSW	N	Y	After CXR	Hemothorax	N

PH, prehospital; GSW, gunshot wound; MVC, motor vehicle collision; ED, emergency department; CXR, chest x-ray; DOA, dead on arrival.

so medially that inadvertent cardiac or major vascular injuries almost occurred (see Fig. 2).

On review of prehospital records, ND was judged to be either “indicated” or “potentially indicated” in all cases (Table 2). Two patients arrived to hospital with clinical signs of tension pneumothorax. In one of them, the catheter length was insufficient to decompress the pleural cavity. This patient received a tube thoracostomy in the trauma room; both patients survived.

On review of the trauma room records of the study patients, one was dead on arrival and so no tube thoracostomy was performed. Of the remaining 16 patients, 11 underwent immediate TT insertion or thoracotomy, and 4 had TTs placed after chest radiography. The remaining patient did not require TT insertion based on clinical status, or chest radiology. His chest x-ray suggested that the needle sheath was kinked, and the chest CT scan confirmed that the catheter length was not sufficient to decompress the pleural cavity (Fig. 3) but also confirmed the absence of any hemo- or pneumothorax (see Table 2).

4. Discussion

The American College of Surgeons Committee on Trauma recommends that needle decompression be performed as the first step in treating tension pneumothoraces [1]. Needle decompression can quickly reverse the severe hemodynamic sequelae of tension pneumothoraces by relieving mediastinal shift and increasing venous return to the heart [1]. Needle decompressions are being increasingly performed in the prehospital setting. Needle decompression can convert and tension pneumothorax into a simple pneumothorax, thus allowing the definitive procedure

(tube thoracostomy) to be deferred until the patient reaches the trauma room.

We reviewed the prehospital performance of NDs in an established trauma system by experienced paramedics. We found that paramedics had a clear understanding of the indications for performing needle decompressions; on review, all NDs were judged to be either “indicated” or “potentially indicated.” However, we noticed a consistent trend to suggest that NDs are being performed too medially. In 8 cases, ND was performed medial to the midclavicular line. When we examined each ND for its placement in relation to the cardiac box, we found that 17/18 ND were



Fig. 3 Catheter sheath is seen on axial CT cut (arrow). Catheter length is insufficient to reach pleural cavity.

performed within the box. Although no major complications were noted as a direct result of ND, a review of radiologic imaging revealed that medial decompressions risked inadvertent penetrating cardiac and/or mediastinal injury.

Several factors may predispose prehospital EMTs to decompress presumed tension pneumothoraces too medially. For one, they may forget that the clavicle extends into the shoulder joint since their patients are often incompletely exposed at the time of assessment in the field. If the lateral border of the clavicle is misidentified, the midclavicular line would also be misidentified. Indeed, emergency physicians in Ireland were able to verbalize that needle decompressions should be performed in the midclavicular line but frequently identified a site for ND on human volunteers that was too medial [8]. In addition, needle decompressions are often performed in difficult field conditions: sometimes at night, in inclement weather, or under stress, which may increase the likelihood of misidentification of appropriate landmarks.

If this observed trend is systemic, there is some urgency in improving the quality of teaching of this resuscitative procedure. In the past, needle decompressions were only being performed by experienced paramedics in established trauma systems. However, there is increasing interest in teaching ND to diverse groups of prehospital personnel, including combat soldiers with little or no medical experience [10,11]. As well, some authors are now advocating that longer needles be used for needle decompression, particularly in the military context. Britten et al. reported that needle decompression can sometimes fail to relieve tension pneumothorax because of insufficient catheter length [12]. Computed tomographic studies of chest wall thickness suggest that 4.5-cm [13] and even 5-cm [14] catheters are required to reliably decompress the pleural cavity. In our study, we also noted that 2 patients were not adequately treated for their tension pneumothorax because of insufficient needle length. However, although major hemorrhage and cardiac injuries from ND are rare, they do occur [15,16]. More major complications may be noted if this procedure continues to devolve to inexperienced personnel using longer needles.

One solution to this problem is to recommend a lateral approach (anterior axillary line) for ND—to avoid potential hemorrhagic complications from injuring mediastinal structures [15]. Lateral needle placements, however, risk dislodgement of the catheter with patient movement. As well, a lateral approach risks its own complications, including injury to the axillary artery and vein, and the brachial plexus. Another approach is to systematically teach providers that needle decompression should be performed lateral to the nipple line, which should avoid mediastinal structures. This avoids the problem of landmarking the midclavicular line in suboptimal field conditions. Providers should also be sensitized to potential hemorrhagic complications, particularly if longer needles are used.

This study has several limitations. It is a small prospective study, with no formal sample size calculation. As well, we

did not find any actual complications but only identified trends in technique errors that may predispose to significant hemorrhagic complications. Larger studies are needed to detect the incidence of actual major hemorrhagic complications of needle decompression and to better quantify the risks using current teaching strategies.

Another limitation of this study was that we only studied medial error from the midclavicular line; we did not evaluate for superior or inferior deviation from the second intercostal space. For example, Fig. 2 depicted a needle decompression that almost injured the heart; this ND was both medial to the midclavicular line and inferior to the second intercostal space. In assessing only medial errors, we may have underestimated the incidence of technique errors. One final limitation of this study was that we did not assess cases where needle decompression was clearly indicated but not performed. Incorporating a measure for underuse of a therapeutic measure would have increased the validity of this study.

In conclusion, needle decompression is a potentially life-saving procedure that can be performed in the prehospital setting. There is a trend to performing ND too medially, which risks hemorrhagic complications by injuring the mediastinal structures. More attention should be focused on teaching appropriate landmarking for ND; providers should also be aware of the potential for causing complications.

Acknowledgments

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