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Is routine tube thoracostomy necessary after prehospital needle decompression for tension pneumothorax?

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Abstract

BACKGROUND: Thoracic needle decompression is lifesaving in tension pneumothorax. However, performance of subsequent tube thoracostomy is questioned. The needle may not enter the chest, or the diagnosis may be wrong. The aim of this study was to test the hypothesis that routine tube thoracostomy is not required.

METHODS: A prospective 2-year study of patients aged ≥18 years with thoracic trauma was conducted at a level 1 trauma center.

RESULTS: Forty-one patients with chest trauma, 12 penetrating and 29 blunt, had 47 needled hemithoraces for evaluation; 85% of hemithoraces required tube thoracostomy after needle decompression of the chest (34 of 41 patients [83%]).

CONCLUSIONS: Patients undergoing needle decompression who do not require placement of thoracostomy for clinical indications may be assessed using chest radiography, but thoracic computed tomography is more accurate. Air or blood on chest radiography or computed tomography of the chest is an indication for tube thoracostomy.

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Prehospital needle decompression is a lifesaving procedure in tension pneumothorax. Physical examination findings include absent breath sounds, increased resonance to percussion, hypotension, and tracheal deviation toward the contralateral side. Because tension pneumothorax can be rapidly fatal, clinical diagnosis is emphasized, and prompt intervention is mandatory. In patients with clinical suspicion of tension pneumothorax and physiologic instability, a 14-gauge angiocatheter is inserted (2 in [5 cm] long) in the second intercostal space at the midclavicular line.¹ The catheter is passed into the pleural space and the needle removed, venting the elevated intrathoracic pressure. A flap valve, Luer-Lock (Becton Dickinson, Franklin Lakes, NJ), or other type of seal may be used to prevent pneumothorax.

However, patients undergoing prehospital needle thoracostomy in crisis situations may not actually have tension pneumothorax, with a reported error rate of 26%.² A possible anatomic explanation may be that chest wall thickness, as assessed by computed tomography, may exceed the length of the catheter used for decompression.³ However, studies using ultrasound imaging have shown chest wall thickness to be <4.5 cm in all patients.⁴ The possibility of iatrogenic injury complicates the procedure and may increase as longer catheters are introduced to address the...
and morbidity of the procedure. A case report of injury to the pulmonary artery and cardiac tamponade is particularly unnerving. Some authors have suggested lateral chest wall placement to reduce the risk for injury to hilar structures, but there are no data to support this theoretically appealing approach. Because air rises in the anterior chest of a supine patient, it is most accessible in this position.

Our standard practice is to place a tube thoracostomy in all patients who have undergone needle decompression in the field. Our rationale was based on concern that, after pleural space decompression, a patient would be at risk for developing a pneumothorax even if one was not present on admission chest radiography. Patients who undergo positive pressure ventilation, either in the operating room or in the intensive care unit, may be at greater risk. However, review of selected cases demonstrated that in some patients undergoing prehospital needle decompression, the catheter was placed tangentially in the soft tissue and did not even enter the chest.

The hypothesis of our study was that routine tube thoracostomy is unnecessary in patients undergoing prehospital needle decompression of the chest. It may be possible to spare some patients the associated discomfort and morbidity of the procedure.

Methods

This study was conducted over a 2-year period at an American College of Surgeons–verified level 1 trauma center. The data were collected prospectively, and informed consent was obtained from patients and/or their next of kin. Approval for this project was obtained from the hospital institutional review board. Patients aged $\geq$ 18 years with blunt or penetrating injuries to the chest who underwent prehospital needle decompression were included. Exclusion criteria were pregnancy, incarceration, and asystole on arrival. Demographic data were recorded. Results of chest radiography and thoracic computed tomography were compared. The clinical diagnostic testing statistics of sensitivity, specificity, and positive and negative predictive value were calculated.

Informed consent was obtained from the remaining 41 patients. Twelve sustained penetrating injuries (7 stab wounds and 5 gunshot wounds), and 29 sustained blunt injuries (15 motor vehicle and 5 motorcycle accidents, 2 motor vehicle–pedestrian injuries, and 7 due to other blunt mechanisms). In the study group, there were 8 women and 33 men. Ages ranged from 18 to 69 years (mean, 38 ± 14 years).

Initial chest radiography was performed; small hemopneumothoraces were observed. If tube thoracostomy was not initially indicated, thoracic computed tomography was performed. If tube thoracostomy was still not indicated, subsequent chest radiography was done at 2, 4, 6, and 12 hours per study protocol to evaluate for progression, and the patient was observed on the trauma unit.

Results

Over a 2-year period, 6,357 trauma patients were admitted to the trauma center. Fifty-one patients (1%) who underwent needle decompression of the chest by prehospital personnel were identified upon arrival in the trauma bay. Nine patients were dead on arrival, and 1 patient had a tube thoracostomy placed at an outside hospital. These 10 patients were excluded from further study.

Penetrating trauma

There were 15 decompressions in 12 patients: 3 right, 6 left, and 3 bilateral decompressions. One patient died in the operating room after a pneumonectomy. Tube thoracostomy was placed on the side of the penetrating injury in 2 patients for clinical indications (hypotension with decreased breath sounds). Four tube thoracostomies were placed for hemopneumothorax present on initial chest radiography and 4 more for a normal-appearing chest radiograph followed by identification of a significant hemopneumothorax on thoracic computed tomography shortly after arrival. One patient developed a progressive hemothorax on chest radiography 12 hours after admission and had a tube placed. However, the hemothorax was incompletely evacuated, and he required a video-assisted thoracoscopy at a later point in his course. Only 1 penetrating trauma patient, with a stab wound, who had needle decompression for hypotension, escaped tube thoracostomy.

Blunt trauma

Twenty-nine blunt trauma patients underwent 37 needle decompressions of the chest: 6 right, 15 left, and 8 bilateral. Eight patients died, 2 in the operating room and 2 later of death by neurologic criteria. Seven patients underwent tube thoracostomy for clinical indications, 3 for abnormal initial chest radiographic findings, 9 for findings on thoracic computed tomography, 3 delayed 2 hours, 2 delayed 4 hours, and another 1 at 12 hours; all these patients had normal-appearing initial chest radiographs and abnormal thoracic computed tomographic findings. Four blunt trauma patients did not require tube thoracostomy.

Data analysis

Data for penetrating and blunt trauma patients were combined because there were no significant differences between the 2 groups in the likelihood of positive radiographic findings or need for tube thoracostomy. Each individual hemothorax was treated as a separate data point; 52 needle-decompressed hemothoraces were evaluated. Five patients who did not undergo initial chest radiography were not studied further; this left 47 hemothoraces with adequate data for evaluation.
Of these 47 needle-decompressed hemithoraces, initial chest radiography revealed that 26 were normal (55%), 9 needed a tube thoracostomy (21%), and 12 should be observed (25%). For tube thoracostomy, chest radiography had sensitivity of 54%, specificity of 100% and accuracy of 62%. The positive predictive value was 100%, and the negative predictive value was only 31%.

Subsequent thoracic computed tomography in 31 hemithoraces demonstrated that 5 normal chest radiographs were confirmed normal (16%); these patients underwent serial chest radiography over the following 24 hours and did not subsequently require a tube thoracostomy. Ten hemithoraces with normal chest radiographic results on admission required a tube thoracostomy on the basis of more significant findings on computed tomography. Twelve hemithoraces observed on the basis of initial chest radiography with small hemopneumothoraces all had a tube placed; 5 had clinical deterioration. Of the 9 hemithoraces observed after normal chest radiography with additional positive computed tomographic findings, 7 of 9 hemithoraces (78%) developed delayed pneumothorax and required tube thoracostomy placement, 2 of them emergerently because of hypotension and hypoxia. For tube thoracostomy, thoracic computed tomography had sensitivity of 100%, specificity of 71%, and accuracy of 94%. The positive predictive value was 92%, and the negative predictive value was 100%. Thus, only 15% of hemithoraces avoided tube thoracostomy after needle decompression of the chest.

Comments

The use of needle thoracostomy by prehospital personnel may be lifesaving in appropriately selected patients with the clinical hallmarks of tension pneumothorax. Some patients clearly have improvement in their field vital signs, and some have subjective improvement of their dyspnea after needle decompression. The error rate is reported to be approximately 26%. Accuracy of pneumothorax identification by prehospital personnel may vary widely by regional expertise and patient circumstances. The “hanging drop technique” may facilitate recognition of tension pneumothorax without creating injury.

Thoracic computed tomography and ultrasound have been used to assess chest wall thickness. In 1 study, the mean thickness of the thoracic wall was measured to be 4.5 ± 1.5 cm on the right and 4.1 ± 1.4 cm on the left. Half of the patients had ≥ 1 hemithorax chest wall measuring >4.4 cm. A similar study in deployed military personnel measured mean perpendicular chest wall thickness at 4.9 cm. However, ultrasound found that only 1% of the population would exceed 4.5 cm chest wall thickness. The catheters used currently for needle decompression are a standard 5 cm in length. Longer catheters may result in a higher potential for intrathoracic injury.

We tested the hypothesis that patients undergoing prehospital needle decompression did not require routine tube thoracostomy. This pathway was supported in only 15% of needled hemithoraces. The remaining patients required tube thoracostomy. Subgroup evaluation revealed no significant differences between penetrating and blunt injuries.

Supine anteroposterior chest radiographs obtained in the trauma bay are suboptimal in as many as 25% of patients. Attention to the “deep sulcus sign” may aid recognition, rather than relying on the pleural stripe. Thoracic computed tomography is considerably more sensitive than chest radiography and reveals 3 times the number of pneumothoraces identified on chest radiography. Therefore, thoracic computed tomography is the gold standard for the identification of pneumothorax. However, screening thoracic computed tomography has not previously been applied to those patients undergoing prehospital needle decompression.

In our study, initial supine anteroposterior chest radiographic screening was performed in the trauma resuscitation bay. Chest radiographic findings were normal in 55% of hemithoraces; 21% of patients underwent tube thoracostomy, and 23% were selected for observation. After thoracic computed tomography, 52% of the remaining patients underwent tube thoracostomy. Five patients with normal chest radiographic and thoracic computed tomographic findings never required a tube thoracostomy; consequently, thoracic computed tomography is an accurate screening test, with negative predictive value of 100% and positive predictive value of 92%.

Additionally, with the increasing availability of ultrasound in trauma resuscitation bays, the probe may be used to identify “lung sliding” or “comet tails” to confirm the presence of complete lung expansion. Any pneumothorax in a patient undergoing prehospital needle decompression is an indication for tube thoracostomy.

Performance of prehospital needle decompression has a strong relationship with the need for tube thoracostomy. However, in those in whom the initial judgment is in error, subsequent chest radiography is not sufficiently accurate to identify the need for tube thoracostomy, and thoracic computed tomography should be performed. However, the routine performance of tube thoracostomy would result in only a 15% nontherapeutic tube rate and would result in decreased cost of care by avoiding thoracic computed tomography. A confirmatory assessment of the performance of local prehospital personnel may demonstrate variation from our results, but similar principles apply.

Conclusions

Patients undergoing prehospital needle decompression who do not require placement of tube thoracostomy for clinical indications may be assessed for pneumothorax with chest radiography, but thoracic computed tomography is a better initial assessment in stable patients. The presence of air or blood on chest radiography or thoracic computed tomography is an indication for tube thoracostomy.
Discussion

**James G. Tyburski, M.D.** (Detroit, MI): Congratulations to the Wright State group, surgical group, on their really trying to answer a very simple question, do you need to put a chest tube in patients that come in with a prehospital needle decompression? And certainly in Dayton, the answer looks like a resounding yes from the study. Were all the decompressions prehospital done in the second intercostal space as described in the ATLS? Can you outline the findings of the CT scans that made you go ahead and put a chest tube in? Based on that, what is your current recommendation for what we should do with these patients when they come in?

**Kathleen M. Dominguez, M.D.** (Dayton, OH): First, these were anterior mid-clavicular line needle decompressions. Initially we had intended to calculate a percentage on all the patients. We quickly discovered that that was not really feasible in the context of the timeliness of taking care of the patients. Our cutoff was about 20% pneumothorax in context with the patient’s clinical stability overall.

Obviously, a patient that’s not doing well in other ways we’re going to be a little more likely to insert that chest tube quickly. In terms of our recommendations, yes, we do recommend placing a chest tube on these patients now. The caveat in that would be if they are going to be undergoing imaging for some other reason that’s going to give you a look into the chest, you may wait until afterwards, but I wouldn’t obtain a chest CT strictly for the purpose of ruling out that prior to placing a chest tube.

**Dr Jeffrey Claridge** (Cleveland, OH): I like simple questions that have a simple answer, however, I don’t think we had a simple answer yet on this topic. Are you going to recommend a standard chest tube, so a 36 or 32, or are you thinking about doing anything else? Have you done any education to your prehospital people on when to use these catheters?

**Dr Dominguez:** In terms of educating the prehospital personnel, we have patients that we’ll see that really we can’t discern exactly what made them decompress. The patients were identified prospectively as they came in the hospital, but the data collection was done retrospectively, and often it was very difficult to discern exactly what made a clinician decide to place a chest tube at one point. In terms of exact recommendations for chest tube, we routinely use large bore chest tubes in adults, traditionally in the range of 32 to 36.

**Dr Roxie M. Albrecht** (Oklahoma City, OK): We don’t find that same percentage in our large size patients in Oklahoma. We actually leave the needles in when we CT scan, if they need a CT scan, and we find that the needles are woefully too short to reach the thoracic cavity in that second intercostal space. So the majority of our patients don’t appear to need chest tubes. There are some recent studies looking at saying that chest tube size doesn’t matter, and I was wondering if you are putting in pigtails or percutaneous catheters?

**Dr Dominguez:** We did include patients that were on positive pressure and going to the operating room, and it was essentially we made sure everyone involved had to have this done or if they had any pneumothorax. I think it’s perfectly reasonable to move towards the smaller chest tube, particularly if there is no identified pneumothorax and if it’s solely for the indication that these patients have had the needle decompression.

**Dr Alan L. Beal** (Buffalo, MN): Just to follow-up on that. So how many patients did you have normal chest x-rays and normal CT scans, in other words, it didn’t reach the chest?

**Dr Dominguez:** I believe it was 5. It was not very many.

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**References**