Injury, Int. J. Care Injured 45 (2014) 107–111

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Proper catheter selection for needle thoracostomy: A height and weight-based criteria

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ARTICLE INFO

Article history:
Accepted 28 August 2013

Keywords:
Needle thoracostomy
Body mass index
Obesity

ABSTRACT

Background: Obesity increases the incidence of mortality in trauma patients. Current Advanced Trauma Life Support guidelines recommend using a 5-cm catheter at the second intercostal (ICS) space in the mid-clavicular line to treat tension pneumothoraces. Our study purpose was to determine whether body mass index (BMI) predicted the catheter length needed for needle thoracostomy.

Methods: We retrospectively reviewed trauma patients undergoing chest computed tomography scans January 2004 through September 2006. A BMI was calculated for each patient, and the chest wall thickness (CWT) at the second ICS in the mid-clavicular line was measured bilaterally. Patients were grouped by BMI as underweight ($\leq$18.5 kg/m2), normal weight (18.6–24.9 kg/m^2), overweight (25–29.9 kg/m^2), or obese ($\geq$30 kg/m^2).

Results: Three hundred twenty-six patients were included in the study; 70% were male. Ninety-four percent of patients experienced blunt trauma. Sixty-three percent of patients were involved in a motor vehicle collision. The average BMI was 29 [SD 7.8]. The average CWT was 6.2 [SD 1.9] cm on the right and 6.3 [SD 1.9] cm on the left. As BMI increased, a statistically significant ($p < 0.0001$) CWT increase was observed in all BMI groups. There were no significant differences in ISS, ventilator days, ICU length of stay, or overall length of stay among the groups.

Conclusion: As BMI increases, there is a direct correlation to increasing CWT. This information could be used to quickly select an appropriate needle length for needle thoracostomy. The average patient in our study would require a catheter length of 6–6.5 cm to successfully decompress a tension pneumothorax. There are not enough regionally available data to define the needle lengths needed for needle thoracostomy. Further study is required to assess the feasibility and safety of using varying catheter lengths.

Introduction

Approximately one-third of U.S. adults are obese, with the South having the highest prevalence of obesity consisting of almost 30% of the population [1]. Obesity is likely to affect the outcomes for emergency procedures for obese trauma patients given a body mass index (BMI) >31 kg/m^2 significantly increases the incidence of pulmonary complications and mortality in trauma patients [2]. Needle thoracostomy is an emergency procedure required when a tension pneumothorax is present. Correctly performed, needle thoracostomy can be a life-saving procedure, converting a tension pneumothorax into a simple pneumothorax. The diagnosis of tension pneumothorax before needle decompression relies on clinical signs and is well documented in the Advanced Trauma Life Support® (ATLS) manual/course; however, indications and implementation for the use of needle thoracostomy vary by region and have recently been questioned in the literature [3–5].

Current Advanced Trauma Life Support (ATLS) guidelines recommend using a 5-centimetre (cm) catheter at the second intercostal space (ICS) in the mid-clavicular line for needle thoracostomy [6]; however, in a study by Givens et al. [7], this catheter would only appropriately treat approximately 75% of patients. Other recent work has suggested failure of needle thoracostomy is related to the overall length of the catheter [3,8,9]. Several studies have evaluated using computed tomography (CT) scan and chest wall thickness to determine the cannula length

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0020–1383/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.injury.2013.08.026

needed for needle thoracostomy [4,7–12]. Two studies advocate using a catheter length of 7 cm placed in the second ICS to ensure the pleural space is entered, successful decompression of the tension pneumothorax is achieved, and to minimize the risk of injury to surrounding structures [11,12]. Wax and Leibowitz [11] discovered that increasing weight and BMI correlated with an increasing depth-to-pleura ratio, but this was believed to be clinically insignificant due to the time necessary to calculate this complex relationship in an emergency setting. Our purpose was to determine whether BMI was a predictor of the catheter length needed to properly and effectively perform needle thoracostomy at the second ICS in the mid-clavicular line.

Patients and methods

After Institutional Review Board approval, we retrospectively reviewed the trauma registry at New Hanover Regional Medical Centre in Wilmington, North Carolina using the CPT codes for chest CT scan (71260, 71250, 71270, 71275). Trauma patients with a chest CT scan from January 2004 to September 2006 were included in the study. The records of 682 patients were reviewed; 356 patients were excluded (26 patients had no chest CT, 28 patients' records were not accessible, 84 patients were <18 years old, and 218 patients had no recorded height and/or weight to calculate BMI (Fig. 1). For the 326 patients in the study group, height and weight, mechanism of injury, needle decompressions performed by emergency services personnel, chest tube placement in the emergency department, Injury Severity Score (ISS), Glasgow Coma Score (GCS), ICU days, ventilator days, and length of stay were recorded. BMI was calculated using a standard formula (BMI = [mass (lbs) × 703]/[height (in) [2]]), and the chest wall thickness at the second ICS in the mid-clavicular line was measured. As previously described by Zengerink, the coronal scout film was reviewed and the mid-clavicular line identified. The coronal scout film and the axial images were viewed side-by-side, and a cross reference line was used to identify the second ICS in the mid-clavicular line on the scout film and the axial Images [8]. Patients were then grouped by BMI as underweight (≤18.5 kg/m^2), normal weight (18.6–24.9 kg/m^2), overweight (25–29.9 kg/m^2), or obese (≥30 kg/m^2). Failure rates were calculated based on patients having a measured distance from skin to pleura > 5 cm in the second ICS as described by Sanchez et al. [12].

Data were reported in counts, frequencies, means, standard deviations, medians, and interquartile range. Categorical data were analysed with the X^2 Test of Independence, while numerical variables used the ANOVA, with post hoc analysis done with Fisher's Least Squares Difference or Kruskal Wallis for severely non-normal data. To determine the relationship between BMI and intercostal space, Pearson's correlation was used. All analyses were performed in SAS® 9.1 (SAS Institute, Cary NC), and *p*-values less than 0.05 were considered significant.

Table 1
Patient characteristics.

Characteristic	*N*(%)/mean [SD]
Gender	
Male	228 (69.9)
Female	98 (30.1)
Age (years)	42.6 [19.2]
Body mass index (kg/m^2)	29.0 [7.8]
Right 2nd intercostal space (cm)	6.2 [1.9]
Left 2nd intercostal space (cm)	6.3 [1.9]
Injury type	
Blunt	306 (93.9)
Penetrating	20 (6.1)
Complaint	
Motor vehicle collision	204 (62.6)
Fall	42 (12.9)
Motorcycle crash	25 (7.7)
Pedestrian	14 (4.3)
Gunshot wound	10 (3.1)
Struck	6 (1.8)
Accident	5 (1.5)
ATV	3 (0.9)
Assault	3 (0.9)
Animal	2 (0.6)
Bicycle	2 (0.6)
Unknown	1 (0.3)
Stab wound	9 (2.8)
Pre-hospital needle thoracostomy	1 (0.3)
Injury Severity Score	17.8 [11.0]
ED Revised Trauma Score	10.3 [3.1]
ED Glasgow Coma Score	12.1 [4.9]
Length of stay (days)[a]	7.0 (3.0–15.0)
ICU length of stay (days)[a]	2.0 (0.0–7.0)
Days on ventilator[a]	0.0 (0.0–5.0)

[a] Median (Q1–Q3).

Results

There were CT scans available for 326 patients during the study period. Patients were predominately male (69.9%, Table 1), with a mean age of 42.6 [SD 19.2] years. Almost all had experienced blunt trauma (93.9%). Most patients had been in a motor vehicle collision (62.6%), which rose higher if ATV and motorcycle incidents were included (71.2%).

Patients had a mean Injury Severity Score (ISS) of 17.8 [SD 11.0] (Table 1). On admittance to the Emergency Department, patients had a mean Revised Trauma Score (RTS) of 10.3 [SD 3.1] and Glasgow Coma Score (GCS) of 12.1 [SD 4.9]. The average right 2nd intercostal space (ICS) was measured at 6.2 [SD 1.9] cm, and the left was measured at 6.3 [SD 1.9] cm.

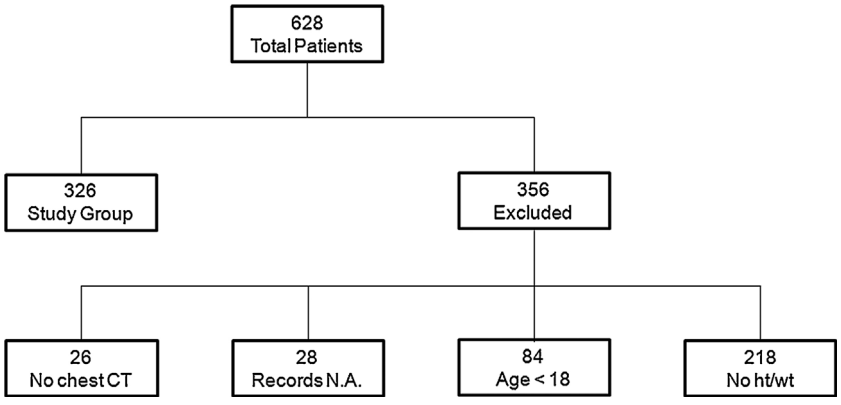

Fig. 1. Patients included or excluded from the study. NA, not accessible; ht, height; wt, weight.