Original Article

Average Chest Wall Thickness at the Point of Needle Decompression in Thai Patients

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Background: Tension pneumothorax is a life-threatening condition, requiring emergent needle decompression. The standard insertion site is the second intercostal space at the midclavicular line (2nd ICS MCL). Recent studies have shown a higher success rate with needle decompression at the fifth intercostal space anterior to axillary line (5th ICS AAL) because the chest wall is thinner at that point. However, no studies about this have been conducted in Thai patients.

Objective: To compare chest wall thickness at the 2nd ICS MCL and the 5th ICS AAL.

Materials and Methods: The present research was a cross-sectional study that reviewed elective computed tomographic angiography (CTA) images of 155 Thai patients over 18 years of age between January 2016 and July 2017. Chest wall thickness was measured from the superficial skin layer to the pleural space at the 2nd ICS MCL and 5th ICS AAL on both sides by a radiologist and an emergency medicine resident.

Results: Average chest wall thickness at the 5th ICS AAL was greater than at the 2nd ICS MCL. Female participants had thicker chest walls than male (p=0.027), and chest wall thickness increased with body mass index (p=0.008). The success rate of needle decompression performed by inserting a 16-gauge catheter at the 2nd ICS MCL was higher than at the 5th ICS AAL.

Conclusion: Chest wall thickness at the 5th ICS AAL was greater than at the 2nd ICS MCL.

Keywords: Tension pneumothorax, Needle decompression, Chest wall thickness, Emergency room, Emergency medicine

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Tension pneumothorax is a life-threatening emergency condition occurs immediately after injury to the chest wall. The incidence is 0.20% to 1.71%[1] and has been found to be the cause of 33% of preventable deadly injuries on the battlefield[2]. Therefore, it is necessary to diagnose and treat the condition quickly based on history, mechanism of injury, and physical examination. There is no need to wait for diagnostic images as this may delay treatment[3]. Treatment is performed by using a needle to penetrate the pleural cavity (needle decompression) and ventilate the lungs. The suggested location for penetration is at the second intercostal space at the mid-clavicular line (2nd ICS MCL)[4-10]. The goal is to achieve 50% to 60% needle decompression[11]. The primary reason for failure of the procedure is insufficient needle length or factors that increase the distance between the skin and the pleura[4]. According to pre-hospital trauma life support eighth edition[12], needle decompression should be performed between the fifth intercostal space anterior to the axillary line (5th ICS AAL) where the chest wall is thinner, as it raises the chances of success[13]. However, chest wall thickness varies by population. There have yet been no studies regarding chest wall thickness conducted in Thailand. Thus, the objective of the present study was to compare chest wall thickness at the 2nd ICS MCL

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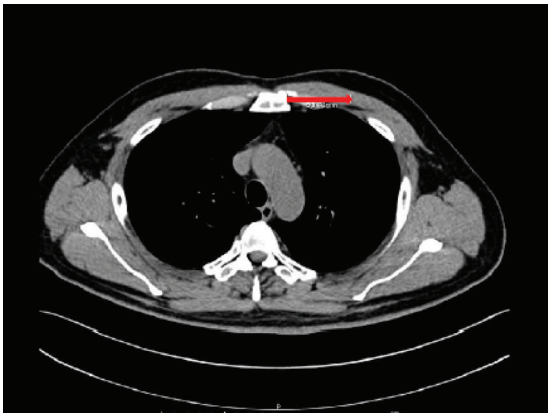

Figure 1. Horizontal line five centimeters from the lateral aspect of the sternum.

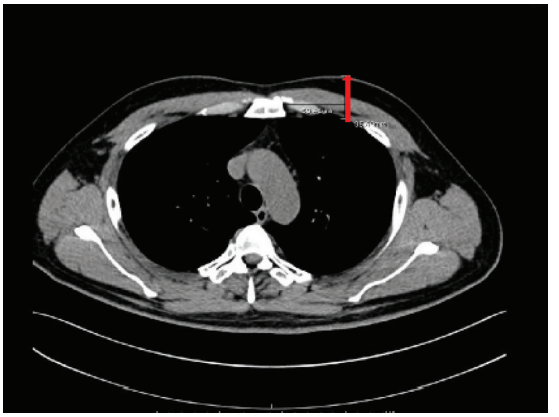

Figure 2. Second line at a 90-degree to the first.

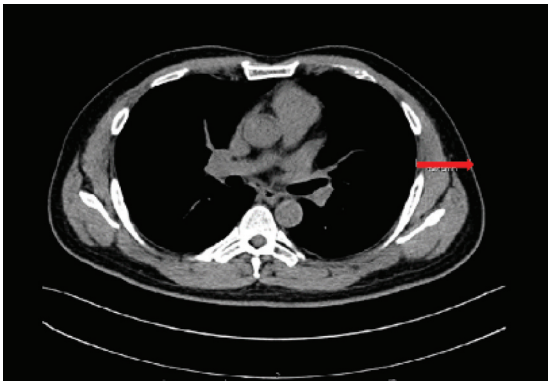

Figure 3. Horizontal distance from the skin to the pleura between the fifth and sixth rib.

and at the 5th ICS AAL in Thai subjects.

Materials and Methods

The present research was a cross-sectional study.

Table 1. Characteristics of the subjects

	n (%)
Age (years), Mean±SD	66.0±11.0
Sex: male	115 (74.1)
BMI (kg/m^2)	
<18.5 (underweight)	30 (20.6)
18.6 to 22.9 (Normal weight)	51 (32.9)
23 to 27.4 (Overweight)	58 (37.4)
>27.5 (Obese)	16 (10.3)

SD=standard deviation; BMI=body mass index

The study sample consisted of 155 patients over 18 years of age that underwent elective computed tomographic angiography (CTA) of the chest at Srinagarind Hospital between January 2016 and July 2017. The exclusion criteria were history of chest surgery, tumor, open chest wound, and anatomical defects. Ethics approval was provided by The Khon Kaen University Ethics Committee for Human Research (HE591443).

The sample size was calculated based on the standard deviation of chest wall thickness reported in a previous study by Schroeder et al[7]. In order to achieve a significance level of 5% and power of test of 0.8, a sample size of 155 would be required.

Statistical analysis was performed using SPSS for Windows version 16.0 (SPSS Inc., Chicago, IL, USA). Categorical data were presented as percentages, and continuous data were presented using mean and standard deviation. Univariable analysis was performed using a two-sample t-test for numerical data and a Pearson's correlation for data relationship between the two groups.

Measurement of chest wall thickness at the 2nd ICS MCL was conducted by drawing a horizontal line five centimeters from the lateral aspect of the sternum (Figure 1) and then drawing another line at a 90-degree angle to the first line to measure the distance from the skin to the pleura (Figure 2).

Chest wall thickness at the 5th ICS AAL was measured as the horizontal distance from the skin to the pleura between the fifth and sixth rib in the vertical direction (Figure 3).

Results

One hundred fifty-five subjects were examined. The characteristics are shown in Table 1. The mean age of the patients was 66.0±11.0 years and 74.1% (n=115) were male. The most common body mass index (BMI)

Table 2. Chest wall thickness by sex

Sex	Chest wall thickness (cm), Mean±SD					
	Right			Left		
	2nd ICS MCL	5th ICS AAL	p-value	2nd ICS MCL	5th ICS AAL	p-value
Male (n=115)	2.52±0.73	3.38±1.15	0.025*	2.49±0.75	3.25±1.15	0.030*
Female (n=40)	3.26±1.18	4.52±1.83	0.027*	3.23±1.21	4.54±1.89	0.020*

SD=standard deviation; 2nd ICS MCL=second intercostal space at the midclavicular line; 5th ICS AAL=fifth intercostal space anterior to the axillary line

* Statistical significance

Table 3. Chest wall thickness by BMI

BMI (kg/m^2)	Chest wall thickness (cm), Mean±SD			
	Right		Left	
	2nd ICS MCL	5th ICS AAL	2nd ICS MCL	5th ICS AAL
Underweight	1.72±0.41	2.31±0.91	1.69±0.43	2.23±0.64
Normal weight	2.38±0.49	3.12±0.98	2.31±0.53	2.92±0.90
Overweight	3.24±0.72	4.31±0.89	3.23±0.78	4.22±1.01
Obese	3.75±1.03	5.73±1.66	3.74±0.91	5.97±1.59
p-value	0.008*	0.012*	0.006*	0.010*

SD=standard deviation; BMI=body mass index; 2nd ICS MCL=second intercostal space at the midclavicular line; 5th ICS AAL=fifth intercostal space anterior to the axillary line

* Statistical significance

Table 4. Comparison of chest wall thickness at the 2nd ICS MCL and 5th ICS AAL

	Chest wall thickness (cm), Mean±SD				
	2nd ICS MCL	5th ICS AAL	Mean difference	95% CI	p-value
Right	2.714±0.92	3.677±1.44	0.963±1.01	–1.123 to –0.804	0.015*
Left	2.681±0.95	3.586±1.48	0.905±0.98	–1.060 to –0.748	0.018*

SD=standard deviation; CI=confidence interval; 2nd ICS MCL=second intercostal space at the midclavicular line; 5th ICS AAL=fifth intercostal space anterior to the axillary line

* Statistical significance

range was 23 to 27.4 (overweight), followed by 18.6 to 22.9 (normal) and less than 18.5 (underweight).

Analysis of chest wall thickness at the 2nd ICS MCL and 5th ICS AAL by gender revealed that female patients had significantly greater chest wall thickness than male participants (Table 2). Also, there was a statistically significant increase in chest wall thickness relative to BMI (Table 3).

Comparison of the thickness of the chest wall at each of the two positions revealed that the chest wall was significantly thicker at the 5th ICS AAL than at the 2nd ICS MCL on both sides (p=0.015) (Table 4).

The predicted success rate using a five-centimeter needle to drain the air from the pleura at the 2nd ICS MCL was higher than at the 5th ICS AAL, as shown in Table 5.

Relation of success rate for needle decompression both sides with BMIs at the 2nd ICS MCL and the 5th ICS AAL was statistically significant (p<0.001), as shown in Table 6.

Discussion

The present study found that the average chest wall thickness at the 5th ICS AAL was significantly greater than at the 2nd ICS MCL, consistent with the results of previous studies[7,11,13]. A study by Sanchez et al[13] in which the chest wall thickness was measured with patients lifting both arms, found that the average

Table 5. Prediction of success rate by insertion location

	Success rate (chest wall thickness <5 cm)	
	2nd ICS MCL	5th ICS AAL
Right	97.42%	84.52%
Left	96.13%	85.16%

2nd ICS MCL=second intercostal space at the midclavicular line; 5th ICS AAL=fifth intercostal space anterior to the axillary line

Table 6. Relation of success rate for needle decompression with BMIs

	2nd ICS MCL	5th ICS AAL	p-value
Right	0.7593	0.7702	<0.001
Left	0.7424	0.8041	<0.001

BMI=body mass index; 2nd ICS MCL=second intercostal space at the midclavicular line; 5th ICS AAL=fifth intercostal space anterior to the axillary line

Pearson's correlation (r)=0.87

chest wall thickness was greater than that found in the present study. This may be due to a previous study conducted in Caucasian patients, who tend to have higher BMIs and more fat than those of Asian descent[4]. A study by McLean et al[11] found that chest wall thickness at the 4th ICS AAL was significantly greater than at the 2nd ICS MCL. However, the value may be because of the participants, which were healthy doctors and medical students, and having the skin pressed by the ultrasound. Many studies have found chest wall thickness at the 2nd ICS MCL to be thicker than at the 5th ICS AAL[2,4,6,8,9]. These studies were conducted in injured patients who may have had subcutaneous emphysema, soft tissue edema, soft tissue hematoma, or who were average younger than those in the present study.

When analyzing the data by gender, the authors found the female participants had thicker chest walls than males, which is consistent with the results of previous studies[2,4,6,7,10,14-16]. This is because women have more soft breast tissue than men.

The authors also found that increased BMI had a statistically significant connection to greater chest wall thickness, which is also consistent with the previous studies[4-7,11,16,17]. This is due to the greater amounts of chest fat in obese patients. Needle decompression was conducted using a number-16 needle with a length of five centimeters[18]. There was a greater predicted chance of success when the needle was inserted at the 2nd ICS MCL than at the 5th ICS AAL (96.13% to 97.42% versus 84.52% to 85.16%). The result is consistent with those of the study by Sanchez et al[13], which found that the failure rate for decompression at the 2nd ICS MCL was 33.6% and at the 5th ICS AAL was 55.3%. However, the present study was limited as it did not examine patients who had been injured. These patients may have greater chest wall thickness due to subcutaneous emphysema, soft tissue edema, soft tissue hematoma, or not being able to raise both arms during the procedure according to the standard CTA protocol. The actual chest wall thickness may deviate from the values obtained from the measurement of chest wall thickness in the present research.

Conclusion

The present study found that the average chest wall thickness at the 2nd ICS MCL was lower than at the 5th ICS AAL, and there was a higher predicted success rate for decompression at the former site than at the latter. The women in the study exhibited greater chest wall thickness than the men. In addition, chest wall thickness increased with BMI.

What is already known on this topic?

Tension pneumothorax is a life-threatening condition, requiring emergent needle decompression. The standard insertion site is the 2nd ICS MCL. Recent studies have shown a higher success rate with needle decompression at the 5th ICS AAL because the chest wall is thinner at that point.

What this study adds?

Average chest wall thickness at the 2nd ICS MCL was lower than at the 5th ICS AAL, and there was a higher predicted success rate for decompression at the former site than at the latter. The women in the study exhibited greater chest wall thickness than the men. In addition, chest wall thickness increased with BMI.

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Conflicts of interest

The authors declare no conflict of interest.

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