Comparison of ultrasonography and surface landmarks in detecting the localization for cricothyroidotomy

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Abstract

Objective: The aim of the study was to compare ultrasonography (US) and surface landmark techniques for detecting the cricothyroid membrane (CTM) to perform a cricothyroidotomy on healthy volunteers.

Methods: In this prospective observational study, 5 operators and 24 models were included. The borders of the CTM were marked with an invisible pen. The operators were asked to point the CTM either with the palpation method or the US-guided fashion.

Results: The CTM was detected accurately in 80 (66.7%) attempts with palpation and 83 (69.2%) attempts with US. There was no statistically significant difference in the accuracy of detection of the CTM with palpation and US. The mean time for detecting the CTM with palpation was 8.25 ± 4.8 seconds (95% confidence interval, 7.3-9.1). The mean time for detecting CTM with US was 17 ± 9.2 seconds (95% confidence interval, 15.3-18.7).

Conclusion: According to the results of this study, the accuracy of US and palpation was similar in detecting the localization of the CTM. However, the duration for detecting the CTM was longer with US when compared with the palpation technique.

1. Introduction

The incidence of difficult airways in the emergency medicine literature ranges from 2% to 14.8%; the incidence of surgical airways is much lower than that, at 0.06% [1].

The surgical airway is an infrequently needed yet important procedure, as complications during this procedure may result in morbidity and mortality. Although the cricothyroid membrane (CTM) is superficial and surface landmarks are easily palpated, patients suffering from obesity, patients with short necks, as well as those with secondary conditions affecting the neck region, such as subcutaneous emphysema or previous surgery, may all complicate the situation and may also increase the complication rates of the surgical airway procedure. In those cases where an emergency airway is needed, multiple attempts may not only prolong the hypoxia time but also lead to complications.

Ultrasoundography (US) is being used for a variety of purposes in the practice of emergency medicine. Ultrasoundography has gained popularity in the evaluation of airways, with a previous study demonstrating that emergency physicians can obtain the CTM 100% of the time [2]. Real-time screening of the related landmarks during surgical airway may be useful, particularly in patients with obscure neck anatomy [3].

In this study, the aim was to compare US and surface landmark techniques for detecting the CTM to perform a cricothyroidotomy on healthy volunteers.

2. Materials and methods

This prospective observational study was performed in a tertiary care facility with 90,000 annual ED patient visits. The study has been approved by the institutional review board (09.04.2013/75). All operators and participants gave their informed consent before the study.

2.1. Study protocol

A Sonosite-M-Turbo bedside US machine with a linear transducer was used (Sonosite Inc, Bothell, WA) to identify the CTM. The participants were prepared for the study according to the protocol mentioned below [2,4]. The physicians completing the protocol were an attending emergency physician (EP) and a fourth-year resident of emergency medicine.

1. The neck of the participants was supported with a pillow in a slightly extended fashion.
2. The transducer was positioned just lateral to the midline in the longitudinal orientation with the probe marker toward the head. The thyroid and cricoid cartilage were identified, and the borders of CTM were marked with an invisible pen.
3. The transducer was rotated 90°, and the borders of the CTM were again marked with an invisible pen.
4. The anterior neck region was covered with an 11*14-cm occlusive dressing (Leukomed T; BSN Medical GmbH, Hamburg, Germany).

Five operators and 24 participants were included in this study. Participants with instances of previous neck surgery or neck deformity...
were excluded from the study. A brief surgical airway anatomy and US training to detect the CTM was given to the operators before initiating the study. Firstly, they were told to hold the linear transducer in their nondominant hand in the longitudinal orientation just lateral to the midline, with the probe marker toward the patient’s head to identify the CTM; to center it on the screen; and to draw a horizontal line on the occlusive dressing with a board marker. Secondly, they were told to rotate the probe 90° without lifting their hands so that the probe marker pointed to the operator’s left and the CTM was again centered in the screen, and a second perpendicular line, crossing the first line, was created (Figure A-C and D).

The borders of the CTM were drawn with an invisible pen before the study, and an occlusive dressing was applied to the anterior neck region. The spot on the occlusive dressing was wiped clean between each participant. Operators were asked to identify the CTM of the model with palpation and US technique, respectively, and point out the CTM with a board marker. After every attempt, the point estimate of the operator—to reveal the CTM—was evaluated with the revealer light of the invisible pen while the operators were away from the models.

Data regarding the accuracy of palpation and US method, as well as the duration of procedures and body mass index (BMI) and neck circumference of the participants, were measured and recorded. The duration of the procedure was recorded as the time from first palpation of the neck with hand or US probe to the marking of the CTM puncture site [4,5].

2.2. Statistical analysis

The study data were analyzed in SPSS 16.0 for Windows (SPSS Inc, Chicago, IL). Demographic and baseline characteristics were summarized as a mean ± SD for continuous variables and as a percentage of the group for categorical variables. Nonnormally distributed data are presented as medians (interquartile range [IQR]). The normality analysis was performed with the Kolmogorov-Smirnov test. The duration for detecting the CTM was not normally distributed, and the Mann-Whitney U test was performed to test the significance of pairwise differences. The \( \chi^2 \) was used to compare the categorical data. A \( P \) value of less than .05 was considered significant.

3. Results

Five operators (3 PGY4 and 2 PGY2) and 24 participants (8 female and 16 male) were included in this study. The mean age of the models was 24.4 ± 5.1 years. The mean BMI was 23.8 (20.8–26.1), and the median neck circumference was 37.1 ± 3.8 cm. Seventeen of the participants were of normal weight, 6 participants were overweight, and only 1 of them was categorized as obese according to their BMI calculation. The CTM was detected accurately in 80 (66.7%) attempts with palpation and 83 (69.2%) attempts with US. There was no statistically significant difference in the accuracy of detecting the CTM with palpation and US. The mean time for detecting the CTM with palpation

Figure. A-C, Methods of marking CTM with US. D, Left parasagittal scan through the CTM using a linear transducer. The sonogram shows the CTM, CC, and TC. TC: thyroid cartilage, CC: cricoid cartilage, CTM: cricothyroid membrane.
was 8.25 ± 4.8 seconds (95% confidence interval [CI], 7.3-9.1 seconds). The mean time for detecting CTM with USG was 17 ± 9.2 seconds (95% CI, 15.3-18.7). The duration for detecting the localization of the CTM was longer with the US.

4. Discussion

According to the results of this study, the accuracy of the US and palpation was similar for detecting the localization of the CTM. The duration for detecting the CTM was, however, longer with the US when compared with the palpation technique.

Previous studies reported that the complication rate for surgical cricothyroidotomy is between 6.1% and 54.5% [6]. Misplacement of the palpation was similar for detecting the localization of the CTM. The procedure was longer with the US.

An important complication of the airway into the trachea was achieved in 88% of cases with the Seldinger technique and 84% with the surgical cricothyroidotomy method [8]. In our study, successful palpation of the CTM correlated with the previous studies but was higher than the study of Elliot et al; the reason may be that the cricothyroidotomy is a procedure performed in the ED rather than the operation room.

Ultrasonography has been shown to correctly identify the CTM in patients after those administering it have received a brief period of training on cadavers. According to this study, the CTM, cricoid cartilage, thyroid cartilage, first tracheal ring, and thyroid gland were identified along with US in all 50 participants. The mean time to visualization of the CTM was 24.32 ± 20.18 seconds (95% CI, 18.59-30.05 seconds). Although a significant relationship between palpation difficulty and BMI was noted, BMI did not impact on physician ability to identify the CTM. In this study, the US procedure was only performed by 2 EPs, both of whom declared a special interest in this procedure, in contrast to the EPs in our study, who generally had various levels of US experience and training [2]. The mean time to visualize the CTM was similar between the studies.

In the study of Curtis et al describing a novel technique—US-guided, bougie-assisted cricothyroidotomy on cadavers—there was only 1 failure out of 21. The median time to visualize the CTM was 3.6 [IQR, 1.9-15.3] seconds, and the median time to endotracheal intubation was 26.2 [IQR, 10.7-50.7] seconds. According to this study, there was no relation between BMI and the completion of the procedure [2,9]. In their study, they simplified the procedure: the linear transducer was oriented longitudinally, and CTM was centered on the screen, whereas a single horizontal incision was performed for cricothyroidotomy. This technique shortened the duration of the procedure and might increase the overall success rate, but it should be noted that the operators performing the procedure were experienced US fellowship-trained EPs.

A study measuring the accuracy of US-guided marking of the CTM before failed intubation indicated that the marking of CTM of healthy volunteers before simulated intubation accurately identifies the CTM [5].

4.1. Limitations

This study has several limitations; initial detection of CTM does not mean that cricothyroidotomy will be successful. In addition, a prospective study design is almost impossible for this rare procedure, and the controlled environment of laboratory may not be translated to real-life scenarios. Although previous studies showed that BMI is not an important issue in cases of US-guided procedure, a similar study with a larger BMI may show differences in terms of palpation and US-guided methods [9].

Previous studies demonstrated better results of locating the CTM with US, as most of these studies were done by ED physicians experienced in airway anatomy [2,9]. Our US operators were ED residents who had less experience with the US anatomy of the airway, and we believe that our result reflects the common practice of US in general EDs because ED physicians who train US fellows are unavailable in most of the EDs.

Despite this being an infrequently needed procedure, EPs will almost certainly face this emergency airway situation once or twice in their lifetime, and in the case of a difficult airway marker, a technique such as US marking of the CTM with static technique, or US-guided bougie-assisted methods, may be preferential; educational efforts should therefore focus on these techniques.

References