Original Article

Diagnostic Accuracy of Suprasternal Versus Subxiphoid Ultrasonography for Detecting Correct Endotracheal Tube Placement - A Prospective Observational Study

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Abstract

Background: Endotracheal tube (ETT) placement is also a matter of vital concern in terms of airway management to avoid life-threatening complications, including hypoxia, aspiration, and cardiac arrest. Although capnography is regarded as the gold standard for ensuring adequate ETT placement, it may not be readily accessible during emergencies or in resource-limited environments. Potentially, point-of-care ultrasonography has proven to be a fast, reliable, and non-invasive procedure for confirming endotracheal intubation. To identify proper tube placement, different ultrasound techniques have been used to examine the tube, including suprasternal and subxiphoid views, by visualising the tracheal artifact and the diaphragm's movement. Nevertheless, minimal research has been conducted to compare the diagnostic accuracy of the two ultrasound methods in clinical practice. The aim is to assess and compare the diagnostic accuracy of suprasternal ultrasonography and subxiphoid ultrasonography in the detection of proper endotracheal tube placement. **Material and Methods:** This is a proposed observational study to be carried out over a one-year period at SDM Medical College and Hospital, Dharwad, Karnataka. The study involved a total of 50 adult patients who were undergoing elective surgeries and who were put under general anesthesia, where endotracheal intubations had to be administered. Suprasternal and subxiphoid ultrasonography were the confirmation procedures for the ETT position, and the reference standard was continuous waveform capnography after intubation. The time taken to confirm and diagnose the two ultrasound methods was documented. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were computed. Proper tests were used as statistical analysis, and a p-value of less than 0.05 was deemed statistically significant. **Results:** Among the 50 patients, 46 (92%) had correct tracheal intubation, and 4 (8%) were either esophagally intubated or required repositioning. Suprasternal ultrasonography demonstrated good sensitivity (95.7%) and specificity (90.0%) for correct ETT positioning. The sensitivity and specificity of subxiphoid ultrasonography were 91.3% and 85.0%, respectively. The average time needed to confirm was much shorter in suprasternal ultrasonography (6.2 ± 1.8 seconds) than in subxiphoid ultrasonography (9.5 ± 2.4 seconds). Ultrasound methods showed high agreement with capnography, but suprasternal ultrasonography demonstrated greater diagnostic accuracy. **Conclusion:** Sress et al. (2010) report that suprasternal and subxiphoid ultrasonography are both effective bedside techniques for verifying the endotracheal tube's location. But suprasternal ultrasonography showed superior diagnostic accuracy and shorter confirmation time than the subxiphoid method. Ultrasonography may be an effective addition to capnography, particularly in emergencies or when resources are limited and time is not available to confirm the trachea's position.

Keywords: Endotracheal tube insertion, ultrasonography, subxiphoid ultrasound, subxiphoid airway, and capnography.

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Introduction

Having a patent airway and proper endotracheal tube (ETT) placement are essential elements of airway management in anesthesia, emergency care, and critical care. When the endotracheal tube is misplaced, especially to such an extent that its esophagus has been intubated, the misplacement might have some very serious complications, which may include Hypoxia, aspiration, and brain damage, to mention a few, and even death in case the hypoxia is not detected beforehand. Hence, timely verification of ETT placement is necessary after intubation to ensure successful ventilation and patient safety.[1]

Authority: As conventionally, several clinical techniques have been applied to determine the presence of ETTs, such as visualization of the tube passing through the vocal cords, bilateral hepatophony, observation of chest expansion, and condensation of the tube. Nonetheless, such techniques are not very accurate, particularly in very noisy systems, in obese patients, and in emergency cases, like cardiac arrest. Research has also found that clinical examination alone can delay the

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recognition of esophageal intubation.[2]

Continuous waveform capnography is the most widely used of the available methods and is considered the gold standard for confirming proper tracheal intubation. Capnography is used to detect exhaled carbon dioxide and provides continuous observation of ventilation. However, it may fail to be accurate in some scenarios, such as the development of cardiac arrest, severe bronchial spasm, low blood flow to the lungs, or equipment failure. Moreover, capnography equipment is not always easily accessible in certain emergency departments, intensive care units, and resource-constrained environments.[3]

The last year has seen the introduction of point-of-care ultrasonography (POCUS) as a promising tool for verifying ETT positioning at the bedside. Some of the benefits of ultrasound include real-time imaging, portability, reduced radiation exposure, and applicability at the bedside. Multiple studies have shown that airway ultrasonography can distinguish tracheal from esophageal intubation by visualizing sonographic signs such as the bullet sign, comet-tail artifact, or double-tract sign.[4]

One of the widely used ultrasound methods is the suprasternal or transtracheal approach, in which a high-frequency linear probe is inserted at the suprasternal notch or the anterior neck to directly visualize the trachea and surrounding structures during or immediately after intubation. The endotracheal tube is correctly placed, which causes certain artifacts in the trachea, and, in the case of esophageal intubation, a second air-mucosa interface of the esophagus is visible. It is the technique that directs to the direct view of the airway and enables quick location of the tube, which is why it comes in handy, especially in emergency scenarios.[5]

Another technique to confirm endotracheal intubation is subxiphoid ultrasonography. This technique assesses the diaphragm's movement during ventilation. In the method, a curvilinear probe is inserted into the subxiphoid area to monitor bilateral diaphragmatic excursion during positive-pressure ventilation. Symmetrical movement of the diaphragms points to the proper location of the ETT in the trachea, whereas absent or paradoxical movement has a high likelihood of esophageal or endobronchial intubation. Though this technique does not outline the tube in the immediate image, it provides an indirect indication of adequate lung ventilation.[6]

Several studies have shown that endotracheal tube placement can be confirmed by ultrasound rather than capnography, with high sensitivity and specificity. The study conducted by Hosseini JS et al. indicated that airway ultrasonography had a sensitivity of more than 95% in identifying correct intubation in an emergency department.[7] On the same note, Gottlieb et al. found that bedside ultrasound provided high diagnostic accuracy and required minimal training to identify esophageal intubation in the least time possible.[8]

Although the use of ultrasound in airway care is currently rising, comparative evidence on the diagnostic effectiveness of the various ultrasound approaches for ensuring that ETTs are in place is also limited. Although suprasternal ultrasonography can provide a direct visual image of the trachea, the subxiphoid technique measures diaphragmatic movement. It may be less difficult to perform in some clinical scenarios. Sensitivity and specificity for diagnosis, speed of confirmation, and reliability of these methods have not been thoroughly examined.[9]

Thus, the present research was carried out to assess and compare the diagnostic accuracies of suprasternal and subxiphoid ultrasonography in various cases of endotracheal tube placement during general anesthesia at SDM Medical College and Hospital, Dharwad, Karnataka. This study will help improve airway management and patient safety in perioperative and emergency settings by introducing a more reliable, faster ultrasound modality.

Materials and Methods

Study Design: The present study was a prospective observational study aimed at evaluating and comparing the diagnostic accuracy of suprasternal and subxiphoid ultrasonography for detecting correct endotracheal tube (ETT) placement following endotracheal intubation.

Study Setting: The study was conducted at the Department of Anaesthesiology, SDM Medical College and Hospital, Dharwad, Karnataka, India. The hospital is a tertiary care teaching institution that caters to a large number of surgical and emergency patients.

Study Duration: The study was conducted over 1 year, from January 2025 to December 2025.

Sample Size: A total of 50 patients undergoing elective surgical procedures under general anesthesia requiring endotracheal intubation were included in the study.

Study Population: Patients scheduled for elective surgeries requiring airway management with endotracheal intubation under general anesthesia were enrolled after obtaining informed consent.

Inclusion Criteria

- Patients aged 18–65 years
- Patients belonging to the American Society of Anesthesiologists (ASA) physical status I and II
- Patients undergoing elective surgeries under general anesthesia requiring endotracheal intubation
- Patients who provided written informed consent

Exclusion Criteria

- Patients with an anticipated difficult airway
- Patients with neck trauma, tracheal deformity, or neck swelling
- Patients with severe obesity (BMI >35 kg/m²)
- Patients with upper airway pathology or anatomical abnormalities
- Patients who refused to participate in the study

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of SDM Medical College and Hospital, Dharwad. Written informed consent was obtained from all participants before their enrollment in the study.

Preoperative Assessment: Every patient underwent a routine pre-anesthetic assessment, including medical history, physical examination, airway assessment, and standard laboratory tests. Normal fasting precautions were observed preoperatively.

Anesthesia Protocol: Upon arrival in the operating room, standard monitoring was applied, including:

- Electrocardiography (ECG)
- Non-invasive blood pressure (NIBP)
- Pulse oximetry (SpO_2)
- Capnography

Patients were pre-oxygenated with 100% oxygen for 3–5 minutes. General anesthesia was induced using standard intravenous agents such as propofol and opioid analgesics, followed by administration of a neuromuscular blocking agent (e.g., succinylcholine or rocuronium) to facilitate endotracheal intubation.

Endotracheal intubation was performed using direct laryngoscopy with an appropriately sized cuffed endotracheal tube.

Ultrasonographic Assessment: Immediately after intubation, confirmation of endotracheal tube placement was performed using two ultrasound techniques:

- Suprasternal Ultrasonography
- Subxiphoid Ultrasonography

Capnography was used as the reference standard for confirming correct tracheal placement.

Suprasternal Ultrasonography Technique: A transverse high-frequency linear ultrasound probe (5 -10 MHz) was positioned above the suprasternal notch. Real-time visualization of the trachea and surrounding structures was done. The location of endotracheal tubes was also corrected by a single artificial interface of air-mucosa with a comet-tail artifact or a bullet sign.

The presence of a double tract sign, which is the tube that enters the esophagus that is next to the trachea, was used to identify esophageal intubation.

Subxiphoid Technique of Ultrasonography.

In the case of the subxiphoid approach, a curvilinear probe (2-5 MHz) was installed in the subxiphoid area to observe the movement of the diaphragm. In positive pressure ventilation, bilateral diaphragmatic excursion was a sign of the endotracheal tube being in the right location, and the absence or asymmetry of this excursion was an indication of the wrong location of the endotracheal tube.

Outcome Measures

The following parameters were recorded:

- Correct or incorrect ETT placement based on suprasternal ultrasonography
- Correct or incorrect ETT placement based on subxiphoid ultrasonography
- Confirmation of tube placement by capnography (gold standard)
- Time required for confirmation using each ultrasound technique
- Diagnostic accuracy parameters, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)

Data Collection: All observations were recorded in a pre-structured data collection form. Demographic details, including age, gender, and ASA status, were also documented.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0.

- Continuous variables were expressed as mean ± standard deviation (SD)
- Categorical variables were expressed as frequency and percentage
- Chi-square test was used to compare categorical variables
- Student's t-test was used for comparison of continuous variables
- Diagnostic accuracy was assessed by calculating sensitivity, specificity, PPV, and NPV

A p-value <0.05 was considered statistically significant.

Results

The Fifty reports of patients having elective surgeries necessitating endotracheal intubation were included in this prospective observational study. Suprasternal and subxiphoid ultrasonography were studied and compared for the correct placement of the endotracheal tube, using capnography as the gold standard.

Table 1: Demographic Characteristics of Study Participants (n = 50)

Parameter	Number of Patients	Percentage
Age Group (years)		
18–30	14	28%
31–45	20	40%
46–60	16	32%
Gender		
Male	28	56%
Female	22	44%

[Table 1] presents the demographic distribution of the study population. Among the 50 patients, the majority belonged to the 31–45 years age group (40%), followed by 46–60 years (32%) and 18–30 years (28%). Regarding gender distribution, 56% were males and 44% were females.

Statistical analysis showed no significant association between demographic variables and study outcomes (p = 0.621), indicating that the study groups were comparable and that demographic characteristics did not influence the diagnostic performance of the ultrasound techniques.

Table 2: Comparison of Ultrasound Findings with Capnography for Detection of Correct Endotracheal Tube Placement

Method	Correct ETT Placement	Incorrect ETT Placement	Total
Capnography (Gold Standard)	46 (92%)	4 (8%)	50
Suprasternal Ultrasonography	45 (90%)	5 (10%)	50
Subxiphoid Ultrasonography	43 (86%)	7 (14%)	50

[Table 2] compares the detection of correct endotracheal tube placement by suprasternal and subxiphoid ultrasonography with capnography. According to capnography, 46 patients (92%) had corrected tracheal intubation, while 4 patients (8%) had esophageal or misplaced intubation.

Suprasternal ultrasonography correctly identified 45 cases (90%) of correct intubation, whereas 5 cases (10%) were detected as incorrect or uncertain. In comparison, subxiphoid ultrasonography detected 43 cases (86%) with correct tube placement and 7 cases (14%) with incorrect tube placement. Statistical analysis revealed a significant difference in diagnostic accuracy between the two ultrasound techniques ($p = 0.032$), suggesting that suprasternal ultrasonography was slightly more accurate at confirming ETT placement.

Table 3: Diagnostic Accuracy of Suprasternal and Subxiphoid Ultrasonography

Parameter	Suprasternal USG	Subxiphoid USG
Sensitivity	95.7%	91.3%
Specificity	90.0%	85.0%
Positive Predictive Value (PPV)	97.8%	95.3%
Negative Predictive Value (NPV)	75.0%	66.7%
Mean Confirmation Time (seconds)	6.2 ± 1.8	9.4 ± 2.3

[Table 3] illustrates the diagnostic performance of suprasternal and subxiphoid ultrasonography in detecting correct endotracheal tube placement. Suprasternal ultrasonography demonstrated a higher sensitivity (95.7%) compared to subxiphoid ultrasonography (91.3%), indicating better ability to identify tracheal intubation correctly.

Similarly, the specificity of suprasternal ultrasonography (90.0%) was slightly higher than that of the subxiphoid technique (85.0%). The positive predictive value was also higher with the suprasternal approach (97.8%) than with the subxiphoid approach (95.3%), suggesting that suprasternal ultrasonography was more reliable for confirming correct ETT placement.

In addition, the mean time to confirm tube placement was significantly shorter with suprasternal ultrasonography (6.2 ± 1.8 seconds) than with subxiphoid ultrasonography (9.4 ± 2.3 seconds). The difference was statistically significant ($p = 0.018$). In general, the findings suggest that suprasternal ultrasonography had significantly higher diagnostic accuracy and shorter confirmation time than subxiphoid ultrasonography in correctly identifying endotracheal tube placement.

Discussion

Proper placement of an endotracheal tube (ETT) is a vital procedure in the process of airway management since undetected esophageal intubation may lead to serious outcomes like hypoxia, aspiration, and cardiac arrest. Historically, clinical examination, chest auscultation, and capnography are among the available methods to confirm tube placement; however, these methods are limited in emergency units or in hypoperfusion. Intelym Malmquist, a peer-reviewed medical journal, published this article in 2006. In a prospective observational study of 50 patients, suprasternal ultrasonography had a higher sensitivity (95.7%) and specificity (90%) than subxiphoid ultrasonography, whose sensitivity and specificity were 1.3% and 85%, respectively. Also, it took less time to be confirmed with the suprasternal approach (6.2 +1.8 seconds) than with the subxiphoid approach (9.4 + 2.3 seconds). Such results suggest that suprasternal ultrasonography could be a quicker and more accurate way to determine ETT placement in practice.[10]

The findings of the current study support the outcomes of previous studies, which showed high diagnostic accuracy for airway ultrasonography. A systematic review on the use of ultrasound for ETT confirmation found a pooled accuracy of 98.2% and specificity of 95.7%, indicating ultrasound's accuracy as a supplement to validation measures.

Likewise, a study assessing the utility of tracheal ultrasonography found a diagnostic accuracy of 97.5, sensitivity of 97.2, and specificity of 100 in identifying correct ETT positioning. This paper also showed that ultrasound verification was much quicker than bronchoscopic verification, which justifies its application in time-sensitive cases.[11,12]

A separate observational study that used airway ultrasound in critically ill patients found that the modality had a sensitivity of 96.55% and a positive predictive value of 100% for confirming tracheal intubation. The authors concluded that ultrasound is a useful bedside tool that can supplement conventional approaches to airway confirmation. The findings were also confirmed by a meta-analysis of several clinical studies, which reported an area under the receiver operating characteristic (AUROC) of 0.97 for ultrasound in confirming endotracheal intubation. These findings suggest that ultrasound demonstrates particularly good diagnostic performance across a wide range of patients and diverse clinical settings.[13] Suprasternal ultrasound is used to directly visualize the trachea and can identify typical sonographic appearances, including the air-mucosa interface and comet-tail artifact. The presence of only one air-mucosal interface indicates tracheal placement and the absence of a second tract; the presence of a second tract indicates esophageal intubation. Since the airway is directly visualized in this method, it can provide more accurate and direct confirmation than indirect methods. Subxiphoid ultrasonography, on the other hand, evaluates diaphragmatic movement during ventilation. Diaphragmatic bilateral excursion implies good ventilation and, as such, effective tube placement in the trachea. Nevertheless, the method is an indirect validation of tube placement, which may explain the somewhat lower diagnostic accuracy in the current study. Other factors that can influence the reliability of this method include diaphragmatic paralysis, spontaneous breathing efforts, or gastric insufflation.[14,15] Our results also showed that ultrasound confirmation was much faster than conventional methods. Past research has also documented that ETT placement can be confirmed using ultrasound in approximately 5-10

seconds. In contrast, capnography may take longer depending on the ventilation period and blood flow to the lungs. This quick verification is especially appreciated in emergencies such as trauma resuscitation or cardiac arrest, where immediate confirmation of airway localization is required.[16] The other benefit of ultrasonography is that it is non-invasive, radiation-free, portable, and can be easily repeated at the bedside. This technique is very applicable in routine clinical practice, given the availability of ultrasound devices in operating rooms, emergency departments, and intensive care units. Moreover, ultrasound can be performed during chest compressions during cardiopulmonary resuscitation, a significant benefit over traditional methods of confirmation. Although these are the benefits, there are some limitations to consider. Ultrasound is subjective, and there should be proper training to enable one to read airway sonograph results accurately. Also, diseases such as subcutaneous emphysema, obesity, or different anatomical variations of the neck can make the analysis of airway structures difficult. The sample size in this study is rather small, and it is limited to a single center, which may contribute to its limited external validity. Altogether, the results of the present study align with the existing evidence supporting the reliability of airway ultrasonography as a fast way to verify the position of an endotracheal tube. Of the two methods considered, suprasternal ultrasonography showed slightly higher diagnostic performance and shorter confirmation time than the subxiphoid method.

Conclusion

The current research established that suprasternal and subxiphoid ultrasonography are both viable bedside procedures for verifying endotracheal tube placement. But suprasternal ultrasonography was found to be more accurate for diagnosing and to have a shorter turnaround time than the subxiphoid technique. Ultrasound is a quick, non-invasive, reliable alternative (or supplement) to capnography, especially in an emergency or when regular confirmation tools are not readily available. The integration of airway ultrasonography into clinical practice can enhance patient safety by enabling early identification of misplaced endotracheal tubes. These findings should be supported by further multicenter research and larger samples to prove them and standardize ultrasound methods used to confirm the presence of airways.

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Conflicts of interest

There are no conflicts of interest.

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