Section: Anesthesiology

Original Research Article

# EVALUATION OF EFFICACY OF TRANSTRACHEAL AND LUNG ULTRASOUND FOR CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT IN ANAESTHETIZED PATIENT

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## Abstract

**Background:** Securing the airway of the patient is a crucial and fundamental skill of an anaesthesiologist. Unrecognized esophageal intubation is a significant source of mortality and morbidity. Confirming ETT placement early is of paramount importance in preventing hypoxia and its consequences. Ultrasound is an efficacious tool with some advantages over capnography. It can be performed rapidly, offers a real-time view, does not require ventilation of the patient and is independent of the pulmonary blood flow. The objective is to evaluate and compare transtracheal and lung ultrasound with conventional methods for confirmation of ETT placement in terms of rapidity and accuracy. **Materials and Methods:** This study was carried out from January 2017 till August 2018 in 144 patients aged 18-60 years, belonging to ASA PS I&II, scheduled for elective surgeries requiring intubation. After induction and neuromuscular blockade, we performed a transtracheal ultrasound at the time of intubation to visualize the passage of ETT. Bilateral lung sliding sign was elicited during bag ventilation as a sign of correct placement of ET tube simultaneous with capnography and auscultation. The primary outcome was time difference between transtracheal ultrasound and capnography and auscultation. **Result:** Ultrasound confirmed 142 out of 144 intubations, with a sensitivity of 98.6%. capnography and auscultation confirmed all 144 intubations with a sensitivity of 100%. Mean duration to confirm intubation by transtracheal ultrasound was 15.16s, capnography took 23.06s to confirm, mean duration for auscultation was found to be 20.29s and lung sliding sign took 20.27s. **Conclusion:** Transtracheal and lung ultrasound confirmed intubations with similar accuracy as auscultation and capnography. Further, it yielded results significantly faster than the conventional methods of confirmation. Thus, ultrasound can be used as an efficacious adjunct in confirming correct ET tube placement.

## INTRODUCTION

Securing the airway of a patient by endotracheal intubation is a crucial and fundamental skill of an Anaesthesiologist. Unrecognized esophageal intubation is a significant source of mortality and morbidity.[1] Various methods have been described for identifying correct placement of ETT like the visualization of the passage of ETT through vocal cords at the time of laryngoscopy, auscultation of the chest and detection of CO2 by capnography. Other methods to verify are using flexible bronchoscope and chest x-ray. But these methods vary in their accuracy.[2] ACLS guidelines recommend capnography for confirmation of ET tube.[3]

Though capnography is considered gold standard, it has some drawbacks like:

a) It depends on pulmonary blood flow. So its accuracy is limited in patients with cardiac arrest and pulmonary embolism.[4]
b) For confirming capnography respiration has to be maintained for several breaths. Trauma patients are considered as full stomach and inadvertently ventilating these patients with misplaced ETT in

the stomach will result in aspiration and vomiting.[5]

c) Capnography sometimes gives false negative results in situations like airway obstruction.[6]

Recently there is an increased focus in using ultrasound in the management of airway. It is widely available in ICU, operation theatre and emergency wards. Portable ultrasound is non-invasive, easy to carry, easily reproducible and relatively cheaper.[7]

Various studies reported ultrasound as a novel tool in confirming ETT placement.[8] Ultrasound can identify endotracheal intubation in several ways:

a) Direct visualization of ETT passage through vocal cords by scanning at the cricoid membrane level.[9]
b) By scanning at the level of suprasternal notch, inability to visualize the esophageal shadow in the paratracheal area during intubation indicates ETT placement.
c) Finally, post-intubation, by identifying specific dynamic signs in ultrasound at the pleural interface known as 'lung sliding sign.[10]

Hence this study was conducted to evaluate and compare transtracheal and lung ultrasound with conventional methods for confirmation of ETT placement in terms of rapidity and accuracy.

## MATERIALS AND METHODS

A prospective, investigator blinded study was conducted among Adult patients undergoing elective surgical procedures in K.S.Hegde Hospital. Duration of study was From January 2017 to August 2018.

After institutional ethical committee clearance, patients were evaluated during their pre anaesthetic visit.

Written informed consent was obtained from patients after explaining the procedure. Patients were fasted as per standard protocol. Pre-medicated with 150mg of tablet ranitidine and tablet diazepam 5mg for those <50kg and 10mg for those >50kg on previous night and at 2h before the surgery.

After shifting the patient to the operation theatre (OT), electrocardiogram ECG, pulse oximeter and non invasive blood pressure (NIBP) monitors were connected. Baseline values were noted. A portable ultrasound “Sonosite Micromaxx” machine with 6-13 MHz linear array probe was used.

**Figure 1: demonstrating tranducer position over the neck**

A preliminary airway scan was performed on the awake patient in supine position to identify trachea, esophagus and other surrounding structure. The tracheal position was determined by a hyper echoic air-mucosal (A-M) interphase with reverberation artifact posteriorly (comet tail artifact).

Additional scanning was performed to confirm b/l normal lung sliding sign.

A screen was setup between the anaesthesiologist performing intubation and the anaesthesiologist performing the ultrasound scan.

ETCO2 waveforms were made visible only to Anaesthesiologist performing the intubation.

Second Anaesthesiologist was ready with a well lubricated linear ultrasound probe, positioned over the trachea in suprasternal notch.

All tracheal intubations were performed under general anaesthesia with fentanyl, propofol, atracurium/vecuronium sequence using laryngoscope and appropriate size ETT.

Use of stylet was at the convenience of anaesthesiologist

First anaesthesiologist informs about the insertion of laryngoscope and ETT. Following intubation second anaesthesiologist identified the ETT as:

a) Tracheal intubation if only one A-M interface with comet tail artifact and posterior shadowing. **OR**
b) Esophageal intubation if two A-M interfaces with comet tail artifacts and posterior shadowing which is called as “double tract sign”
c) Absence of double tract sign was an indirect confirmation of tracheal intubation

The probe was then shifted to right side of the chest and subsequently to the left side and looked for the lung sliding sign as an indicator of bilateral lung ventilation which will rule out endobroncheal placement.

Anaesthesiologist intubating auscultated over right and left lung and over the epigastrium.

Continuous square waveform capnography for 6 ventilations was taken as final proof of endotracheal intubation.

**Timing (in seconds) was noted by separate observers:**

a) From point of laryngoscope insertion to confirmation by auscultation and capnography.
b) From point of laryngoscope insertion to confirmation by transtracheal ultrasound and lung sliding sign

If esophageal intubation was detected, it was redirected into trachea. If more than 2 attempts required, it was taken as a failure.

## RESULTS

This study was conducted to evaluate and compare transtracheal and lung ultrasound to confirm endotracheal tube placement with conventional methods in terms of rapidity and accuracy. We studied 144 adult patients aged 18 to 60 yrs from January 2017 to august 2018.


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We included patients belonging to ASA-PS 1 and 2 who were scheduled for elective surgeries including end tracheal intubation.

We compared the time taken for the point of laryngoscope introduction to the point of confirmation of endotracheal tube placement by ultrasound, auscultation and capnography. We found that capnography confirmed intubations in all the 144 patients, trans tracheal and lung ultrasound confirmed 142 out of 144 intubations, showing similar accuracy. But time taken by transtracheal ultrasound was significantly lesser than the time taken by auscultation capnography. Time taken by lung ultrasound was similar to time taken by auscultation but significantly lesser than capnography.

**Table 1: Patient distribution according to ASA-PS.**

| | Frequency | Percent |
|---|---|---|
| 1 | 76 | 52.8 |
| 2 | 68 | 47.2 |
| Total | 144 | 100.0 |

**Table 2: Intubations confirmed by transtracheal ultrasound.**

| | Frequency | Percent |
|---|---|---|
| NO | 2 | 1.4 |
| YES | 142 | 98.6 |
| Total | 144 | 100.0 |

Sensitivity of transtracheal ultrasound is 98.6%

**Table 3: Time taken by capnography and transtracheal ultrasound**

| | N | Mean | Std. Deviation | Mean difference | S.D of difference | t test p value | |
|---|---|---|---|---|---|---|---|
| Capnography | 142 | 23.06 | 2.27 | 7.89 | 1.39 | .000 | HS |
| Transtracheal Ultrasound | 142 | 15.16 | 2.32 | | | | |

Both the methods were compared using student t test and it is found to be highly significant

**Table 4: Time taken by auscultation and transtracheal ultrasound**

| | N | Mean | Std. Deviation | Mean difference | S.D of difference | t test p value | |
|---|---|---|---|---|---|---|---|
| Ausculation | 142 | 20.29 | 2.45 | 5.13 | 1.01 | .000 | HS |
| Transtracheal Ultrasound | 142 | 15.16 | 2.32 | | | | |

Both the methods were compared using student t test and it is found to be highly significant

**Table 5: Time taken by capnography and lung sliding sign**

| | N | Mean | Std. Deviation | Mean difference | S.D of difference | t test p value | |
|---|---|---|---|---|---|---|---|
| Capnography | 142 | 23.06 | 2.27 | 2.78 | 1.71 | .000 | HS |
| Lung sliding sign | 142 | 20.27 | 2.47 | | | | |

Both the methods are compared using student t test and found to be highly significant

**Table 6: Time taken by auscultation and lung sliding sign**

| | N | Mean | Std. Deviation | Mean difference | S.D of difference | t test p value | |
|---|---|---|---|---|---|---|---|
| Auscultation | 142 | 20.29 | 2.45 | .01 | 1.49 | .910 | NS |
| Lung sliding sign | 142 | 20.27 | 2.47 | | | | |

Both the methods are compared using student t test and found to be not significant

## DISCUSSION

Our study demonstrated that Anaesthesiologists with basic training in ultrasonography can differentiate tracheal intubation from esophageal intubation in controlled environment.

**Using ultrasound in confirming endotracheal intubation is beneficial in several ways like:**

a) Ultrasound is a simple technique and relatively easy to learn.
b) Ultrasound is available in many critical care areas and emergency departments
c) Low pulmonary blood flow have no effect on ultrasonographic images, as compared to capnography
d) Ultrasonographic detection of esophageal intubation is made before ventilation of the patient, whereas capnography requires ventilation. So this early detection prevents ventilation of stomach and the complications associated with it like aspiration and emesis.

Other added advantage of ultrasound is its application in out of hospital settings where there are more chances of esophageal intubation.

Standard criteria to confirm endotracheal tube placement is by auscultation of chest and


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capnography. But this method has its own limitations like:

Auscultation of chest for verification of endotracheal tube placement could be difficult in pathological breath sounds. ETCO2 measurement could be misleading in patients with cardiac arrest or low flow states. In esophageal intubation, ingestion of carbonated drinks or antacids, prolonged bag and mask ventilation before intubation results in misleading capnography.

Principle finding of our study is that transtracheal ultrasound for identifying endotracheal tube placement is faster than auscultation and capnography.

Furthermore bilateral lung ultrasound was as quick as auscultation and was faster than auscultation and capnography.

We preferred placing transducer just above the suprasternal notch as there is increased accuracy of detecting ET tube placement with superior visualization of tracheal and esophageal areas.[11] Schmitt et al revealed increased accuracy of transducer when placed suprasternally in detecting ET tube placemen.[12] Another scanning position is the cricothyroid membrane for assessing ET tube placement by visualizing the changes around vocal cords.[13] But an observational study showed that vocal cords are visualized in only 71% human subjects by ultrasound.[14] So this position is less efficacious than the suprasternal. In addition avoiding placing transducer over the cricothyroid membrane will avoid pressure over this membrane during intubation. We placed transducer in the transverse axis, so that we could visualize both the tracheal and esophageal areas at the time of intubation. Only the long axis of trachea or paratracheal space is visible in sagittal axis.

The typical air mucosal artifact (intubation image) is seen as a result of sound impedence shift between the interface of air and water-filled mucosa. This pattern is easier to detect wherein the tube itself is not visualized.[15]

A meta-analysis conducted by Li J showed that capnography had sensitivity of 93% and specificity of 97%.[16] Our study showed sensitivity of capnography to be 100%.

Another study used ultrasound in confirming intubation in cadavers using tracheal longitudinal view. They found that ultrasound to be 100% sensitive and 98% specific for esophageal intubation.[17] We found that Anaesthesiologist with basic ultrasound training can interpret endotracheal intubation reliably.

Another study described capnography to be 100% sensitive and 100% specific in identifying endotracheal intubations.[18] Our study showed comparable results.

We could confirm correct endotracheal tube placement in 142 out of 144 patients and not able to confirm in 2 situations. This could be due to artifacts like calcification around the thyroid gland. Another explanation could be the experience of Anaesthesiologist in ultrasound. On one instance we intentionally placed ET tube in esophagus, which was correctly identified by ultrasound as esophageal intubation.

Recently two studies reported utility of ultrasound for verifying endotracheal intubation. They studied 30 intubations with lung sliding and cricothyroid ultrasound. They described this technique to be highly sensitive and specific,[19] which is in consistence with our study.

Ma et al conducted a study describing real time detection of esophageal versus tracheal intubation in a cadaveric study and found ultrasonography has 100% sensitivity and 97% specificity.[20] Sensitivity of ultrasound in our study was 98.6% showing comparable results.

Time taken to confirm intubation is an important aspect of any method used. Transtracheal ultrasound confirms ET tube placement while intubation is being done or upon completion, whereas capnography requires patient to be ventilated for minimum 5 to 6 times.[21] Thus ultrasound confirms intubation faster than capnography.

Several studies reported time taken to perform ultrasound ranged from 5-45s.[22] In our study time taken to confirm intubation by ultrasound was 15.16s, whereas capnography took 23.06s. Thus ultrasound is significantly faster than capnography.

Other studies compared time taken by ultrasound and capnography to confirm intubation and found that time taken by ultrasound was significantly shorter than capnography,[23] thus justifying our results.

Similarly we found that lung sliding sign was as fast as auscultation in confirming ET tube placement (20.27 vs 20.29 s). Further, we found lung sliding sign was significantly faster than the combination of capnography and auscultation (20.27 vs 23.06s), with comparable sensitivity of both the techniques.

## CONCLUSION

Transtracheal and lung ultrasound can confirm ET tube placement with similar accuracy as conventional methods of auscultation and capnography. Further, it is faster than the combination of auscultation and capnography in confirming ET tube placement, so this method can be considered as secondary confirmatory tool.

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