

The feasibility of bedside ultrasound in confirmation of Endotracheal tube position in neonates compared with CXR

Nasrin Khalesi

Iran University of Medical Sciences

Marzie Dehgan

Iran University of Medical Sciences

Elham Zarei (✉ zareie@iums.ac.ir)

Iran University of Medical Sciences <https://orcid.org/0000-0002-2130-405X>

Research article

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Abstract

Background:

Endotracheal intubation is a common procedure in the neonatal intensive care unit (NICU). Rapid and accurate confirmation of the endotracheal tube (ETT) position is critical. Routinely CXR is used for evaluation of ETT position that has some disadvantages. So there has been a considerable interest to find alternative modality with minimal complication and acceptable accuracy.

The purpose of our study is the evaluation of ultrasound efficacy in confirmation of ETT position in neonates comparison to CXR.

Methods: This cross-sectional study was conducted on 66 intubated neonates in NICU of Ali -Asghar children Hospital, between January 2018 and January 2019. To determine the ETT position, CXR and ultrasound were requested at the same time and only patients who could have an ultrasound immediately after intubation and without repositioning of tracheal tube between CXR and ultrasound were included in the study. Each neonate had a bedside ultrasound (US) with a high-frequency linear transducer. Accuracy, sensitivity, specificity, negative predicted value (NPV), positive predicted value (PPV) and Kappa agreement coefficient was used to compare the US and CXR results.

Results: Sixty-six intubated neonates included in this study had a mean gestational age of 34.98 ± 3.7 weeks and mean birth weight of 2284.7 ± 915 g. US images were taken a mean of 3 ± 0.6 h after CXR. The ETT was visualized by the US in all newborns examined. US revealed a sensitivity of 88% (95% CI, 68.78% to 97.45%), specificity of 84% (95% CI, 63.92% to 95.46%), PPV of 84.62% (95% CI, 68.89% to 93.18%), NPV of 87.50% (95% CI, 70.49% to 95.35%), diagnostic accuracy of 86% (95% CI, 73.26% to 94.18%), positive likelihood ratio of 5.50 (95% CI 2.21 to 13.66), and Negative Likelihood Ratio of 0.14 (95% CI 0.05 to 0.46) compared to chest radiography. Overall, the Kappa value showed very good agreement in confirming the correct position of the tracheal tube placement (Kappa coefficient 0.72, p-value <0.001). The mean time taken for confirmation of ETT position by US 4 minutes and by CXR was 20 minutes.

Conclusion: The findings of this study demonstrate ultrasound has acceptable accuracy for confirmation of ETT position in neonates and is a safer and faster method in comparison to CXR.

Background

Endotracheal intubation is a common procedure in the neonatal intensive care unit (NICU) (1, 2). Because malposition of ETT is a common finding in infants (3) and could be associated with various serious outcomes such as esophageal intubation, Rt upper lobe or left lung atelectasis and hypoxemia, pulmonary air leak syndrome, fast and accurate determination of ETT position is critical (1, 4). There are numerous methods for ETT position confirmation such as visualizing vocal cords during direct laryngoscopy auscultation, observation of chest movement and capnography (4). In most centers, CXR is routinely used after each intubation and reintubation for confirmation of ETT position. [9, 10]

Despite the reliability of CXR in detecting ETT position, this modality is associated with some disadvantages such as radiation exposure, inability to differentiate esophageal intubation from tracheal intubation, time-consuming, and need to reposition of sick neonates (5).

Regarding the mentioned disadvantages, there has been increasing interest to find an alternative method with similar accuracy and minimal complications.

The ultrasound could be done quickly and bedside without radiation exposure and causes no or minimal disturbance of the sick neonate position.

Multiple studies suggested that bedside ultrasound has good effectiveness for ETT position in adults, nevertheless, there is no consensus

In replacing CXR with bedside ultrasound for confirmation of the proper position of ETT in neonates.

Our aim in this study is evaluation of the efficacy of bedside ultrasound in the determination of ETT position in intubated neonates in NICU compared with CXR.

Methods

This study population included 66 neonates who were admitted to the NICU of Ali – Asghar children hospital and required intubation for respiratory distress between January 2018 and January 2019.

Neonates that ETT tip was not obviously seen by CXR and whose bedside ultrasound could not be done simultaneously with CXR were excluded from the study.

After each intubation or re-intubation, CXR was routinely obtained.

The appropriate position of ETT on CXR was defined as between thoracic inlet (C7-T1 disc space) and 10 mm above the carina (or T2 – T3 disc space).

If the ETT tip was located more than 10 mm from carina (or beyond the body of T3) or located above thoracic inlet (or C7-T1 disc space), it would be considered deep and high position respectively (1 ,11, 12)

After intubation ,ETT position was confirmed with clinical signs and oxygen saturation monitoring and CXR and ultrasound were requested at the same time.

The ultrasound was performed by Five trained radiologists were unaware of CXR results.

All radiologists have been trained in chest ultrasound for at least one month and airway ultrasound training for at least one hour by an assistant professor of radiology that has seven years' experience in neonatal ultrasound .

The ultrasound was done with a high-frequency linear probe that placed superior to the suprasternal notch in axial and longitudinal axis and then in the parasternal region with the longitudinal axis (for visualization aortic arch)with the neck slightly extended.

To better localization, gentle longitudinal movement of ETT about 2 mm in each direction was done.

When ETT is inside the trachea, axial ultrasound shows one air-mucosal interface with a reverberation artifact and posterior shadowing.

In the longitudinal view, ETT produces double continuous linear echogenicity immediately posterior to the tracheal rings with broken linear echogenicity appearance.

The distance between the ETT tip and maximal curvature of the aortic arch (AA) as a marker was measured

If ETT tip was between the lower level of thyroid and more than 10 mm from AA was defined as proper position, if it was above the lower level of thyroid or less than 10 mm above the apex of AA was classified as high and deep position respectively. (7,8,9,11)

The ETT was visualized in all subjects on ultrasound. There was no case of esophageal intubation.

The required time for evaluation of the ETT position by two modalities was recorded for each patient.

Results

A total of 66 intubated neonates enrolled in the study. The mean gestational age and birth weight of the neonates were 34.98 ± 3.7 weeks and 2284.7 ± 915 g respectively. Of the neonates, 44 (66.7%) were male and 22 (33.3 %) were female. The demographics and clinical characteristics of study subjects are presented in Table 1.

Characteristics	Minimum	Maximum	Mean \pm SD	Median
Birth weight(g)	850	3820	34.98 ± 3.7	2500
Gestational age(week)	28	40	2284.7 ± 915	36

Endotracheal tube position determined by CXR was proper in 56 (84.8%), and improper in 10 (15.2%) cases while endotracheal tube position as determined by Ultrasound was proper in 47 (71.21%) cases, and improper in 19 (28.78%) cases, and none showed esophageal intubation.

Compared to CXR, US examination for detecting the proper position of ETT revealed a sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, positive likelihood ratio, and negative likelihood ratio of 88%, 84%, 84.62%, 87.5%, 86%, 5.5%, 0.14% respectively. Accuracy of detecting the proper position of ETT by ultrasonography in comparison with CXR is presented in Table 2.

Table 2: Accuracy of detecting proper position of ETT by ultrasonography in comparison with chest radiograph	
Index	Value (95% CI)
Sensitivity	88% (68.78% to 97.45%)
Specificity	84% (63.92% to 95.46%)
Positive predictive value	84.62% (68.89% to 93.18%)
Negative predictive value	87.5% (70.49% to 95.35%)
Diagnostic accuracy	86% (73.26% to 94.18%)
Positive likelihood ratio	5.5 (2.21 to 13.66)
Negative likelihood ratio	0.14 (0.05 to 0.42)
CI: Confidence Interval	

There was no complication during the bedside ultrasound in the studied neonates. The total accuracy of US in affirmation of ETT position based on the area under the receiver operating characteristic (ROC) curve was 86%. Mean (SD) time interval between CXR and US evaluation was 3 ±0.6 h. The median time required for CXR and US assessment for determination of ETT position was 20 minutes and 4 minutes respectively.

Discussion

Because the improper position of ETT is common and considered as one of the most important complications of ETT in neonates, the presence of quick and accurate method for localization of ETT tip is critical in neonates. Among various methods for evaluation of the ETT position, a reliable and commonly used modality is CXR.

Nevertheless, CXR is associated with some disadvantages such as radiation exposure, inability to differentiate esophageal intubation from tracheal intubation, time-consuming, and need to reposition of sick neonates (5).

Ultrasound seems to be a good alternative method for evaluation of ETT tip position regarding its potential advantages such as no radiation, portability and being fast, and with no or minimal disturbance of sick neonates position during the performance.

For the first time, ultrasound was used for evaluation of ETT position in two small trials in the 1980s (7, 8) that showed the ETT tip was reliably identified by ultrasound in neonates.

Since that time, various studies assessed the accuracy of bedside ultrasound to the determination of ETT position in comparison to CXR.

Most of them demonstrated no statistically significant differences between the US and CXR in identifying the correct ETT position (2, 9, 10, and 11) nevertheless de Kock et al. showed there was poor agreement between findings of CXR and US (12)

Our study results showed that bedside ultrasound had acceptable accuracy comparison to CXR for detecting the correct position of ETT in the neonate and also, was the faster and safer method than CXR with no complication during performance.

Despite agreement among various investigations about the accuracy of ultrasound, but there was no consensus about the method to find out the proper position of ETT by the US so that some authors were used aortic arch as ultrasound marker (7,8,9,11) and some of them were used Rt pulmonary artery(10,13).

Also about the definition of the high position of ETT on ultrasound, various markers were used.

Despite awareness of adverse outcomes of early radiation exposure, and regarding the accuracy of ultrasound, there is less acceptance in the use of ultrasound in neonatal intubation. (14)

Two major limitations of most studies were that ultrasound images were obtained by one or two highly skilled pediatric radiologist and the sample size were small. (7, 8, 9 and 15)

Our study included 66 intubated neonates that are the one of largest investigations of its kind to date, also we used a larger number of radiologists without previous skill in tracheal ultrasound that was trained for one hour by an attending pediatric radiologist which increase the generalizability of this technique.

Conclusion

Regarding multiple advantages of ultrasound and its good accuracy in determination of ETT tube position we recommended with training neonatologist, could replace CXR with ultrasound for evaluation ETT position and avoid unnecessary radiation exposure.

List Of Abbreviations

NICU: neonatal intensive care unit

ETT: endotracheal tube

US: ultrasound

Declarations

Ethic approval and consent to participate

The informed consent was verbally confirmed by all participants and the Ethics committee of Iran University of Medical Sciences confirmed all procedures of this study (IR.IUMS.FMD.REC.1397.257).

Prior to ultrasound, written informed consent was obtained from all parents subjects.

Consent to publish

The authors declare that they consent to publish

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interest

No competing interest

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Author's Contributions

EZ (study conception & design and Critical revision), NK and MD (Acquisition of data, Analysis and interpretation of data & Drafting of manuscript). All authors have read and approved the manuscript.

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Authors' information

Nasrin Khalesi

Department of Neonatology, Ali Asghar Hospital, Iran University of Medical Sciences (IUMS), Tehran, Iran

nasrinkhalessi@yahoo.com

Marzie Dehgan

Department of Neonatology, Ali Asghar Hospital, Iran University of Medical Sciences (IUMS), Tehran, Iran

marzi.dehgan@gmail.com

Elham Zarei

Department of Radiology, Ali Asghar Children Hospital, Iran University of Medical Sciences, Tehran, Iran

Email: zareie@iums.ac.ir

ORCID: <https://orcid.org/0000-0002-2130-405X>

Corresponding Author: Elham Zarei

Department of Radiology, Ali Asghar Children Hospital, Iran University of Medical Sciences, Tehran, Iran.

Email: zareie@iums.ac.ir

ORCID: <https://orcid.org/0000-0002-2130-405X>

Telephone: +98 9197377864

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