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Diagnostic Accuracy of Point-of-Care Ultrasound for Confirmation of Endotracheal Tube Position in Preterm and Term Neonates: A Prospective Observational Study.

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Abstract

Background: Accurate confirmation of endotracheal tube position is essential in neonatal airway management, as malposition can result in inadequate ventilation, accidental extubation, selective bronchial intubation, atelectasis, hypoxemia, or air leak. Chest X-ray is commonly used as the reference standard, but it involves radiation exposure, handling of fragile neonates, and possible delay in bedside decision-making. Point-of-care ultrasound is a rapid, repeatable, and radiation-free modality that may help confirm endotracheal tube position in neonates. ***Methods:*** This prospective observational diagnostic accuracy study was conducted in the Department of Neonatology, Government Rajaji Hospital, Madurai Medical College, Madurai, over a period of six months. A total of 160 preterm and term neonates requiring endotracheal intubation were included. Baseline neonatal and intubation-related characteristics were recorded. Point-of-care ultrasound was performed at the bedside to assess endotracheal tube position, and findings were compared with chest X-ray, which was considered the reference standard. Sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, concordance, and Cohen's kappa were calculated for confirmation of correct endotracheal tube placement. ***Results:*** Among the study participants, 116 (72.5%) were preterm and 44 (27.5%) were term neonates. Point-of-care ultrasound identified correct endotracheal tube position in 137 (85.6%) neonates, high position in 12 (7.5%), deep position in 8 (5.0%), and non-visualization in 3 (1.9%). Chest X-ray showed correct tube position in 138 (86.3%) neonates and malposition in 22 (13.7%). Ultrasound showed sensitivity of 97.1%, specificity of 86.4%, positive predictive value of 97.8%, negative predictive value of 82.6%, diagnostic accuracy of 95.6%, and substantial agreement with chest X-ray. ***Conclusion:*** Point-of-care ultrasound is a reliable, rapid, and radiation-free bedside tool for confirming correct endotracheal tube position in preterm and term neonates.

Keywords: Point-of-care ultrasound; Endotracheal tube; Neonates; Chest X-ray; Diagnostic accuracy.

INTRODUCTION

Endotracheal intubation is a lifesaving procedure frequently performed in neonatal intensive care units and delivery rooms for preterm and term neonates requiring respiratory support.[1] It is commonly indicated in conditions such as respiratory distress syndrome, birth asphyxia, meconium aspiration syndrome, apnea of prematurity, sepsis, and other causes of respiratory failure. [2] In neonates, especially preterm infants, airway anatomy is small and delicate, making accurate placement of the endotracheal tube essential for effective ventilation and prevention of complications. [3]

Correct positioning of the endotracheal tube is as important as successful tracheal intubation. [4] A tube placed too high may lead to accidental extubation and inadequate ventilation, whereas a deeply placed tube may enter the right main bronchus and result in unilateral ventilation, atelectasis, hypoxemia, air leak, or lung injury. [5] In neonates, even minor movement of the head and neck can alter the depth of the endotracheal tube, making tube position vulnerable to displacement after initial fixation. [6] Therefore, reliable confirmation of endotracheal tube position is a critical component of neonatal airway management. [7]

Clinical methods such as visualization of chest rise, bilateral air entry, improvement in heart rate, oxygen saturation, and color change are useful for immediate assessment after intubation. [8] However, these methods may not reliably determine the exact depth of the endotracheal tube tip. [9] End-tidal carbon dioxide detection helps confirm tracheal rather than esophageal placement, but it does not provide information regarding whether the tube tip is optimally positioned within the trachea. Hence, imaging is often required to confirm the level of the endotracheal tube tip. [10]

Chest X-ray is traditionally considered the reference standard for confirming endotracheal tube position in neonates. [11] Although radiography provides useful anatomical confirmation, it has several limitations. It exposes neonates to ionizing radiation, involves handling and repositioning of fragile infants, and may not provide immediate bedside information in urgent clinical situations. [12] Repeated radiographs may be required in mechanically ventilated neonates because tube displacement can occur during nursing care, procedures, transport, or changes in head position. These concerns are particularly important in preterm neonates, who are more vulnerable to radiation exposure and clinical instability. [13]

Point-of-care ultrasound has emerged as a promising bedside tool in neonatal intensive care. [14] It is portable, repeatable, radiation-free, and can be performed without moving the neonate from the incubator or warmer. In the context of endotracheal tube confirmation, ultrasound can help assess the position of the tube tip in relation to anatomical landmarks such as the aortic arch or pulmonary artery. [15] The ability to rapidly assess endotracheal tube position at the bedside may reduce the delay associated with radiographic confirmation and may help clinicians make earlier decisions regarding tube repositioning. [16]

Despite the potential advantages of point-of-care ultrasound, further evidence is required regarding its diagnostic accuracy in different neonatal populations, including both preterm and term neonates. Establishing the sensitivity, specificity, predictive values, diagnostic accuracy, and concordance of ultrasound with chest X-ray will help determine whether it can be used as a reliable bedside modality for confirmation of endotracheal tube position. Hence, the present study was undertaken to evaluate the diagnostic accuracy of point-of-care ultrasound for confirmation of endotracheal tube position in preterm and term neonates, using chest X-ray as the reference standard.

Aims and Objectives

Aim

To evaluate the diagnostic accuracy of point-of-care ultrasound in confirming the position of endotracheal tube among preterm and term neonates, using chest X-ray as the reference standard.

Objectives

1. To assess the position of the endotracheal tube among preterm and term neonates using point-of-care ultrasound and chest X-ray.
2. To determine the sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, and concordance of point-of-care ultrasound in identifying endotracheal tube malposition, using chest X-ray as the reference standard.

Review of literature

Slovis and Poland conducted one of the earliest studies evaluating sonographic positioning of endotracheal tubes in neonates. In this study, 21 real-time sonographic assessments were performed in 16 neonates and compared with simultaneously obtained chest radiographs. The authors used the relationship between the endotracheal tube tip and the aortic arch as the sonographic landmark. They observed that the endotracheal tube tip could be identified sonographically and that an optimal position was present when the tube tip was approximately 1 cm above the aortic arch. This landmark-based approach provided the foundation for later neonatal ultrasound studies on endotracheal tube localization. [1]

Lingle evaluated a modified sonographic technique for verification of endotracheal tube position in neonates. The study used ultrasound to identify the endotracheal tube tip and related anatomical landmarks, including the aortic arch. The modified approach attempted to improve visualization of the tube tip, which had been a practical limitation in earlier neonatal ultrasound studies. The study demonstrated that sonography could be used to assess endotracheal tube position in neonates and supported the feasibility of bedside ultrasound as a non-radiation method for tube localization. This work was important because it further refined the technical approach for neonatal ETT sonography. [2]

Galicinao et al. conducted a feasibility study to assess bedside ultrasonography for confirming endotracheal tube placement in pediatric patients, including neonates and infants. The study was conducted in two phases and included 99 patients aged from 1 day to 17 years. Ultrasound was able to detect the endotracheal tube in all patients, although two views were required for accurate identification of tracheal placement. The authors concluded that bedside ultrasonography could rapidly and accurately determine whether the endotracheal tube was present within the trachea. Although the population was pediatric rather than exclusively neonatal, the inclusion of newborns makes the study relevant to neonatal airway confirmation. [3]

Dennington et al. performed a prospective pilot study to determine whether bedside ultrasound could identify the anatomical position of the endotracheal tube in preterm and term infants. The study included 28 neonates and 29 endotracheal tube evaluations. Ultrasound was used to assess ETT position and was compared with standard radiographic confirmation. The authors found that bedside ultrasound could visualize the anatomical position of the ETT in neonates and suggested that it could become a useful bedside tool. However, they emphasized the need for further validation before routine clinical implementation. [4]

Sethi et al. conducted a prospective observational study in India to compare ultrasonography with chest radiography for detecting the level of the endotracheal tube tip in intubated neonates. The study included 53 endotracheal tube evaluations. Ultrasound visualized the ETT tip in 48 out of 53 neonates, and in these cases the tube tip was seen within 0.5 to 1.0 cm from the upper border of the aortic arch, corresponding to normal radiographic position at T2–T3. The five cases in which ultrasound failed to visualize the tube tip had high tube position on radiograph. The mean time for confirmation was shorter with ultrasound than with chest radiography, suggesting that POCUS may provide earlier bedside information while avoiding radiation exposure. [5]

De Kock and Otto conducted a prospective cross-sectional study in South Africa to determine the feasibility of bedside ultrasonography for locating endotracheal tube position in neonates compared with chest radiography. The study included 30 intubated neonates in a neonatal intensive care unit. Although bedside ultrasound was feasible and could be performed at the cot side, agreement between ultrasound and chest radiograph findings was poor. The authors suggested that patient handling and secondary movement of the tube between the two assessments might have contributed to discordant results. This study highlighted an important limitation of ultrasound–radiograph comparison, namely tube migration due to positioning and handling. [6]

Chowdhry et al. conducted a prospective observational clinical trial to assess concordance between ultrasound and X-ray in identifying whether neonatal endotracheal tubes were deeply positioned. The study included 29 neonates and 56 ultrasound/X-ray image pairs. Ultrasound had 95% concordance with X-ray for identifying deeply and not deeply positioned tubes. The sensitivity of ultrasound for detecting deeply positioned ETTs was 86%, while specificity was 96%; the negative predictive value was particularly high at 98%. The study concluded that ultrasound was a feasible and reliable imaging modality for determining whether an ETT was deeply positioned in neonates. [7]

Najib et al. compared ultrasonographic measurement of endotracheal tube tip-to-carina distance with chest X-ray measurement in neonates. The study included 40 neonates who underwent chest radiography and ultrasonography within one hour after intubation. The mean ETT tip-to-carina distance did not differ significantly between ultrasound and chest X-ray, and a moderate intraclass correlation was observed between the two methods. The authors concluded that ultrasonography and chest X-ray were similarly accurate for determining ETT tip-to-carina distance in infants. This study supported the use of ultrasound as a safer and more accessible alternative to radiography for confirming proper tube position. [8]

Singh et al. conducted a neonatal study to generate normative data for the distance between an optimally placed endotracheal tube tip and the arch of the aorta using point-of-care ultrasound. The study included 143 neonates and focused on establishing ultrasound-based reference values across neonatal weight and maturity groups. Instead of only determining whether the tube was correctly placed, the study attempted to define expected sonographic distances for optimal positioning. This is clinically relevant because ultrasound interpretation requires reliable reference landmarks and cut-off values. The study provided practical normative data that may assist clinicians in bedside assessment of ETT tip position in neonates. [9]

Ariff et al. conducted a large cross-sectional diagnostic accuracy study in Pakistan comparing point-of-care ultrasound with standard-of-care methods for confirming endotracheal tube placement in neonates. The study included 348 neonates and assessed tracheal versus esophageal placement using POCUS, with comparison against standard clinical methods including auscultation, colorimetric capnography and chest X-ray. POCUS demonstrated very high diagnostic performance, with 99.7% sensitivity, 91% specificity and 98.9% agreement when compared with standard-of-care methods. The median time required for POCUS interpretation was only a few seconds. This study provides strong evidence that POCUS is a rapid and reliable bedside method for confirming neonatal ETT placement. [10].

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational diagnostic accuracy study conducted in the Department of Neonatology, Government Rajaji Hospital, Madurai Medical College, Madurai. The study was designed to evaluate the diagnostic accuracy of point-of-care ultrasound for confirmation of endotracheal tube position among preterm and term neonates, using chest X-ray as the reference standard. As the study was observational in nature, no additional intervention was performed for research purposes, and all neonates received standard clinical care according to institutional protocol.

Study Population

The study population comprised preterm and term neonates admitted to the neonatal intensive care unit who required endotracheal intubation for clinical indications. Neonates who were intubated for respiratory distress syndrome, birth asphyxia, meconium aspiration syndrome, apnea of prematurity, sepsis, pneumonia, or other causes of respiratory failure were considered eligible. Both newly intubated neonates and neonates who required reassessment of endotracheal tube position were included, provided they fulfilled the eligibility criteria and written informed consent was obtained from the parent or legal guardian.

Study Duration

The study was conducted over a period of six months in the Department of Neonatology, Government Rajaji Hospital, Madurai Medical College, Madurai.

Inclusion and Exclusion Criteria

Preterm and term neonates admitted to the neonatal intensive care unit who underwent endotracheal intubation for clinical indications and required confirmation of endotracheal tube position were included in the study. Neonates were enrolled only after obtaining written informed consent from the parent or legal guardian.

Neonates with major congenital anomalies involving the airway, thorax, or cardiovascular system were excluded. Neonates with congenital heart disease or abnormal mediastinal anatomy that could interfere with the identification of ultrasound landmarks were also excluded. Neonates in whom either point-of-care ultrasound or chest X-ray could not be performed within the required time interval, and those whose parents or guardians did not provide consent, were excluded from the study.

Sample Size and Sampling Technique

The total sample size was 160 neonates. All eligible neonates who underwent endotracheal intubation during the study period and satisfied the inclusion criteria were recruited until the required sample size was achieved. A consecutive sampling technique was followed, in which every eligible neonate admitted during the study period was included after obtaining informed consent.

Study Procedure

After confirming eligibility, written informed consent was obtained from the parent or legal guardian. Baseline demographic and clinical details, including gestational age, sex, birth weight, postnatal age at intubation, indication for intubation, type of intubation were recorded using a predesigned data collection proforma.

Endotracheal intubation was performed by the treating neonatal team based on clinical requirement. The endotracheal tube was inserted and secured according to standard neonatal practice, using the appropriate tube size and insertion depth based on birth weight, gestational age, and clinical judgement. Initial clinical confirmation of tracheal placement was done by observing chest rise, improvement in heart rate and oxygen saturation, auscultation of bilateral air entry, and other routine bedside parameters.

Following intubation, point-of-care ultrasound was performed at the bedside using a high-frequency probe. The neonate was maintained in a neutral or sniffing position as clinically appropriate. A parasternal or high parasternal view was used to identify relevant anatomical landmarks, particularly the aortic arch. The endotracheal tube tip was identified sonographically, and its relationship to the aortic arch was assessed. When the tube tip was visualized, the distance between the endotracheal tube tip and the aortic arch was measured and recorded. If required, gentle tube movement was performed by the clinical team without displacing the tube to improve visualization.

Chest X-ray was performed as part of routine standard care for confirmation of endotracheal tube position. The radiographic position of the endotracheal tube tip was assessed with reference to thoracic vertebral level and its relation to the carina. Chest X-ray findings were considered the reference standard. The ultrasound findings were compared with chest X-ray findings to determine whether the endotracheal tube was in correct position, high position, or deep position. Corrective repositioning of the endotracheal tube, whenever required, was carried out based on clinical judgement and standard treatment protocol and was not delayed for the purpose of the study.

Operational Definitions

A preterm neonate was defined as a neonate born before completion of 37 weeks of gestation. A term neonate was defined as a neonate born at or after 37 completed weeks of gestation. Correct endotracheal tube position on chest X-ray was defined as the endotracheal tube tip lying at an appropriate level within the trachea, above the carina and without evidence of high placement or deep bronchial placement. High endotracheal tube position was defined as the tube tip lying too proximally in the trachea, with risk of accidental extubation or inadequate ventilation. Deep endotracheal tube position was defined as the tube tip lying too close to the carina or extending beyond the desired tracheal level, with risk of selective bronchial intubation. On point-of-care ultrasound, correct tube position was defined as visualization of the endotracheal tube tip at an appropriate distance from the aortic arch, consistent with the expected tracheal position. High tube position was considered when the tube tip was positioned higher than the expected sonographic landmark level, and deep tube position was considered when the tube tip was positioned too close to or beyond the expected lower tracheal landmark. Endotracheal tube malposition included both high and deep positions.

For diagnostic accuracy analysis, correct placement of the endotracheal tube was considered the positive outcome, and chest X-ray was considered the reference standard. A true positive was defined as a correctly placed endotracheal tube detected by point-of-care ultrasound and confirmed as correctly placed by chest X-ray. A true negative was defined as malposition of the endotracheal tube detected by point-of-care ultrasound and confirmed as malposition by chest X-ray. A false positive was defined as a correctly placed endotracheal tube detected by point-of-care ultrasound but not confirmed as correctly placed by chest X-ray. A false negative was defined as malposition of the endotracheal tube detected by point-of-care ultrasound despite correct position on chest X-ray.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using SPSS version 26. Categorical variables such as sex, gestational age category, indication for intubation, point-of-care ultrasound findings, and chest X-ray findings were expressed as frequency and percentage. Continuous variables such as gestational age, birth weight, and distance between the endotracheal tube tip and aortic arch were expressed as mean and standard deviation. Chest X-ray was considered the reference standard for diagnostic accuracy analysis. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of point-of-care ultrasound were calculated for confirmation of correct endotracheal tube position. Concordance between point-of-care ultrasound and chest X-ray was assessed using Cohen's kappa statistic. The chi-square test or Fisher's exact test was used to assess the association between ultrasound findings and chest X-ray findings, as appropriate. A p-value of less than 0.05 was considered statistically significant.

Ethical Consideration

The study was conducted after obtaining approval from the Institutional Ethics Committee of Madurai Medical College, Madurai. Written informed consent was obtained from the parent or legal guardian before enrolment. Participation in the study did not interfere with routine clinical management, and no additional invasive procedure was performed for research purposes. Point-of-care ultrasound was performed at the bedside and did not expose the neonate to ionizing radiation. Confidentiality of all patient information was maintained throughout the study, and data were used only for research purposes.

RESULTS

Table 1. Distribution of Study Participants According to Baseline Neonatal Characteristics (N = 160)

Baseline characteristic	Category	Frequency (n)	Percentage (%)
Gestational age	Extremely preterm (<28 weeks)	18	11.3
	Very preterm (28–31+6 weeks)	36	22.5
	Moderate to late preterm (32–36+6 weeks)	62	38.7
	Term (≥37 weeks)	44	27.5
Sex	Male	101	63.1
	Female	59	36.9
Birth weight	<1000 g	22	13.8
	1000–1499 g	45	28.1
	1500–2499 g	55	34.4
	≥2500 g	38	23.7
Age at intubation	≤24 hours	92	57.5
	>24 hours to 7 days	52	32.5
	>7 days	16	10.0

Note. Mean gestational age was 33.4 ± 4.5 weeks, and mean birth weight was 1.84 ± 0.71 kg.

A total of 160 neonates who underwent endotracheal intubation were included in the study. Among them, 18 (11.3%) were extremely preterm, 36 (22.5%) were very preterm, 62 (38.7%) were moderate to late preterm, and 44 (27.5%) were term neonates. The mean gestational age of the study participants was 33.4 ± 4.5 weeks. Male neonates constituted 101 (63.1%) of the study population, while females constituted 59 (36.9%). With respect to birth weight, 22 (13.8%) neonates weighed less than 1000 g, 45 (28.1%) weighed between 1000 and 1499 g, 55 (34.4%) weighed between 1500 and 2499 g, and 38 (23.7%) weighed 2500 g or more. More than half of the neonates were intubated within the first 24 hours of life, accounting for 92 (57.5%) cases, followed by 52 (32.5%) neonates who were intubated between 24 hours and 7 days, and 16 (10.0%) after 7 days of life (Table 1).

Table 2. Distribution of Study Participants According to Intubation-Related Clinical Characteristics (N = 160)

Intubation-related characteristic	Category	Frequency (n)	Percentage (%)
Type of intubation	Emergency	143	89.4
	Elective	17	10.6
Intubation episode	First-time intubation	148	92.5
	Repeat intubation	12	7.5
Indication for intubation	Respiratory distress syndrome	74	46.3
	Birth asphyxia	29	18.1
	Meconium aspiration syndrome	19	11.9
	Apnea of prematurity	16	10.0
	Sepsis/pneumonia	14	8.7
	Other indications	8	5.0

Emergency intubation was the most common type of intubation, observed in 143 (89.4%) neonates, whereas elective intubation was performed in 17 (10.6%) neonates. Most of the study participants underwent first-time intubation, accounting for 148 (92.5%) cases, while repeat intubation was required in 12 (7.5%) neonates. The most common indication for intubation was respiratory distress syndrome, observed in 74 (46.3%) neonates, followed by birth asphyxia in 29 (18.1%), meconium aspiration syndrome in 19 (11.9%), apnea of prematurity in 16 (10.0%), sepsis or pneumonia in 14 (8.7%), and other indications in 8 (5.0%). (Table 2).

Table 3. Distribution of Endotracheal Tube Position Based on Point-of-Care Ultrasound and Chest X-ray Findings (N = 160)

Endotracheal tube position	Point-of-care ultrasound, n (%)	Chest X-ray, n (%)
Correct position	137 (85.6)	138 (86.3)
High position	12 (7.5)	14 (8.7)
Deep position	8 (5.0)	8 (5.0)
Not clearly visualized	3 (1.9)	—
Total	**160 (100.0)**	**160 (100.0)**

Note. Chest X-ray was considered the reference standard for confirmation of endotracheal tube position. The mean distance between the endotracheal tube tip and the aortic arch on ultrasound was 0.83 ± 0.22 cm.

On point-of-care ultrasound assessment, correct endotracheal tube position was identified in 137 (85.6%) neonates. High endotracheal tube position was detected in 12 (7.5%) neonates, while deep endotracheal tube position was observed in 8 (5.0%) neonates. In 3 (1.9%) neonates, the endotracheal tube tip could not be clearly visualized by ultrasound. In comparison, chest X-ray showed correct endotracheal tube position in 138 (86.3%) neonates, high position in 14 (8.7%), and deep position in 8 (5.0%). The mean distance between the endotracheal tube tip and the aortic arch on ultrasound was 0.83 ± 0.22 cm (Table 3).

Table 4. Comparison of Point-of-Care Ultrasound with Chest X-ray for Confirmation of Correct Endotracheal Tube Position (N = 160)

Point-of-care ultrasound finding	Correct position on chest X-ray, n	Malposition on chest X-ray, n	Total, n
Correct position detected on ultrasound	134	3	137
Malposition/not clearly visualized on ultrasound	4	19	23
Total	**138**	**22**	**160**

Note. Correctly placed endotracheal tube was considered the positive outcome. There was a statistically significant association between point-of-care ultrasound and chest X-ray findings, $\chi^2 = 108.49$, $p < 0.001$.

When point-of-care ultrasound findings were compared with chest X-ray findings for confirmation of correct endotracheal tube position, ultrasound correctly identified correct tube placement in 134 out of 138 neonates confirmed by chest X-ray. Among 22 neonates with malposition on chest X-ray, ultrasound correctly identified malposition or non-visualization in 19 neonates. Ultrasound showed false-positive correct placement in 3 neonates and false-negative findings in 4 neonates. There was a statistically significant association between point-of-care ultrasound and chest X-ray findings for confirmation of correct endotracheal tube position, $\chi^2 = 108.49$, $p < 0.001$ (Table 4).

Table 5. Diagnostic Accuracy of Point-of-Care Ultrasound for Confirmation of Correct Endotracheal Tube Position Using Chest X-ray as Reference Standard (N = 160)

Diagnostic parameter	Value
Sensitivity	97.1%
Specificity	86.4%
Positive predictive value	97.8%
Negative predictive value	82.6%
Diagnostic accuracy	95.6%
Concordance with chest X-ray	95.6%
Cohen’s kappa	0.82
p-value	<0.001*

Note. $p < 0.05$ was considered statistically significant. Correct endotracheal tube placement was considered the positive outcome for calculation of diagnostic accuracy.

Point-of-care ultrasound demonstrated high diagnostic performance for confirmation of correct endotracheal tube position when chest X-ray was used as the reference standard. The sensitivity of ultrasound was 97.1%, specificity was 86.4%, positive predictive value was 97.8%, and negative predictive value was 82.6%. The overall diagnostic accuracy was 95.6%, and the concordance rate between ultrasound and chest X-ray was also 95.6%. Cohen’s kappa value was 0.82, indicating substantial agreement between the two modalities. The diagnostic association was statistically significant, with a p-value of <0.001 (Table 5).

DISCUSSION

Endotracheal intubation is an important lifesaving procedure in neonatal intensive care, but accurate confirmation of tube position remains essential to ensure effective ventilation and prevent complications. In the present study, point-of-care ultrasound was evaluated as a bedside diagnostic modality for confirmation of endotracheal tube position among preterm and term neonates, using chest X-ray as the reference standard. The study included 160 neonates, and the findings demonstrated that point-of-care ultrasound had high diagnostic accuracy, good concordance with chest X-ray, and substantial agreement for confirming correct endotracheal tube placement.

The baseline neonatal profile showed that the majority of the study participants were preterm neonates, with 18 (11.3%) extremely preterm, 36 (22.5%) very preterm, and 62 (38.7%) moderate to late preterm neonates, while term neonates constituted 44 (27.5%) of the study population. The mean gestational age was 33.4 ± 4.5 weeks, and the mean birth weight was 1.84 ± 0.71 kg. This distribution reflects the frequent need for respiratory support among preterm and low-birth-weight neonates due to respiratory immaturity and associated neonatal morbidities. Sethi et al. reported a mean gestational age of 36.1 weeks and mean birth weight of 2.067 kg among intubated neonates assessed using ultrasound [5]. Chowdhry et al. included a more premature neonatal population, with a mean gestational age of 28.3 weeks and mean birth weight of 1282 g, supporting the applicability of ultrasound even in smaller and less mature neonates [7]. Similarly, Dennington et al. included both preterm and term infants and demonstrated the feasibility of bedside ultrasound for assessing endotracheal tube position [4]. Salvadori et al. also evaluated ultrasound in both term and preterm infants, including very low-birth-weight neonates, suggesting that the technique may be useful across different neonatal maturity groups [13].

In the present study, emergency intubation was the predominant mode of intubation, observed in 143 (89.4%) neonates, while elective intubation was performed in 17 (10.6%). First-time intubation accounted for 148 (92.5%) cases, and repeat intubation was required in 12 (7.5%). Respiratory distress syndrome was the most common indication for intubation, seen in 74 (46.3%) neonates, followed by birth asphyxia, meconium aspiration syndrome, apnea of prematurity, sepsis or pneumonia, and other indications. This pattern is consistent with the common neonatal conditions requiring ventilatory support in intensive care settings. Sethi et al. similarly reported that most intubations were emergency procedures and that first-time intubations were more common [5]. Ariff et al. emphasized the importance of rapid bedside confirmation of endotracheal tube placement in neonates, particularly in acute care settings where delays in confirmation may affect ventilation and stabilization [10]. Takeuchi et al. highlighted the usefulness of ultrasound in extremely low-birth-weight infants, where rapid and reliable confirmation of airway placement is critical [14]. Dincer et al. also supported the role of ultrasound for tube position assessment among very low-birth-weight infants, in whom repeated radiographic exposure is undesirable [15].

Point-of-care ultrasound identified correct endotracheal tube position in 137 (85.6%) neonates, high position in 12 (7.5%), and deep position in 8 (5.0%), while the tube tip could not be clearly visualized in 3 (1.9%) neonates. The high visualization and correct identification rate in the present study supports the feasibility of bedside ultrasound in routine neonatal airway assessment. The mean distance between the endotracheal tube tip and the aortic arch on ultrasound was 0.83 ± 0.22 cm, which was consistent with the concept of using vascular landmarks for sonographic assessment of tube depth. Sethi et al. reported successful visualization of the endotracheal tube tip in 90.6% of neonatal evaluations, with normally positioned tubes seen within 0.5 to 1.0 cm from the upper border of the aortic arch [5]. Chowdhry et al. reported that 98.0% of ultrasound and X-ray image pairs were suitable for analysis, indicating good feasibility of the technique in intubated neonates [7]. Descamps et al. also reported that ultrasonography was useful for assessing correct endotracheal tube placement in neonates [11]. Şahin et al. further supported that point-of-care ultrasound performed by trained neonatal clinicians was feasible for identifying the endotracheal tube tip [16].

Chest X-ray, which was considered the reference standard in the present study, showed correct endotracheal tube position in 138 (86.3%) neonates and malposition in 22 (13.7%). Among the malpositioned tubes, high position was observed in 14 (8.7%) and deep position in 8 (5.0%). These findings highlight that clinically relevant tube malposition is not uncommon even after initial clinical confirmation. Both high and deep tube placements have important clinical implications, as high tube position may increase the risk of accidental extubation, while deep placement may result in selective bronchial intubation, atelectasis, hypoxemia, and unequal ventilation. Chowdhry et al. identified deeply positioned tubes in 7 out of 56 image pairs using chest X-ray as the reference standard [7]. Sethi et al. reported high tube position on radiograph in five neonates, and these were the cases in which ultrasound failed to visualize the tube tip [5]. Najib et al. found that ultrasound measurements of endotracheal tube tip-to-carina distance were comparable with chest X-ray measurements [8]. Zaytseva et al. also used both X-ray and ultrasound to evaluate optimal endotracheal tube depth, emphasizing the value of imaging-based confirmation in neonatal airway care [12].

When point-of-care ultrasound findings were compared with chest X-ray findings, ultrasound correctly identified correct endotracheal tube position in 134 out of 138 neonates confirmed by chest X-ray. Among 22 neonates with malposition on chest X-ray, ultrasound correctly identified malposition or non-visualization in 19 neonates. There were 3 false-positive cases, where ultrasound suggested correct position but chest X-ray showed malposition, and 4 false-negative cases, where ultrasound suggested malposition or non-visualization despite correct position on chest X-ray. The association between ultrasound and chest X-ray findings was statistically significant, indicating good diagnostic concordance between the two modalities. This finding is comparable to Chowdhry et al., who reported 95.0% concordance between ultrasound and X-ray in assessing whether neonatal endotracheal tubes were deeply positioned or not [7]. Dennington et al. also demonstrated that bedside ultrasound could identify the anatomical position of the endotracheal tube in preterm and term infants [4]. Salvadori et al. reported that ultrasound assessment using the right pulmonary artery as a landmark was reliable and feasible for assessing tube tip position in term and preterm infants [13]. However, De Kock and Otto observed poor agreement between ultrasound and chest radiography, suggesting that tube migration, patient handling, and variation in technique may affect concordance [6].

The diagnostic accuracy analysis in the present study showed that point-of-care ultrasound had a sensitivity of 97.1%, specificity of 86.4%, positive predictive value of 97.8%, negative predictive value of 82.6%, and overall diagnostic accuracy of 95.6% for confirmation of correct endotracheal tube position. The concordance rate with chest X-ray was 95.6%, and Cohen's kappa value was 0.82, indicating substantial agreement. These findings suggest that point-of-care ultrasound is highly effective in identifying correctly placed endotracheal tubes and may serve as a reliable bedside adjunct to chest X-ray. Ariff et al. similarly reported very high sensitivity and excellent agreement for point-of-care ultrasound in confirming neonatal endotracheal tube placement [10]. Chowdhry et al. reported comparable overall concordance and high specificity when ultrasound was used for detecting deeply positioned tubes [7]. Najib et al. concluded that ultrasound and chest X-ray were similarly accurate for assessing endotracheal tube tip position [8]. Dincer et al. also reported that ultrasound was a feasible and faster method for determining endotracheal tube tip position in very low-birth-weight infants [15].

Limitations

The study was conducted in a single tertiary care centre with a limited sample size; therefore, the findings may not be generalizable to all neonatal care settings. Operator dependency of point-of-care ultrasound and non-assessment of interobserver variability were additional limitations.

CONCLUSION

The present study demonstrated that point-of-care ultrasound had high diagnostic accuracy for confirming correct endotracheal tube position among preterm and term neonates when chest X-ray was used as the reference standard. Ultrasound correctly identified most cases of appropriate tube placement and showed good concordance with radiographic findings, with high sensitivity, positive predictive value, overall diagnostic accuracy, and substantial agreement. These findings indicate that point-of-care ultrasound is a reliable, rapid, and radiation-free bedside modality for early confirmation of endotracheal tube position in neonatal intensive care settings.

It is recommended that point-of-care ultrasound may be used as an early bedside adjunct for confirmation of endotracheal tube position, particularly in critically ill, preterm, and low-birth-weight neonates where repeated handling and radiographic exposure should be minimized. However, chest X-ray may still be required in doubtful or discordant cases and where additional thoracic assessment is clinically indicated. Training of neonatal clinicians in standardized ultrasound technique, use of consistent anatomical landmarks, and periodic quality assurance are recommended. Further multicentric studies with larger sample sizes and assessment of interobserver agreement are needed before point-of-care ultrasound can be adopted as a routine replacement for chest X-ray.

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