RESEARCH PAPER

Point of Care Ultrasonography for Position of tip of Endotracheal Tube in Neonates

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Received: April 03, 2013; Initial review: May 30, 2013; Accepted: October 09, 2013.

Objective: To compare ultrasonography with chest radiograph to detect the level of endotracheal tube tip in intubated neonates.

Design: Observational.

Setting: Neonatal care unit of a teaching hospital.

Participants: 53 neonates selected by convenience sampling.

Intervention: Ultrasonography of chest was done with probe of 5 to 8 MHz using high parasternal view. The distance of the endotracheal tube tip to the arch of aorta on ultrasonography was compared with level of endotracheal tube tip in radiograph.

Primary Outcome: Distance of endotracheal tube tip from the upper border of the arch of aorta on ultrasonography.

Results: Endotracheal tube tip was visualised on ultrasonography within 0.5 - 1.0 cm distance from upper border of arch of aorta in 48 out of 53 neonates. This corresponded with the normal position of endotracheal tip in radiograph at T2 to T3. In 5 neonates, endotracheal tube tip was not visualized on ultrasonography and in all these newborns it was at higher level in radiograph.

Conclusions: Distance of endotracheal tip to arch of aorta as measured on ultrasonography is helpful in early identification of the level of endotracheal tube tip.

Keywords: *Arch of aorta, Endotracheal intubation, Ultrasound.*

Endotracheal intubation is a common procedure in neonatal intensive care unit (NICU) and in delivery room. Correct placement in trachea and correct level of endotracheal tube (ET) tip is of paramount importance in emergency as well as elective conditions. Clinical methods, end-tidal carbon-di-oxide ($ETCO_2$) monitor and chest radiography has been used to identify correct intubation [1]. Clinical findings such as direct visualisation of passage of tube through glottis, rising heart rate, improving oxygen saturation and improvement in colour suggest tracheal intubation but are prone to errors [2-5]. $ETCO_2$ measurement in preterm and term neonates has been recommended to confirm tracheal intubation [6-8]. However, $ETCO_2$ measurement does not inform the healthcare personnel about the depth of ET insertion. Chest radiograph is considered as a gold standard investigation for determining level of the ET tip but has radiation hazard [9,10], involves handling of the neonate, and has high turnaround time [11].

There is evidence in adult literature [12,13] about the use of ultrasonography (US) for confirming ET tip but it has not been studied adequately in neonatal and pediatric population. This study attempts to evaluate role of US for determining the level of ET tip in relation with arch of aorta in neonates.

METHODS

We conducted this prospective observational study between August 2011 and September 2012 at 550 bedded tertiary-care rural teaching hospital and medical college in Western India. The study was approved by the Institutional human research ethics committee.

All neonates intubated in NICU irrespective of their gestational age, birth weight and diagnosis were eligible for inclusion in the study. Neonates intubated in delivery room and in emergency room were excluded. After intubation, ET tube was secured (based on ET length formula of weight in kg + 6 cm, lip to tip) and confirmed with clinical signs and oxygen saturation (SPO_2) monitoring. The time of ET insertion was noted and simultaneous calls to radiography technician and US machine were sent. End points were confirmation of ET tip position by radiograph and distance of ET tip to arch of aorta by US. Turnaround times for both the modalities were noted. Head was kept in sniffing position during both procedures.

Sonosite MicroMaxx portable US machine with probe of 5 to 8 MHz frequency was used to identify the ET tip level. All the US were performed by a single investigator, who was trained in tube localization and related anatomy

for a period of 2 weeks by a radiologist prior to initiation of study. Pre-warmed gel was applied on the probe and kept on baby using high parasternal view. Arch of aorta was visualized and subsequently ET tip was identified after producing a gentle motion of less than 0.5 cm ensuring that the ET was not displaced. Distance of the ET tip from superior border of aortic arch was measured and noted. The videos were recorded and stored in flashcard of US machine. These videos were later transferred to the computer for storage and subsequent analysis. Time taken to confirm ET position by US after intubation was noted.

Bedside portable 100 mA radiograph machine (GE) was used for chest radiographs. Radiographs were taken by technician in antero-posterior view in the NICU. Films were collected and checked for correct placement by the investigators in the NICU. Time taken immediately after intubation and visualization of ET tip on radiograph was noted. US and Radiograph findings were compared for position of the tip of ET and the time taken to obtain the results of the procedures. Corrective measures regarding the length of ET tube were taken only after confirming from radiograph.

RESULTS

From August 2011 to September 2012, 310 intubations were performed in neonates in the hospital. Out of these, 123 intubations were done in emergency room and 56 intubations were performed in delivery area. Out of 131 intubations in NICU, 53 (34 males) were studied (depending on availability of AS). Forty-eight were emergency and 5 (9%) were elective intubations; 50 (94%) were first time intubations and three were repeat intubations. Mean (SD) gestational age was 36.1 (2.85) weeks; mean (SD) birth weight was 2.067 kg (0.653), and mean (SD) age at intubation was 3.89 (5.45) days.

On radiograph, ET tip was in correct position in 48 neonates and at higher position in 5 neonates. Ultrasonography was able to identify ET tip in 48 (90.6%) neonates. In all these cases, after gentle motion of the ET, the ET tips were visualized above the upper border of the arch of aorta within the range of 0.5 cm to 1.0 cm. In the five neonates where ET tip was not visualised on US, the radiograph showed ET tip lying at or above the first thoracic vertebra. Ultrasound had sensitivity of 91% for visualization of ET tip with positive predictive value of 100%. As there were no true negative cases in US for ET tip identification, specificity could not be measured. There was no case of esophageal intubation or over insertion of ET in the right main bronchus.

Mean (SD) time taken to confirm ET tip position on US was 19.3 (7.9) minutes and on radiograph was 47.3 (9.0) minutes.

DISCUSSION

We investigated the use of ultrasonography concurrently with clinical signs for confirmation of tracheal intubation and found it to be potentially useful tool to locate the ET tip in neonates.

There are few studies of ET localization in newborn and pediatric population. Slovis, *et al*. [12] used 5-8 MHz probe in neonates and encountered no difficulty in identifying ET tip and related anatomical structures. They also correlated the distance from ET tip to aortic arch and concluded that the ET tip more than 1 cm above aortic arch was optimum. Lingle [14] also used arch of aorta as a landmark during US with 5 MHz probe and ET tip was considered in low position if the tip was located below the superior margin of arch of aorta and high position if the tip is located above the superior border of manubrium sternum assessed by shadow from the tin foil. Kerrey, *et al*. [15] found limited usefulness of US in detection of tracheal intubation by examining movements of both the diaphragms during positive pressure ventilation. Galicinao, *et al*. [11] successfully confirmed tracheal intubation using both curvilinear and linear probes of US through cricithyroid membrane in pediatric and neonatal population. Razzaq [16] proposed potential benefit of using sliding lung sign (movement of pleural line on both side of anterior chest using US with high-frequency linear transducer) with certain limitations like difficulty in interpretation in pneumothorax and in spontaneously breathing intubated patients.

In our study, we were able to get the results of the US earlier than radiography. This difference was because of time required for the technician to come in NICU from radiology department, arrange the radiograph machine, keeping the plate in optimum position under the newborn's chest, wearing the radio protective grown, transporting the plate to the radiology department, printing process of radiography and again transporting back to NICU for reading. Malpositioned tube could cause complications like hemorrhage, mismatched ventilation and hypoxia. Time saved in locating ET tip could be of significance in sick neonates.

The limitation of the study was not checking for inter-observer variability between various operators. There was no esophageal intubation in this study; we were therefore not able to comment on the use of US in esophageal intubation.

We conclude that visualization of ET tip and its distance of 0.5 to 1.0 cm from upper border of arch of aorta by US performed by trained personnel, using 5-8 MHz probe, suggests normal position.

Contributors: AS: designed the study, analyzed the data, wrote the paper, and performed the ultrasonography examinations; AN; designed the study, wrote the paper, and assisted in the ultrasonography examinations DP: analyzed the data, drafted the paper, and assisted in ultrasonography examinations; AK: interpreted the data and wrote the paper and approved the final manuscript; SN: conceived the study, designed the study and revised it critically for important intellectual content and script. He will be the guarantor. All authors approved the final manuscript.

Competing interest: None; *Funding:* None stated.

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