

Use of Point of Care Ultrasound for Confirming Central Line Tip Position in Neonates

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Objective: To assess feasibility of ultrasound (USG) evaluation of tip position of central catheter in neonates and to determine agreement between radiograph and USG-based assessments. **Methods:** This prospective observational study was conducted in a tertiary neonatal intensive care unit from April, 2019 to August, 2019. Point of care USG and radiograph were performed on infants who underwent central line placement. Agreement between the two was determined using Kappa statistics. **Results:** Of the 141 central catheters insertions performed, USG was performed for 65 central catheters. On USG, catheter tip position could be assessed and defined in 62 (95%) of cases. Of these 62 central lines, 24 (38.7%) were defined as optimally placed on radiograph and 20 (32.2%) were defined as optimally placed on USG. There was excellent agreement between radiographic and USG assessment of catheter tip position [K (95% CI) = 0.86 (0.73-0.99), $P < 0.001$]. All 38 lines found to be mal-positioned on radiograph were assessed as sub-optimal on USG as well. **Conclusion:** Point of care USG has excellent agreement with radiography for confirming central line tip position.

Keywords: Bedside, Central catheters, Long line, Radiograph.

Trial Registration: CTRI/2019/01/017282

Preterm infants and sick, term infants frequently require central venous or arterial cannulation. However, central lines are advanced blindly to a predetermined length based on an external anatomic measurement of the estimated catheter pathway. Optimality of catheter tip position is confirmed with chest or abdominal radiographs. Frequently, position of these catheters may be sub-optimal, necessitating manipulation of catheters followed by further radiographs for reconfirmation [1]. This involves handling of critically ill infants, and carries a significant risk of dislodgement of lines, radiation exposure and unacceptable delay in confirmation of central catheter position.

Point of care ultrasound (USG) is an emerging bedside tool in management of sick neonates. It may be used to locate catheter position during and immediately after procedure, reducing the time lag and radiation exposure. Whereas few studies [2] in the past have evaluated the utility of USG in locating umbilical catheters, there is re-emergence of interest amongst neonatologists to evaluate the tip position of various central catheters in neonates [3-7]. We conducted this study to determine the agreement between radiological and USG-based assessment of central line tip position.

METHODS

This was a prospective observational study conducted at the neonatal intensive care unit of a tertiary care centre in India from April, 2019 to August, 2019. All infants admitted to the NICU who underwent central line placement were eligible for enrolment. A written informed consent was obtained from parents of eligible infants. Central catheters [umbilical arterial and venous catheter (UAC, UVC), peripherally inserted central venous catheter (PICC) and femoral venous catheter] were placed by the attending neonatologist using standard techniques. The length of insertion for PICC in the upper and lower limb was measured from point of insertion along the venous pathway till suprasternal notch to right third intercostal space and till level of xiphisternum, respectively. For UAC and UVC insertion, Dunn shoulder umbilical length normogram was used [8]. After placement of central catheter, USG assessment of position of catheter tip was done by a neonatologist, trained in ultrasound. A radiograph was also performed to assess catheter position as the standard of care. The ultrasonologist was blinded to the radiological findings.

Ultrasound was done using Sonosite M Turbo

machine with curvilinear probe with frequency of 8-4 MHz. A sub-xiphoid right parasagittal view was used to assess tip position of UVC, femoral venous lines and lower limb PICC, with additional complementary windows (long axis, apical, modified views) as needed. Once inferior vena cava (IVC) was visualized, probe head was moved back and forth, until catheter tip was clearly seen. For visualization of UAC, a sub-xiphoid left parasagittal view, high parasternal view and suprasternal view were used with similar approach. Tip position of upper limb PICC was assessed using the high parasternal view. If catheter tip was not visible using standard techniques, 0.5-1 mL of normal saline was flushed through catheter to locate the tip, which was seen as a point of origin of jet. Optimal position for UVC, femoral venous catheter, and PICC inserted through lower limb, was defined as catheter tip at IVC/right atrium (RA) junction or 0.5-1 cm proximal to it. For PICC inserted through upper limb, optimal position was defined as catheter tip at superior vena cava (SVC)/RA junction or 0.5-1 cm proximal to it. For UAC, optimal position was defined as catheter tip located in lower half of thorax, between diaphragm below and aortic isthmus above.

On radiograph, UVC, femoral venous line and lower limb PICC catheter position was considered optimal if tip was at the level of diaphragm or slightly above, or at level of vertebral bodies T8-T9 [9,10]. For upper limb PICC, catheter position was considered optimal, if tip was found to be vertically within the SVC within 1-2 vertebral units below the carina [11]. An UAC was said to be optimal if catheter tip was located in thoracic aorta at vertebral bodies T7 and T9 [3]. Radiograph was ordered immediately after insertion of central catheters to confirm tip position and USG was initiated as per method described above. Time elapsed between completion of central line insertion to completion of USG and to availability of X-ray film was noted.

For a disagreement of 10% between the two methods, as reported in a recent study [6], alpha error of 0.01 and power of 80%, the sample size was estimated to be 60.

Statistical analyses: Statistical analyses were performed using SPSS version 19. Catheter tip position was defined as optimal or suboptimal, both on USG and X-ray, as per predefined criteria. Agreement between USG and X-ray defined tip positions was determined using kappa statistics. A *P* value <0.05 was considered significant.

RESULTS

Of the 141 central catheters insertions performed during the study period, USG was performed for 65 central catheters (refusal of consent in 13, and investigator not

available in 63). On USG, catheter tip position could be assessed and defined in 62 (95%) of cases. In three neonates, central lines (2 PICC and 1 UV) were misplaced at aberrant locations and not visualized on USG. Of the 62 catheters, 25 were PICC, 4 were femoral venous catheters, 16 were UVC and 17 were UAC.

The median (IQR) gestation and weight of the enrolled infants were 28 (26, 34.2) weeks and 1060 (860, 2120) g, respectively. Twenty four (38.7%) central lines were defined as optimally placed on radiograph and 20 (32.2%) were defined as optimally placed on USG. There was excellent agreement between radiographic and USG assessment of catheter tip position [K (95% CI) = 0.86 (0.73 – 0.99); *P*<0.001] (**Table 1**). All 38 lines found to be mal-positioned on radiograph were assessed as sub-optimal on USG as well. Four lines, 3 PICC and 1 UVC, which were deemed to be optimal on radiograph were detected to be suboptimal on USG, all entering RA. The mean (SD) time from completion of central line insertion to completion of USG was less than time required for obtaining X-ray film [6.11 (2.7) min vs 122.46 (45.45) min; MD (95% CI) -116.35 (-128.11 to -104.58); *P*<0.001].

DISCUSSION

In this study, we could identify catheter tip position in 95% of cases and there was excellent agreement between USG and X-ray for optimal catheter tip position. In three cases, catheter tip was not visualized as it was mal-positioned in aberrant pathways, two in the neck veins both being upper limb PICC lines and one UV being coiled in the liver. Till date, few studies have reported utility of USG for placement of central catheter in neonates. Ohki, *et al.* [12] assessed the ability of USG to detect the tip of a percutaneous central venous catheter in neonates and reported a consistency of 87% between USG and radiography. Simanovsky, *et al.* [13] measured the distance of UVC tip from the diaphragm on USG and X-ray and reported no significant difference in the distance measured by using the two modalities. Greenberg, *et al.* [2] also demonstrated feasibility and safety of USG for assessment of umbilical venous catheter position. Other authors have also suggested high agreement coefficients between point of care USG and X-ray with respect to overall central venous tip, UVCs and PICCs [14,15].

Although radiograph is considered a gold standard for defining optimal tip position, it has certain limitations. It is difficult to precisely identify junction of RA to IVC or SVC on plain X-ray, which could lead to misinterpretation of correct tip position. We found that 4/24 (16.6%) central lines that were deemed to be appropriate on radiograph were actually lying inside the cardiac chambers on USG

WHAT THIS STUDY ADDS?

- Point of care ultrasound and radiograph have excellent agreement in confirmation of central line tip position in neonates.

assessment. Tazuin, *et al.* [5] have also described limitation of X-ray assessment for PICCs in low birth neonates. They reported that, of all PICCs deemed to be in good position on plain radiographs, 25% were within the heart [5]. Similarly, another small study found that 41% of PICC lines that were deemed to be correctly placed on X-ray were found to be malpositioned on USG [4].

Our study evaluated degree of agreement between USG and radiograph in locating the tip position of different central lines across wide range of weights and gestation. All USGs were performed by a single trained operator. We, therefore, emphasize that USG is a skill-based operator dependent technology and competency training is required before non-radiology users can evaluate central line tip positions at various locations. Sometimes examiners may find it difficult to visualize catheter tips within the liver, outside of IVC or SVC, especially if they are in aberrant pathways. The limitation that point of care ultrasound is performed for specific clinical purpose to answer a clinical question, and it may not mandate a detailed comprehensive examination is also acknowledged.

Ethical Clearance: Ethics Committee, Sir Ganga Ram Hospital; EC/12/18/1454, dated December 18, 2018.

Contributors: AT: conceptualized the project and developed the protocol; AT: had primary responsibility of patient screening, enrolment and data collection; AT: performed the data analysis; AT, VK: wrote the manuscript; NK, PG: participated in protocol development, supervising enrolment, outcome assessment and in writing the manuscript; AT, MM: participated in planning of project and writing of manuscript.

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