

Using Lateral Radiographs to Determine Umbilical Venous Catheter Tip Position in Neonates

Abstract:

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Abstract

We aimed to assess the difference in measurement of the distance of the UVC tip from the diaphragm between (Anteroposterior) AP and lateral radiographs and to determine the reliability of the measurement of UVC tip distance from the diaphragm between the two views. A retrospective review of paired AP and lateral radiographs taken to assess UVC tip position was carried out in 25 infants was conducted and reliability analysis was carried out. There was a significant difference in the mean (SD) distance of the UVC catheter above the diaphragm between the AP and lateral radiographs: 8.7 (7.8) mm versus 11.6 (7.3) mm ($p=0.003$) respectively. Measurements using lateral radiographs were more reliable (Intraclass correlation coefficient: 0.99 vs. 0.93). Inter-observer reliability analysis yielded similar results. Lateral radiographs are more reliable in measurement of UVC tip position and should be performed in conjunction with AP films to aid in determining UVC position.

Introduction

Umbilical venous catheters (UVC) provide vascular access for neonates in the first few days of life for administration of parenteral nutrition, fluids and medications. The ideal position of the UVC tip is the right atrial / inferior vena cava (RA/IVC) junction, which lies just above the diaphragm. Currently, anteroposterior (AP) radiographs are commonly used to determine catheter tip position in relation to the diaphragm. However, reliance on this view alone may lead to an incidence of catheter tip mal-position of up to 75%. AP films are not ideal in determining the landmarks required to assess line position for several reasons: The IVC passes through the diaphragm posterior to and lower than the dome of the diaphragm. Therefore using the superior border of the diaphragm to identify the RA/IVC junction may be misleading. The tip of the UVC may be difficult to appreciate due to the projection of the catheter over the vertebrae. It may be difficult to accurately assess where the medial border of the diaphragm is as there is no clear distinction between the cardiac shadow and the diaphragm.

All these factors may contribute to the difficulty in accurately determining the relationship of the UVC tip to the diaphragm. This will also have implications for further catheter manipulation. UVC mal-position can lead to major morbidity and mortality related to complications such as: liver abscess and necrosis, perforation into the peritoneal cavity, thrombus formation in the liver vessels and heart, cardiac arrhythmias, pericardial or pleural effusions or lung abscesses. Lateral radiographs demonstrate the level of the diaphragm in a much clearer manner (Figure 1). There is evidence that lateral radiographs provide a clearer view of the peripherally inserted central catheters (PICC). In our unit, we introduced into our clinical practice lateral radiographs in addition to AP to determine UVC catheter tip position in relation to the diaphragm in November of 2012. In this study, we aimed to assess the difference in measurement of the distance of the UVC tip from the diaphragm between AP and lateral radiographs. In addition we aimed to determine the intra- and inter-observer reliability of the measurement of UVC tip distance from the diaphragm between the two views.

Methods

Any infant requiring an umbilical venous catheter between November 2012 and March 2013 was eligible for inclusion. Anteroposterior radiographs were performed on infants following insertion of umbilical venous catheters. Insertion distance was calculated based on the infants' weights using an accepted formula. UVCs were sutured in position once the AP view confirmed the catheter tip was not in the liver. A lateral radiograph was taken after confirming clinically that the catheter had not migrated between radiographs. The distance from the catheter tip to the level of the diaphragm was measured for each infant using both views. Measurements were performed offline using Fujifilm, Synapse (PACS software version 5.1.24-9). The ruler function was used and the measurement was initiated from the tip of the catheter towards the diaphragm.

If the tip was above the diaphragm, the measurement was given a positive sign. A negative sign was given if the tip was below the diaphragm. Radiographs were viewed using the same monitor and views were optimized by adjusting window level and image magnification to improve accuracy of measurements. Measurements were calculated two weeks apart by one observer to assess intra-observer reliability and avoid recall bias. A second observer performed a set of measurements blinded from the other measurements. Patient demographics including gestation and birth weight were collected. This retrospective project was approved by the Audit and Quality Improvement department of our institution. Normality was assessed using a histogram representation of the data and the Shapiro-Wilk test. Data were presented as mean (standard deviation) if normally distributed and median [inter-quartile range] if skewed. Means were compared using a paired t-test. Intra and inter observer reliability of UVC distance measurements between AP and lateral radiographs were assessed using the intraclass correlation coefficient (ICC) version 2.1. Bland-Altman analysis was used to assess the bias and the 95% limits of agreement between the measurements. We accepted a p value less than 0.05 as significant.

Results

Thirty infant radiograph pairs were assessed. Five were excluded due to a catheter manipulation occurring between the acquisition of the AP and lateral radiograph. Twenty five infants with a median [IQR] gestation and birth weight of 27.5 [26.4 - 32.6] weeks and 960 [755 - 2370] grams respectively were included in the analysis. The median time between the acquisition of the AP and lateral radiographs was 16 [9 - 20] minutes. When compared to the AP films, catheter tip measured on the lateral radiographs was deeper (above the level of the diaphragm) than the AP measurement in 17 infants (68%). The distances measured ranged from 4.6 mm below the diaphragm to 12.7 mm above the diaphragm. There was a statistically significant difference in the mean (SD) distance of the UVC catheter above the diaphragm between the AP and lateral radiographs: 8.7 (7.8) mm versus 11.6 (7.3) mm ($p=0.003$) respectively.

Measurement using the AP radiograph under-read the UVC tip distance above the diaphragm by a mean (SD) of 2.9 (4.3) mm when compared with the lateral radiograph. Measurements using lateral radiographs were more reliable when compared with AP films, with an intra-observer ICC (95% confidence interval) of 0.93 (0.57 - 0.97, $p < 0.001$) for AP and 0.99 (0.98 - 1.0, $p < 0.001$) for lateral radiographs. Inter-observer reliability analysis yielded similar results favouring the lateral radiographs (AP ICC: 0.93 [0.84-0.97, $p < 0.001$], Lateral ICC: 0.99 [0.97-1.0, $p < 0.001$]). The intra-observer repeated measurements bias and limits of agreement were higher in AP compared with lateral radiographs: 2.14 (-1.92 - 6.20) mm versus 0.16 (-1.74 - 2.06). Inter-observer bias assessment yielded similar results favouring the lateral radiographs [1.37 (-4.20 - 6.94) mm versus 0.95 (-1.32 - 2.40) mm].

Discussion

We demonstrated that lateral radiographs are more reliable in representing the relationship between the catheter tip and the border of the diaphragm when compared with AP films. In addition, AP radiographs tend to under-read the UVC tip distance above the diaphragm by about 3 mm. Although this under-reading is arguably small, it is very relevant in preterm infants and can result in the tip being inadvertently placed in the right or even the left atrium. In a study using echocardiography to assess UVC tip position following confirmation on AP films, 28% and 45% of UVCs deemed in good position on AP films were in the right and left atria on echocardiography respectively. The study also identified that the use of lateral radiographs can lead to UVC placement within the heart. However, they fared better than AP films. Ultrasonography should therefore be ideally used to confirm UVC and PICC placement. This however is not feasible in all centres as it requires expertise in neonatal echocardiography and may not be available 24 hours per

day. As a result, reliance on radiographs to determine catheter positions will remain standard of care for the foreseeable future. Measurement of the distance between the tip and the diaphragm is more reliable when using lateral radiographs with less intra and inter observer variability between the repeated measurements when compared to AP films. This is of particular importance in centres where the person inserting the UVC remains at the bedside in a sterile environment while receiving instruction from another colleague reviewing the radiographs and providing instruction on line manipulation distance.

The more accurate appraisal of the tip position using lateral films may result in fewer post insertion manipulations and reduce the overall number of radiographs taken. This may result in a reduction of the radiation burden these infants are exposed to. AP films remain necessary during the initial assessment to ensure that the catheter has not coursed medially or laterally into a hepatic vein as this may be difficult to establish on lateral films. We suggest that lateral radiographs may be a useful in conjunction with AP films to aid in determining and manipulating UVC tips. In addition, following manipulation, we recommend the use of lateral radiographs alone to assess UVC tip distance.

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