Original Article

A comparative study of landmark-based topographic method versus the formula method for estimating depth of insertion of right subclavian central venous catheters

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ABSTRACT

Background and Aims: Subclavian central venous catheterisation (CVC) is employed in critically ill patients requiring long-term central venous access. There is no gold standard for estimating their depth of insertion. In this study, we compared the landmark topographic method with the formula technique for estimating depth of insertion of right subclavian CVCs. **Methods:** Two hundred and sixty patients admitted to Intensive Care Unit requiring subclavian CVC were randomly assigned to either topographic method or formula method (130 in each group). Catheter tip position in relation to the carina was measured on a post-procedure chest X-ray. The primary endpoint was the need for catheter repositioning. Mann–Whitney test and Chi-square test was performed for statistical analysis using SPSS for windows version 18.0 (Armonk, NY: IBM Corp). **Results:** Nearly, half the catheters positioned by both the methods were situated >1 cm below the carina and required repositioning. **Conclusion:** Both the techniques were not effective in estimating the approximate depth of insertion of right subclavian CVCs.

Key words: Central venous catheter tip, formula method, topographic method

INTRODUCTION

Subclavian route for insertion of central venous catheters (CVCs) is commonly employed in critically ill patients requiring long-term central venous access as it has a lower risk of infection and has better patient comfort. Misplacement of CVC tip can rarely cause erosion of the catheter through the right atrium or right ventricle, leading to haemothorax, hydrothorax or cardiac tamponade and can be fatal. It is hence recommended to locate the tip in the superior vena cava, outside the pericardium to avoid cardiac tamponade.[1]

There is no universally accepted standard method of estimating the depth of insertion of CVCs. Surface landmarks,[2] various formulae,[3] electrocardiography and transesophageal echocardiography have been used for positioning the catheter tip in adults. Cadaver studies[4] and computerised tomography in adults have shown the carina to be above the level of pericardium. The pericardium cannot be seen on a chest X-ray that is routinely done to check the position of the catheter tip. However, carina can be easily identified on a chest X-ray and can be used as a reference point for optimal position of CVC tip.[5]

The clavicular notch is an oval articular surface on either side of the manubrium sternum for articulation with the sternal end of the clavicle, and can be easily identified. The subclavian vein (SCV) lies beneath the ipsilateral clavicular notch. The angle of Louis, the

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prominence formed by the manubriosternal joint is at the same horizontal plane as the carina.[6]

The present study compares the measurement of surface landmarks along the course of right SCV with that of the formula method to estimate the appropriate depth of insertion for right sided subclavian CVCs.

METHODS

The patients admitted to Critical Care Units at our institution in whom subclavian CVC was deemed necessary were recruited into the study after approval from Ethics Committee. Patients with gross deformities of the chest (pigeon chest, barrel chest) were excluded from the study. The patients were randomly assigned to one of the two groups with a computer generated random number table to formula group or topographic group for calculating the depth of catheter insertion. The right SCV was cannulated by infraclavicular approach under standard aseptic precautions using a double-lumen CVC (Certofix®, B Braun, Melsugen, Germany) as per the institutional protocol for CVC insertions. The formula as described by Peres[3] was used to calculate the depth of catheter insertion in the formula group (for right SCV, height [cm]/10, -2). The depth of insertion for the topographic group was determined as described by Kim *et al*.[2] Patient's head and neck were placed in neutral position after insertion of the guide wire. Topographical measurement was done by placing the catheter naturally with its own curvature over the draped skin (without direct contact with the skin), starting from the insertion point of the needle through the ipsilateral clavicular notch, and to the insertion point of the second right costal cartilage to the manubriosternal joint.

The position of CVC tip, in relation to carina, was measured on a post procedure chest X-ray from the Picture Archiving and Communication System. CVC tips positioned above the carina were presented as positive values, and those below the carina were presented as negative values. The primary endpoint of the study was the need for CVC repositioning. Catheter tip position was considered acceptable if it was in the range of up to 1 cm above and up to 1 cm below the carina. If the tip was more than 1 cm above the carina, a new catheter was inserted. If the tip was more than 1 cm below the carina, it was repositioned by pulling back. Any other untoward immediate periprocedure complications were also noted.

In a study[7] with the landmark technique, 96.1% of CVC tips were positioned appropriately. Expecting similar results with 10% minimum difference between landmark and formula method, and to get 80% power, 95% confidence level in the results, a minimum of 124 subjects in each group was required. We included 130 patients in each group to compensate for any dropouts. A Mann–Whitney test and Chi-square test was performed for statistical analysis using SPSS for windows version 18.0 (Armonk, NY: IBM Corp). $P < 0.05$ was considered statistically significant.

RESULTS

Patient characteristics are as described in Table 1. There were no catheterisation failures during the study period. One patient in the formula group and two from the topographic group had catheter malposition and were excluded from the data analysis. The median (interquartile range) CVC tip position relative to the carina was −0. 9 cm (−2.93, −0.6) in the formula group and −0.96 cm (−3.1, 0.95) in the topographic group. The CVC tips, positioned by both methods were situated >1 cm below the carina (49.6% in formula group and 44.5% in topographic group) [Table 2]. These catheters required repositioning after obtaining post-procedure chest X-ray. Immediate complications such as catheter site haematoma, arrhythmia and catheter malposition noted in both groups were similar [Table 3].

DISCUSSION

This study did not find any significant difference in the CVC tip position with either method used to estimate the depth of catheter insertion. Nearly, half of the catheters inserted in both the groups were >1 cm below the carina, thus requiring repositioning.

There is no gold standard to estimate the approximate depth of insertion of CVCs. It is intended that the CVC tip should lie at the superior venacava-right atrial junction. The most reliable radiological landmark in identifying this point is the right tracheobronchial angle or carina.[8-10] The package insert that accompanies the CVC packs states that it is not advisable to site the catheter tip in the right atrium, due to the potential risk of cardiac tamponade if the tip erodes the vessel wall below the pericardial reflection. The upper boundary of pericardial sac is not visible on a chest X-ray. Cadaver studies have shown that it is very

Table 1: Patient characteristics

Parameter	Formula group (*n*=130)	Topographic group (*n*=130)
Age (years)	56 (40-67)	52 (35-70)
Height (cm)	160 (160-165)	166 (162-170)
Weight (kg)	60 (50-70)	60 (50-70)
Male/female	68/62	77/53

Data expressed as median (IQR) or number of patients IQR – Interquartile range

Table 2: Central venous catheter insertion depth and repositioning

Parameter	Formula group (*n*=129)	Topographic group (*n*=128)	*P*
CVC insertion depth (median [IQR]){in cm}	−0.9 (−2.93, –0.6)	−0.96 (−3.1, 0.95)	0.46
Repositioning required (number of patients (%))	64 (49.6)	57 (44.5)	0.45

IQR – Interquartile range; CVC – Central venous catheter

Table 3: Central venous catheter insertion complications

Immediate complication noted during the study	Formula group (*n*=130)	Topographic group (*n*=128)
Arrhythmia	9	8
Insertion site haematoma	2	3
Catheter malposition	1	2

unlikely to be above the level of carina.[11] Carina is thus a reliable radiological landmark for positioning the CVC tip.

The parallax effect is the magnification of structures located anteriorly or posteriorly and peripherally on a chest X-ray and should be taken into account when using chest X-ray for measurements. This effect is more pronounced in anteroposterior chest X-ray obtained in the Critical Care Unit. The carina is located in the centre of the thorax, thus has less potential for image distortion and measurement error due to parallax effect.[5,7] Hence, in the present study we considered the carina as the radiological reference point for measuring the distances to the catheter tip.

Other investigators[2,12] in their study found landmark technique to be a reliable bedside predictor of optimal insertion depth for right subclavian CVC. Variation in anatomical morphological features among various racial groups is a well-known fact. Our study population being different form the one in the above study may explain the difference. The landmark techniques employed to estimate the depth of catheter insertion may need to be validated in various racial groups before applying them universally. A study[13] in Asian population with computerised tomography found formula method to be less accurate in optimal positioning of CVC catheter tip.

CONCLUSION

Landmark technique was no better than formula method in estimating the appropriate depth of catheter insertion for right SCV CVCs in Indian population. Bedside predictors of CVC insertion depth may need to be validated prior to universal use in specific population groups.

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Conflicts of interest

There are no conflicts of interest.

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