Original Article

Depth of insertion of right internal jugular central venous catheter: Comparison of topographic and formula methods

ABSTRACT

Background: Central venous catheters (CVCs) are inserted in many critically ill patients, but there is no gold standard in estimating their approximate depth of insertion. Many techniques have been described in literature. In this study, we compare the topographic method with the standard formula technique.

Materials and Methods: 260 patients, in whom central venous catheterization was warranted, were randomly assigned to either topographic method or formula method (130 in each group). The position of the CVC tip in relation to carina was measured on a postprocedure chest X-ray. The primary endpoint was the need for catheter repositioning.

Results: The majority of the CVCs tips positioned by the formula method were situated below the carina, and 68% of these catheters required repositioning after obtaining postprocedure chest X-ray ($P < 0.001$).

Conclusion: The topographic method is superior to formula approach in estimating the depth of insertion of right internal jugular CVCs.

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

Introduction

Central venous catheters (CVCs) are inserted in many critically ill patients and like most invasive procedures can cause life-threatening complications. Misplacement of the catheter tip can cause lethal complications such as malignant arrhythmias and erosion of catheters through the right atrium or right ventricle, leading to hemothorax, hydrothorax, or cardiac tamponade. It is recommended that the tip of the catheter be located in the superior vena cava, outside the pericardium, to avoid cardiac tamponade.

There are no gold standards in estimating the exact CVC insertion depth. Surface landmarks,[1] formulas,[2,3] electrocardiography,[4,5] and transesophageal echocardiography[5,6] have been proposed for positioning the catheter to an adequate depth in adults. The pericardium cannot be seen on a chest X-ray that is routinely done to check the position of the catheters. It has been seen in cadavers[7,8] and computerized tomography studies[9] in adults that carina is above the level of pericardium. Carina is easily identifiable on a chest X-ray and has been used as reference point for optimal position for CVCs.[10,11]

The angle of Louis, the prominence formed by the manubriosternal joint is at the same horizontal plane as the carina. The clavicular notch is an oval articular surface on either side of the manubrium sternum for articulation with the sternal end the clavicle, and

Access this article online

Website: www.saudija.org

DOI: 10.4103/1658-354X.174904

Quick Response Code

How to cite this article: Vinay M, Tejesh CA. Depth of insertion of right internal jugular central venous catheter: Comparison of topographic and formula methods. Saudi J Anaesth 2016;10:255-8.

Vinay M, Tejesh CA[1]

Department of Anesthesiology, Bangalore Medical College and Research Institute, [1]Department of Anesthesiology, MS Ramaiah Medical College and Hospitals, Bengaluru, Karnataka, India

Address for correspondence: Dr. C. Anandaswamy Tejesh, Department of Anesthesiology, MS Ramaiah Medical College, Bengaluru, Karnataka, India. E-mail: drtejeshca@yahoo.com

can be easily identified by palpation. The internal jugular vein (IJV) lies beneath the ipsilateral clavicular notch.[12]

The right IJV is the most widely used route for insertion of CVC in our institution. In the present study, we compared the measurement of surface landmarks along the course of right IJV with that of the formula method to estimate the appropriate depth of insertion for right sided IJV CVCs.

Materials and Methods

The patients admitted to intensive care unit at our institution, for whom CVC was warranted, were recruited into the study after ethics committee approval. The patients with known carotid artery pathology, any gross anatomical or pathological deformities of the neck (scars, a history of multiple central venous catheterizations, and mass in the neck), and gross deformities of the chest (pigeon chest and barrel chest) were excluded from the study. The patients were randomly assigned with a computer-generated random number table to one of the two groups, formula group or topographic group, for calculating the depth of catheter insertion. The right IJV was cannulated by the anterior approach under standard aseptic precautions using a double-lumen CVC (Certofix®, B Braum, Melsugen, Germany) as per the institutional protocol for CVC insertions. The formula as described by Peres[2] was used to calculate the depth of catheter insertion in the formula group (for right IJV height [cm]/10). The depth of insertion for the topographic group was determined as described by Kim *et al*.[1] Patient's head and neck was placed in neutral position after insertion of guidewire. 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 the carina, was measured on a postprocedure 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 5 cm above and up to 1 cm below the carina. If the tip was more than 5 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 periprocedural complications were also noted.

Lee *et al*.[13] in their study have shown that the CVCs were placed in the appropriate position in 96.1% of patients with landmark method. In the present study, a minimum of 124 subjects in each group was required for expecting similar result with 10% minimum difference between landmark and formula method and to get 80% power, 95% confidence level in the result. In order to compensate for any dropout due to catheter malposition, we decided to include 130 subjects in each group. A Mann–Whitney test and Chi-square test were performed for statistical analysis using SPSS for windows version 18.0 (IBM). A $P < 0.05$ was considered statistically significant.

Results

The patient characteristics are described in Table 1. There were no catheterization failures during the study period. Two patients in the formula group and three patients 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 −1.69 (−2.48, −0.53) in the formula group and 0.0 (−0.85, 1.0) in the topographic group [Table 2]. Thus, the majority of the CVC tips positioned by the formula method were situated below the carina, and 68% of these catheters required repositioning after obtaining postprocedure chest X-ray ($P < 0.001$). Immediate complications such as catheter site hematoma, arrhythmia, and catheter malposition noted in both the groups were similar.

Discussion

This study has shown that the catheter tip of CVCs inserted via the right IJV can be reliably positioned near the carina in majority of individuals using clavicular notch and junction of

Table 1: Patient characteristics

Demographics	Formula group (n = 130)	Topographic group (n = 130)
Age (years)	38 (23-56)	40 (22-60)
Height (cm)	160 (155-165)	167 (159-170)
Weight (kg)	60 (50-75)	70 (50-80)
Male/female	52/78	45/85

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

Table 2: CVC insertion depth and repositioning

CVC outcome	Formula group (n = 128)	Topographic group (n = 127)	P
CVC insertion depth (median [IQR])	−1.69 (−2.48−0.53)	0.0 (−0.85–1.0)	<0.001
Repositioning required (number of patients [%])	87 (68)	26 (20.5)	<0.001

IQR: Interquartile range; CVC: Central venous catheter

second right costal cartilage with manubriosternal joint as topographic landmarks.

There is no gold standard in estimating the exact depth of insertion of CVCs. The catheter tip is usually intended to lie at the superior vena cava — right atrial junction. Studies have demonstrated that the most reliable radiological landmark to identify the superior vena cava — right atrial junction is the right tracheobronchial angle or carina.[14-16] Instruction sheets accompanying the CVC packs state that it is not advisable to site the catheter tip in the right atrium, as it carries a potential risk of pericardial tamponade if the tip erodes the vessel wall below the pericardial reflection. On chest X-ray, the distinct upper boundary of the pericardial sac is not visible. Anatomical studies done on cadavers have shown that it is very unlikely to extend above the level of the carina.[7] Carina has thus been considered as a reliable radiological landmark for positioning the CVC tip.

The parallax effect, which is augmentation of structures located anteriorly or posteriorly and peripherally, should be considered when using chest X-ray for measurements. This effect is more in a portable anterio-posterior chest X-ray obtained in the intensive care unit. The carina, being located in the center of the thorax, has less potential for image distortion and measurement error due to parallax effect.[10,13]

Hence, in the present study, we considered the carina as the radiological reference landmark from which the distances to the catheter tip were measured. Furthermore, the lowest acceptable CVC tip position was predetermined to be 1 cm below the carina.

Studies[2,17] done to predict the optimal depth of CVC insertion have proposed formulas using patient height. Variability in needle insertion points, patient's body size and the physical landmarks are a fact and these formulas do not take these features into account.

The results of the present study are similar to Kim *et al*.[1] and Ezri *et al.*[18] where in surface landmarks can be used in estimating the approximate depth of insertion of CVC. Electrocardiography[4,5,13] and transesophageal echocardiography[5,6] have been used to position the CVC tip. When electrocardiogram (ECG) is used an additional accessory in the form of an ECG adapter, which is not easily available, will be required. Transesophageal echocardiography requires expensive equipment and also trained personnel to interpret the echocardiography images. Topographic method requires no extra cost, equipment, or time and is more reliable as compared to using standard formulas. A limitation of the study is the high variability of the technique in obtaining a portable chest radiograph, which in turn may affect the subsequent readings.

Conclusion

The topographic method is superior to formula approach in deciding the depth of insertion of right IJV CVCs. The topographic approach has the advantage of considering the interindividual anatomic variability in CVC insertion depth.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Kim MC, Kim KS, Choi YK, Kim DS, Kwon MI, Sung JK, *et al.* An estimation of right-and left-sided central venous catheter insertion depth using measurement of surface landmarks along the course of central veins. Anesth Analg 2011;112:1371-4.
2. Peres PW. Positioning central venous catheters — A prospective survey. Anesth Intensive Care 1990;18:536-9.
3. Chalkiadis GA, Goucke CR. Depth of central venous catheter insertion in adults: An audit and assessment of a technique to improve tip position. Anesth Intensive Care 1998;26:61-6.
4. Wilson RG, Gaer JA. Right atrial electrocardiography in placement of central venous catheters. Lancet 1988;1:462-3.
5. Jeon Y, Ryu HG, Yoon SZ, Kim JH, Bahk JH. Transesophageal echocardiographic evaluation of ECG-guided central venous catheter placement. Can J Anesth 2006;53:978-83.
6. Andropoulos DB, Stayer SA, Bent ST, Campos CJ, Bezold LI, Alvarez M, *et al.* A controlled study of transesophageal echocardiography to guide central venous catheter placement in congenital heart surgery patients. Anesth Analg 1999;89:65-70.
7. Schuster M, Nave H, Piepenbrock S, Pabst R, Panning B. The carina as a landmark in central venous catheter placement. Br J Anesth 2000;85:192-4.
8. Albrecht K, Nave H, Breitmeier D, Panning B, Tröger HD. Applied anatomy of the superior vena cava-the carina as a landmark to guide central venous catheter placement. Br J Anesth 2004;92:75-7.
9. Caruso LJ, Gravenstein N, Layon AJ, Peters K, Gabrielli A. A better landmark for positioning a central venous catheter. J Clin Monit Comput 2002;17:331-4.
10. Ryu HG, Bahk JH, Kim JT, Lee JH. Bedside prediction of the central venous catheter insertion depth. Br J Anesth 2007;98:225-7.
11. Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. Br J Anesth 2006;96:335-40.
12. Ellis H, Dussek JE. Surface anatomy. In: Williams PL, editor. Gray's Anatomy. 38th ed. New York: Churchill Livingstone; 1995. p. 1916.
13. Lee JH, Bahk JH, Ryu HG, Jung CW, Jeon Y. Comparison of the bedside central venous catheter placement techniques: Landmark vs electrocardiogram guidance. Br J Anesth 2009;102:662-6.
14. Rutherford JS, Merry AF, Occleshaw CJ. Depth of central venous

catheterization: An audit of practice in a cardiac surgical unit. Anesth Intensive Care 1994;22:267-71.
15. Vesely TM. Central venous catheter tip position: A continuing controversy. J Vasc Interv Radiol 2003;14:527-34.
16. Aslamy Z, Dewald CL, Heffner JE. MRI of central venous anatomy: Implications for central venous catheter insertion. Chest 1998; 114:820-6.
17. Czepizak CA, O'Callaghan JM, Venus B. Evaluation of formulas for optimal positioning of central venous catheters. Chest 1995;107:1662-4.
18. Ezri T, Weisenberg M, Sessler DI, Berkenstadt H, Elias S, Szmuk P, *et al.* Correct depth of insertion of right internal jugular central venous catheters based on external landmarks: Avoiding the right atrium. J Cardiothorac Vasc Anesth 2007;21:497-501.