

Evaluation of Central Venous Catheter Insertion using Chest X-ray in Critically Ill Patients

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ABSTRACT

Background: Central venous catheterization is a routine procedure in the intensive care unit (ICU) often requiring the assistance of radiological techniques. The National Institute for Health and Clinical Excellence guidelines strongly advise that the radiological marker for CVC tip be located in the superior vena cava and outside the pericardial sac, which corresponds to the level of the carina based on studies of embalmed cadavers. **Objectives:** The aim was to determine the justification for the post-CVC insertion chest radiograph and to determine if the chest radiograph can accurately confirm correct CVC tip placement. **Materials and Methods:** Fifty consecutive patients on admission in the ICU between January and December 2013, who required central venous catheterization, were studied. Catheterization was performed under strict asepsis via the right internal jugular vein by a skilled Anesthetist. Postcatheterization chest radiographs (anterior-posterior views) were performed. **Results:** The mean age was 36.59 ± 14.69 years, male patients constitute 30 (60%), and females were 20 (40%). CVC tips were correctly inserted in 36 patients (72%) and misplaced in 14 (28%) patients. **Conclusion:** The use of postinsertion chest radiograph was accurate in the determination of correct catheter tip placement. The high prevalence of misplaced catheter noted justifies the need for the chest radiograph after CVC insertion.

Key words: Carina; central venous catheter; chest radiograph; internal jugular vein

Introduction

Central venous catheters (CVCs) insertion is required in patients with unstable hemodynamics requiring rapid fluid transfusion, inotropic support and varying organ support as well as for the insertion of transcutaneous pacing leads and for parenteral nutrition.^[1] There is a surge in the use of radiological techniques to insert CVCs in recent times in critical illness. Techniques such as ultrasonography, Doppler, fluoroscopy, right atrial electrocardiography, and interventional radiology have been shown to increase the speed, accuracy and safety during the insertion of CVCs when compared with anatomic landmarks.^[2] These facilities, however, are not readily available in the intensive care units (ICUs) in our environment.

The immediate complications arising from the insertion of CVC may be directly related to injury during catheter placement, which can result in arterial puncture or injury, hematoma, venous rupture, cardiac tamponade, pneumothorax, hydrothorax, hemothorax, chylothorax, and hydromediastinum. Malposition or migration of the catheter tip can result in arrhythmia, air embolism, and catheter transection.^[3,4] There is on-going controversy as to whether CVC tips should always lie above the pericardial reflection.^[5] The current recommendation is that the tip of the catheter should be just above the junction of the superior vena cava (SVC) and the right atrium at the level of the carina.^[6-8] The carina has been reported to be approximately 0.8 (0.05) cm above the pericardial sac as it transverses the (SVC), the carina was never inferior to the pericardial reflection.^[8]

Occasionally, despite proper technique, the tip of the catheter may not terminate at the desired level, resulting in aberrant placement in the internal thoracic vein, SVC, azygos vein, accessory hemiazygos vein, or axillary vein. Late complications include catheter-related infection, catheter occlusions or thrombosis, catheter fracture and migration. These complications may be lethal, in order to be prevented or for prompt intervention a prompt diagnosis is essential.

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Post-CVCs insertion chest radiograph has been reported to be helpful.^[9,10] Post-CVCs insertion chest radiograph is particularly important in patients with prior multiple and difficult catheterizations.

The posterior-anterior view is the routine position for chest radiographs in the upright or standing position but for patients admitted in the ICU or other emergency situations, who are in the supine or semi-erect position, the anterior-posterior (AP) views is preferred.^[9]

The purposes of this study were to determine the justification of postcatheter insertion chest radiograph, and to compare normal and abnormal positions of CVC insertion using chest radiograph.

Materials and Methods

This was a prospective descriptive study of 50 patients aged 20–60 years. The Institutional Human Research Ethics Committee approval and informed consent were obtained consecutively in patients scheduled for CVCs insertion through the internal jugular veins (IJV). Patients with altered coagulation parameters arrhythmias, pacemaker *in situ*, short neck, burn contractures of the neck and cervical spine injury were excluded from the study. All catheters were placed by intensivist proficient in the insertion of the CVC. All insertions were performed under aseptic technique. A multi-parameter monitor Cardiocap 7100 was attached to the patient, baseline vital signs was measured; thereafter blood pressure and heart rate were done every 5 min while oxygen saturation and electrocardiogram (ECG) monitoring were continuously assessed until the end of the procedure.

Internal jugular vein approach

The patients were placed in the supine Trendelenburg position and the head was turned to the opposite side to where the catheter was intended to be inserted; the right internal jugular vein was attempted first. Measurement of the distance from the proposed insertion site to the 3rd–4th ribs was performed. This was to ensure the correct position of the catheter and prevent the insertion into the heart chambers, pulmonary circulation or pleural cavity. The carotid artery pulsation was located at the level of the cricoid cartilage. Lateral to the pulse a 16–18-gauge needle was introduced at 30° and aimed toward the right nipple while withdrawing the needle during insertion without any imaging guidance.

Post-central venous catheter insertion chest radiography

At the end of the insertion procedure, the lumen of the catheter was flushed with 0.5 units/ml of heparinized saline. An AP chest radiograph was obtained in the supine position on all patients using AMX-4 (GE Medical System Milwaukee, USA) mobile X-ray machine. The procedure involves:^[11]

The patient is lying down in the supine position on a couch. The cassette was placed at the back of the patients. The central ray (CR) is set perpendicular to the long axis of the sternum and the center of the cassette. The point of CR is 8–10 cm below the jugular notch. The optimal ICU chest radiograph is obtained in the AP view at a focal film distance of about 110 cm (about 43 inches).

The film was then developed after exposure with the computed radiograph (CR) monitor.

All the chest radiographs were interpreted by a consultant radiologist. The chest radiographs were assessed for the vertical distance of the CVC tip above or below the carina, without any measurement. The optimal position of CVC catheter tip is at the level of the carina, as illustrated by Figure 1.^[5,6] No radiologic complication was observed. In some of our patients, however, the ECG tracing during CVCs insertion showed evidence of atrial or ventricular arrhythmias, the CVCs tips were immediately repositioned.

Data analysis was done with Statistical Package for the Social Sciences Computer Soft Version 21. Data were expressed as median $\pm$ standard deviation, proportions, and percentages. Chi-square test was employed to detect differences in proportions between groups with our predetermined level of significance being 0.05 ($P < 0.05$).

Results

Fifty patients were studied with a mean age of 36.59 ± 14.69 years, 30 were males (60%), and females were 20 (40%).

Thirty-six CVCs tips (72%) of were optimally placed at the level of the carina, while CVCs tips 14 (28%) were wrongly placed (2 CVCs tips [4%] were above the carina, and 12 [24%] were below the carina) [Figures 2-5].

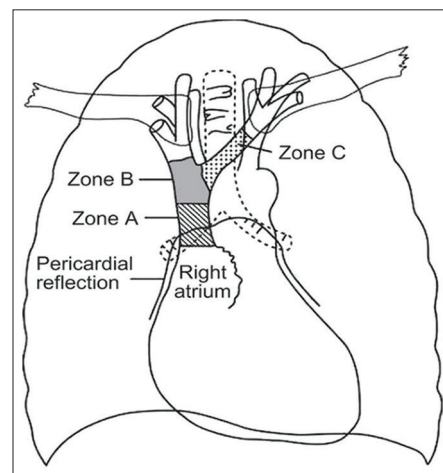


Figure 1: Stylized anatomical figure dividing the great veins and upper right atrium into three zones (A-C) representing different areas of significance for placement of central venous catheter

Central venous catheters tips repositioning was required in 8 males compared to 6 females, $P = 0.345$ [Table 1]. Figure 1 shows the proportion of CVCs tips placement in relation to the carina. See Figures 3 and 4. After repositioning, chest radiograph was repeated to confirm the position of the tip and the catheter insertion depth was noted.

Discussion

This study has demonstrated that a considerable proportion of CVCs tips (28%) were wrongly sited [Figure 2]. This is within the reported range of 10–30% of malposition catheter tip or a catheter tip in the right atrium.^[12] This was slightly higher in a retrospective study in a general ICU in the United Kingdom when 37% of the CVCs tips were misplaced, most of the CVCs tips were in the innominate vein.^[6] This is not surprising as retrospective studies have been reported to either exaggerate or underestimate reports of research.

The majority of CVCs tips (12%) in our review were placed below the carina in the right atrium [Figure 5]. This may

be related to the use of anatomically technique for the CVCs insertion. On the contrary, in a similar study, 47% of CVCs tips were placed in the right atrium. In a similar study, the authors attributed to the use of 30 cm catheters. They recommended 15 or 16 cm CVCs be used in future CVCs insertions.^[13] In our study, we used 15–20 cm CVCs, and estimated the depth of insertion of CVCs by taken a measurement from the site of needle insertion to the 3rd/4th rib. Despite this, malposition catheters were still common, which may be due to individual variability during CVCs insertion. The relatively short CVCs may account for 4% CVCs tips placed above the carina.

Table 1: Appropriate position of CVCs tips

	Male (n=30) (%)	Female (n=20) (%)
Rightly placed CVCs tips	22 (61.1)	14 (38.9)
Wrongly placed CVCs tips	8 (57.1)	6 (42.9)

CVCs – Central venous catheters

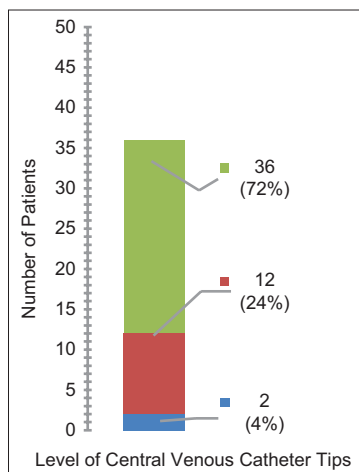


Figure 2: The radiological levels of central venous catheters tips in relation to the carina



Figure 3: Central venous catheters tip at the level of the carina (appropriate position)

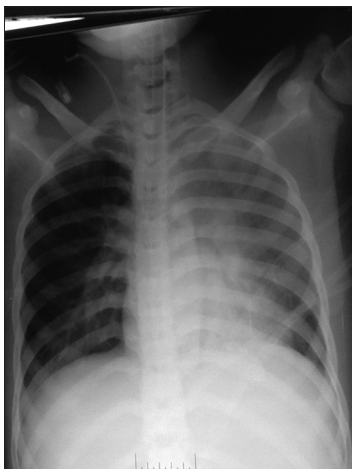


Figure 4: Central venous catheters tip above the carina

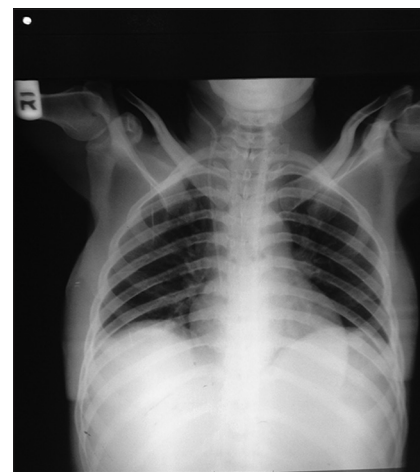


Figure 5: Central venous catheter tips below the carina in the right atrium

Malposition CVCs tips may increase the risk of the vessel wall and cardiac perforation, cardiac tamponade, migration of CVCs tips, pneumothorax, and hemothorax.^[4,13] Fortunately in our review such grave complications were not observed. In some of our patients, however, the ECG tracing during CVCs insertion showed evidence of atrial or ventricular arrhythmias, the CVCs tips were immediately repositioned. This has illustrated the need for adequate monitoring during CVCs insertion.

The right internal jugular venous (IJV) route was used in this study. The right internal jugular vein is one of the preferred veins for central venous access, the anatomy of the jugular venous system and the design of the catheter facilitate proper insertion.^[4,13] Placement of the catheter using the left IJV route may transverse through the left brachiocephalic vein, enters the SVC at 90° and their distal CVC tips may impinge on the right lateral wall of the SVC, thereby increasing the risk of vascular injury. This may be why we did not observe any vascular injury.

Conclusion

This study demonstrated that the postprocedure chest radiograph was helpful in evaluating the position of the tip of the catheter whether it was normal or abnormal in relation to the carina and by extension confirming correct catheter placement. The high prevalence of misplaced catheter seen in this study justifies the need for postcatheter insertion chest radiograph. It is, therefore, imperative that after every CVC insertion, the position of the tip must be confirmed radiographically, and if any repositioning is required, it must be done. This is also true for CVCs inserted through the subclavian vein.

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References

1. Bhatt S, Dahat A, Jain N, Nayak U, Patel V. Indications and

complications of central venous catheterization in critically ill children in intensive care unit. *Natl J Med Res* 2012;2:85-8.

2. Reeves AR, Seshadri R, Trerotola SO. Recent trends in central venous catheter placement: A comparison of interventional radiology with other specialties. *J Vasc Interv Radiol* 2001;12:1211-4.
3. Ruesch S, Walder B, Tramèr MR. Complications of central venous catheters: Internal jugular versus subclavian access – A systematic review. *Crit Care Med* 2002;30:454-60.
4. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med* 2003;348:1123-33.
5. Fletcher SJ, Bodenham AR. Safe placement of central venous catheters: Where should the tip of the catheter lie? *Br J Anaesth* 2000;85:188-91.
6. Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. *Br J Anaesth* 2006;96:335-40.
7. Vesely TM. Central venous catheter tip position: A continuing controversy. *J Vasc Interv Radiol* 2003;14:527-34.
8. Venugopal AN, Koshy RC, Koshy SM. Role of chest X-ray in citing central venous catheter tip: A few case reports with a brief review of the literature. *J Anaesthesiol Clin Pharmacol* 2013;29:397-400.
9. Bankier AA, Mallek R, Wiesmayr MN, Fleischmann D, Kranz A, Kontrus M, *et al.* Azygos arch cannulation by central venous catheters: Radiographic detection of malposition and subsequent complications. *J Thorac Imaging* 1997;12:64-9.
10. Boon J, Kirkb R. Can peripheral central venous lines be inserted safely and successfully where X-ray facilities are not available? *S Afr Fam Pract* 2002;25:4-8.
11. Ballinger PW, Frank ED. Merrill's Atlas of Radiographic Positions and Radiologic Procedures. 9th ed. Chicago: Mosby; 1999. p. 58.
12. Rutherford JS, Merry AF, Occleshaw CJ. Depth of central venous catheterization: An audit of practice in a cardiac surgical unit. *Anaesth Intensive Care* 1994;22:267-71.
13. Pittiruti M, Malerba M, Carriero C, Tazza L, Gui D. Which is the easiest and safest technique for central venous access? A retrospective survey of more than 5,400 cases. *J Vasc Access* 2000;1:100-7.

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