

# Role of chest X-ray in citing central venous catheter tip: A few case reports with a brief review of the literature

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## Abstract

Central venous catheter (CVC) insertions are increasingly performed in surgical patients and intensive therapy. A simple and invasive procedure performed under strict sterile precautions with complications ranging from arrhythmias; infections; and life-threatening complications such as pericardial tamponade, cardiac perforation and even death. A post-procedure chest X-ray (CXR), though does not accurately assess the tip of the catheter in relation to the superior vena cava (SVC) and right atrium (RA), can detect malpositions, safety of catheter tip, pneumothorax and kinking. We would like to share some of the malpositions we encountered in our centre, their management and a brief review of the literature on optimal catheter tip location.

**Key words:** Central venous catheterization, complications, heart, malpositions, radiology

## Introduction

The incidence of central venous catheter (CVC) malpositions ranges from 3.6 to 14%.<sup>[1]</sup> Ultrasound has reduced some of the complications during its insertion, but cannot locate the catheter tip in relation to heart. Only transesophageal echocardiography can accurately detect a CVC tip in relation to superior vena cava (SVC) and right atrium (RA),<sup>[2,3]</sup> but its availability as a bedside tool is limited to major hospitals. In our centre, we routinely perform a post-procedure chest X-ray (CXR) to confirm the tip of the catheter and we could detect some of the catheter malpositions that are illustrated below. A brief review of the literature suggesting optimal CVC tip position with the carina as the radiological landmark is worth mentioning,<sup>[4]</sup> and some of the safe practice guidelines for CVC placement are also discussed.

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## Case Reports

We are illustrating seven cases of abnormal CVC tip positions encountered over a period of 1 year.

Case no. 1: A peripherally inserted CVC (PICC) getting coiled in the ipsilateral axillary vein. Since aspiration did not yield blood, it was removed and reinserted through the opposite side in the ICU [Figure 1].

Case no. 2: A triple-lumen CVC inserted via right internal jugular vein (IJV) getting coiled there itself. Aspiration did not yield blood in any of the lumens and it was therefore removed and reinserted [Figure 2].

Case no. 3: A PICC with the tip reaching the ipsilateral IJV. It was detected in the post-anesthesia care unit where it was removed and reinserted via right IJV [Figure 3].

Case no. 4: A triple-lumen CVC inserted via right subclavian vein with the tip reaching the ipsilateral IJV. It was pulled back up to the 5-cm mark and pushed with the head turned to the same side and applying pressure to the supraclavicular area [Figure 4].

Case no. 5: A triple-lumen CVC inserted via right IJV going into the ipsilateral subclavian vein. It was pulled back again and reinserted confirming its correct position in a repeat CXR [Figure 5].

Case no. 6: Normal position. A triple-lumen CVC inserted via left IJV with the tip near the SVC-RA junction. Note the parallel placement of the catheter in the SVC, with the tip below the carina (arrow mark) [Figure 6].

Case no. 7: A triple-lumen CVC was inserted into the left IJV by Seldinger technique but blood could not be aspirated from the most proximal lumen. A check CXR revealed a

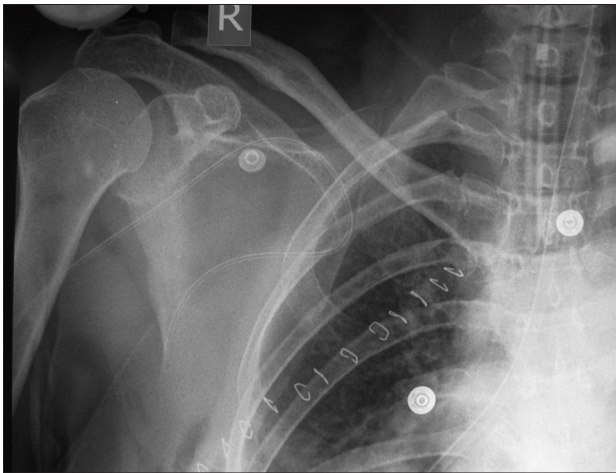


Figure 1: A PICC (45 cm) with the tip found coiled in the ipsilateral axillary vein



Figure 2: A triple-lumen 7 Fr. Right IJV CVC with the tip coiled in the lower part of the IJV itself



Figure 3: A right-sided PICC (45 cm) with tip reaching the same-side IJV

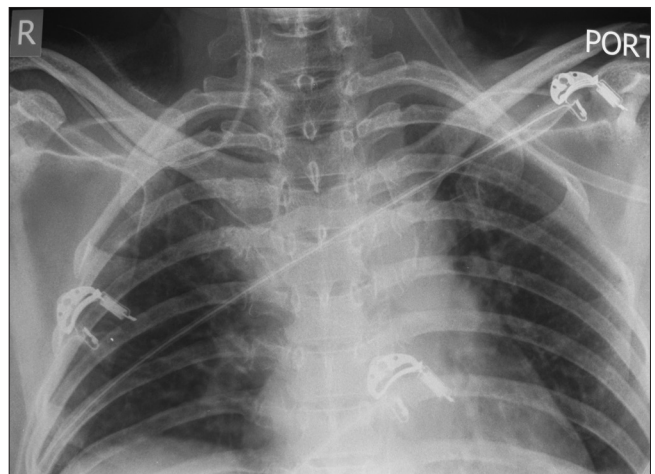


Figure 4: A triple-lumen CVC inserted via right subclavian vein, with the tip reaching right IJV



Figure 5: A triple-lumen 7 Fr. CVC inserted via right IJV whose tip was found to be in the ipsilateral subclavian vein

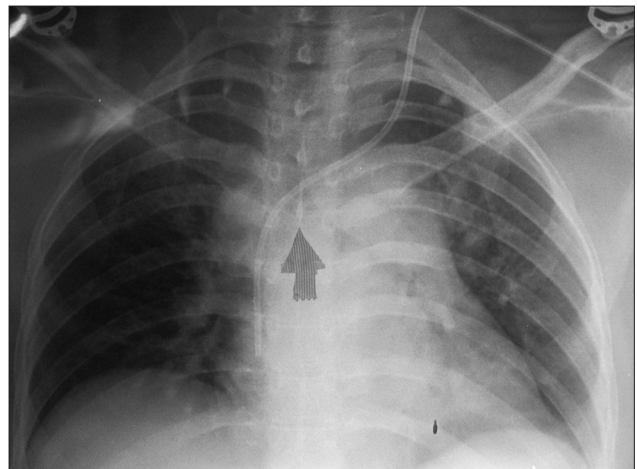


Figure 6: Correctly positioned CVC tip

kinked catheter with its tip in the left IJV. We decided to correct the kink using a “push pull” improvised technique. Under strict aseptic precautions, the proximal straight end of an ethylene oxide-sterilized J tip guide wire was inserted into the distal end of the triple-lumen catheter until resistance was felt—probably the site of the kink. The catheter was pulled out slowly while simultaneously pushing in the guide wire in a similar way. The catheter was pulled out by 4 cm to undo the kink. Now the guide wire could be freely advanced up to 15 cm. The catheter was fully withdrawn over the guide wire and was reinserted again. The guide wire was removed and blood was aspirated from all three lumens. A repeat CXR revealed the tip of the catheter in the SVC. Thus the catheter was salvaged and additional cost burden to the patient was avoided.

Case no. 8: One PICC line inserted for chemotherapy by the cut down method probably went straight into the thoracic duct as chyle could be aspirated. It was corrected by withdrawing the catheter by 1-2 cm.

## Discussion

The traditionally preferred position of the catheter tip is in the distal third of the SVC to minimize complications such as catheter migration, extravasation of irritant agents, vascular perforation, local vein thrombosis, catheter malfunction and cranial retrograde injection.<sup>[5]</sup> The junction of the SVC and RA was considered to be located at the intersection of the right lateral margin of the SVC and the superior border of the RA (cardiac silhouette).<sup>[11]</sup> It should be recognized that the length of the catheter inserted through right IJV to position the tip properly in the SVC will vary according to the height of the patient and puncture site, and is about 3-5 cm more when it is passed from the left IJV compared with the right.<sup>[6]</sup>

The right IJV has been the route preferred by anesthesiologists for CVC placement for various reasons, like fewer complications with a success rate of approximately 90-99%.<sup>[7,8]</sup> Catheters passed through the left IJV must traverse the left brachiocephalic vein and enter the SVC perpendicularly, and their distal tip may impinge on the right lateral wall of the SVC, thereby increasing the potential for vascular injury. Many authors are of the opinion that a right-sided IJV catheter is better placed up in the SVC or in the innominate vein, whereas a left-sided one is safer in the lower part of the SVC or RA.<sup>[3]</sup> An *in vitro* study has shown that an acute angle of  $>40^\circ$  with the wall of the SVC results in a markedly increased risk of vessel perforation.<sup>[9]</sup> This might explain the higher risk of perforation with left-sided catheters.<sup>[10]</sup> All these

necessitate a radiographic confirmation of the CVC tip, which can easily be accomplished with a simple CXR.

The carina is radiologically identifiable in about 96% of all CXRs at the interspace between the fourth and fifth thoracic vertebrae. Stonelake and Bodenham<sup>[4]</sup> in their retrospective audit of the position of the CVC tip on routine post-procedure CXRs of ICU patients suggested three different zones for safe catheter placement. Accordingly, zone-A represents lower SVC and upper RA, zone-B represents upper SVC and the area around the junction of both innominate veins, and zone-C represents the left innominate vein proximal to the SVC. They found that all left-sided IJV catheter tips can be ensured of their placement being parallel to the SVC wall if they are in zone-A but at a rare chance of pericardial tamponade. Another risk in this area is that the azygos vein joins the SVC where the CVC can pass into this venous system. They recommend that all right-sided CVCs are safe if placed in zone-B. Left-sided catheters will enter this area at a steep angle and can abut the lateral wall of the SVC, and hence should be advanced to lower SVC (zone-A). CVC tip in zone-C has been suggested for Central Venous Pressure monitoring and fluid therapy. They conclude that for safety reasons all right-sided catheters are placed with their tips sited above the carina and all left-sided ones below the carina. Existing guidelines recommend that the CVC tip should be located in the SVC outside the pericardial sac to avoid complications, but it should always be remembered that the upper limit of the pericardial reflection on the SVC cannot be seen on CXR. Schuster *et al.*,<sup>[11]</sup> in their study of embalmed cadavers suggested that the pericardium crosses the SVC below the carinal level and emphasized that the lateral wall of the SVC was weaker, explaining the chance for erosion. They suggested that the CVC tip in the SVC above the level of the carina is ideal and safe. In a similar study but of fresh cadavers, Albrecht *et al.*,<sup>[12]</sup> confirmed that the carina is a reliable, simple anatomical landmark for safe CVC tip placement. They confirmed that the pericardial reflection on the SVC was much below the carina compared with that reported by Schuster *et al.*, enhancing safety even if the tip is a little below.

In various studies regarding catheter tip distance down from the carina Wirsing *et al.*,<sup>[13]</sup> and Aslamy *et al.*,<sup>[14]</sup> found that 55 and 29 mm were acceptable cut-off values to ensure extra-atrial catheter position. In a study using computed tomographic angiography of SVC, the carina was found approximately midway in relation to the SVC<sup>[15]</sup> and it was suggested that keeping the catheter tip at or just below the carina assumes placement in the SVC and 4 cm below the carina represents the cavoatrial junction.



Many authors are of the opinion that electrocardiogram-guided CVC tip placement at the SVC-RA junction has an accuracy of 95-100% in confirmation with transesophageal echocardiography.<sup>[3,16-18]</sup> CXR on the other hand is less accurate (parallax error is greater and more variable in a portable CXR - anteroposterior view) but offer a cheap and least sophisticated imaging technique to assess a CVC tip in relation to the carina, which is well accepted as a bedside reliable and cost-effective tool.<sup>[11,18,19]</sup> These two techniques are feasible in all major hospitals. Ultrasound-guided venous puncture and fluoroscopy/C-arm-guided CVC tip placement showed a technical success rate of 98%,<sup>[20]</sup> but they are not feasible for all major hospitals. Use of transesophageal echocardiography was shown to have 100% accuracy,<sup>[2]</sup> but confined only to tertiary hospitals.

## Conclusion

Bedside CXR is still considered the gold standard for identifying catheter malpositions and complications such as pneumothorax. Use of transesophageal echocardiography, fluoroscopy and C-arm can detect a catheter tip more readily and accurately compared with CXR. ECG guidance while insertion and a post-procedure CXR can ensure CVC tip placement above or a little below the carina, which can enhance patient safety.

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