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# CARINA AS A USEFUL AND RELIABLE RADIOLOGICAL LANDMARK FOR DETECTION OF ACCIDENTAL ARTERIAL PLACEMENT OF CENTRAL VENOUS CATHETERS

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**ABSTRACT.** Central venous catheters are commonly used in the management of critically ill patients. Their insertion can be challenging in hemodynamically unstable patients and in those with altered thoracic anatomy. Although ultrasound guided insertion can reduce this problem, this facility may not be available in all locations and in all institutions. Accidental arterial puncture is one of the very serious complications that can occur during central venous catheter insertion. This is usually detected clinically by bright color and projectile/pulsatile flow of the returning blood. However, such means are known to be misleading especially in hypoxic and hemodynamically unstable patients. Other recognized measures used to identify arterial puncture would be blood gas analysis of the returning blood, use of pressure transducer to identify waveform pattern and the pressures. In this article, we propose that trachea and carina can be used as a reliable radiological landmark to identify accidental arterial placement of central venous catheters. We further conclude that this information could be useful especially when dealing with post-resuscitation victims and hemodynamically unstable critically ill patients.

**KEY WORDS.** central venous catheter, accidental arterial, superior vena cava, angiocatheter.

## INTRODUCTION

Central venous catheters (CVC) are essential in the management of numerous patients for facilitating hemodynamic monitoring, intravenous drug therapy, parenteral nutrition, hemodialysis and volume resuscitation. Insertion of central venous catheters can be challenging in hemodynamically unstable patients and in those with altered thoracic anatomy. Accidental arterial puncture can be a very serious complication that can occur during CVC insertion [1–3]. Although ultrasound guided insertion can minimize these problems, this facility may not be available in all locations and in all institutions [3]. Moreover, ultrasound guided approach also has been known to have resulted in accidental arterial punctures [4]. Clinical means of detection of arterial puncture are known to be misleading especially in hemodynamically unstable patients [5]. This could result in placement of the CVC into a great vessel which might remain unrecognized for many hours until resultant complications attract the clinician's attention [3, 4, 6]. Other recognized measures used to identify arterial puncture would be blood gas analysis of

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the returning blood, use of pressure transducer to identify waveform pattern and the pressures [5]. These facilities also may not be available at hand especially in developing and underdeveloped countries. However, a CVC left in artery can result in life threatening complications and hence needs to be identified and managed at the earliest [3]. Therefore, it is important to find a cost effective and universally available measure to reliably and quickly identify arterial placement of CVC.

It is routine practice to do a chest X ray (CXR) following CVC insertion to ensure appropriate position of the tip of the CVC and to rule out possibility of pneumothorax. Carina has been used as a reliable radiological landmark for detecting appropriate positioning of the CVC at the junction of superior vena cava (SVC) and right atrium [7, 8]. Focus of this study is to delineate the radiological relationship of appropriately placed CVC and angiocatheters to tracheobronchial tree (carina) and to establish the utility of trachea and carina as radiological landmark for identification of accidental arterial placement of CVC.

## METHODS

Local Institutional Ethics Committee approval was obtained for a retrospective analysis of anteroposterior (AP) radiological chest images of patients who had undergone CVC insertion in the past 6 months at our intensive care unit and angiocatheter insertion for coronary angiography in the past 1 month at our cardiology catheterization laboratory. A total of 183 patients had undergone CVC insertion and 78 patients had undergone cardiac catheterization in the above mentioned period. All CVC images were analyzed by one anesthesiologist and all angiocatheter images were analyzed by one cardiologist to assess relationship of the CVC/angiocatheter to tracheobronchial tree. We excluded those images where the CVC tip was not pointing towards the heart (misdirected CVC). Files of all these patients were evaluated for confirmation of appropriate vascular placement of CVC/angiocatheter by either transducer or blood gas analysis. The mean entrance dose of each X-ray was reported to be approximately 0.5–1 mGy as per our radiologist. They also reported that approximately a distance of 3 feet (80–90 cm) was maintained between the patient and the cathode at the time of chest X-ray and approximately 22 cm distance was maintained between the patient and the cathode during angiocatheter data in catheterization laboratory. However, since all the radiographs were available online through computerized system (PACS) in our institution, the quality of radiographs were improved where necessary by changing the brightness/contrast as necessary to get clear view of catheter and the carina.

## RESULTS

Out of the 183 CVC images, 4 were excluded as two CVC were inserted from right subclavian vein and had gone towards right IJV, in one image the CVC had gone from right subclavian vein to innominate vein and in another patient the CVC had gone from right IJV to right EJV. Remaining 179 images were included in the study. While venous placement was confirmed by blood gas analysis in 127 patients, other 52 were confirmed with transducer. Of these 179 images, 49 were right sided internal jugular CVC, 103 were right sided subclavian vein CVC, 7 were left sided internal jugular CVC and 20 were left sided subclavian vein CVC. All 78 images of angiocatheters were evaluated. All these were confirmed to be in the artery with transducer. Right femoral artery was used to insert 56 of these, while other 22 were inserted from right radial artery.

It was found that all right sided CVCs remained on the right side of the trachea and did not cross the carina at any point (Figure 2). All left sided CVCs crossed the trachea well above the carina to lie on the right side of the trachea (Figure 3). All angiocatheters inserted from right radial artery crossed the trachea well above the carina and remained on left side of the trachea (Figure 4). All angiocatheters inserted from femoral artery remained on left side of the trachea while in descending aorta and part of the angiocatheter that was in the ascending aorta remained almost in line with the carina (Figure 5).

All the central venous catheters that were used in our intensive care unit were from single manufacturer [Multimed, external diameter 7 F (2.3 mm), 16 cm length radio-opaque catheters, Edwards lifesciences LLC, Irvine, CA 926145686, USA]. All the angiocatheters used during cardiac catheterization were from single manufacturer [Judkin Left/Judkin right 6 F, 105 cm for femoral access and Tiger 5 F, 105 cm for radial artery access, Cordis, Johnson & Johnson, USA].

## DISCUSSION

Understanding of the anatomical relationship of the great vessels to the heart reveals that the superior vena cava lies to the right side of the trachea and aorta lies to the left side of the trachea (Figure 1). Based on this knowledge, it may be possible to radiologically identify accidental arterial placement of CVC. As has been shown in our study, all CVC placed from right side internal jugular vein (IJV)/subclavian vein (SCV) will remain on the right side of the trachea and will never cross the trachea (Figure 2) unless they enter the innominate vein or are placed into the artery. All CVC placed from left side (IJV/SCV) will cross

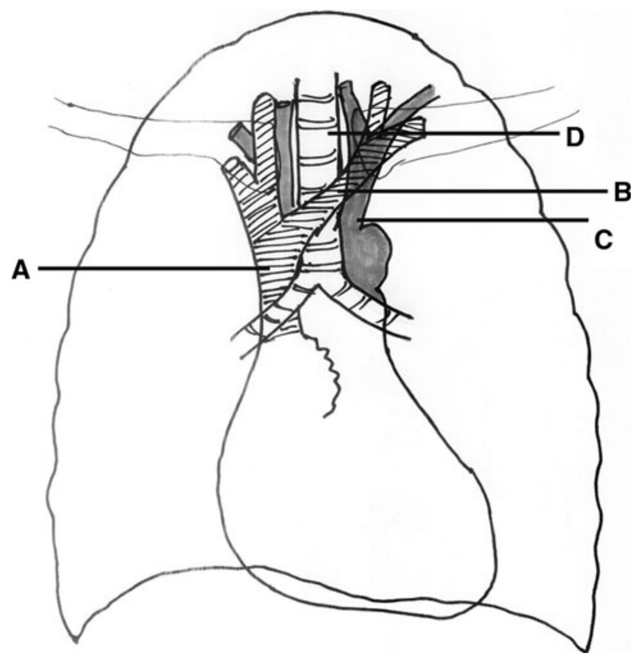


*Fig. 1. A stylized anatomical diagram showing the relationship between the major vessels in the thorax with the tracheobronchial tree (The shaded area represents the arterial system and the striped area represents the venous system). A—Superior vena cava, B—Innominate vein, C—Aorta and its branches, D—Trachea.*

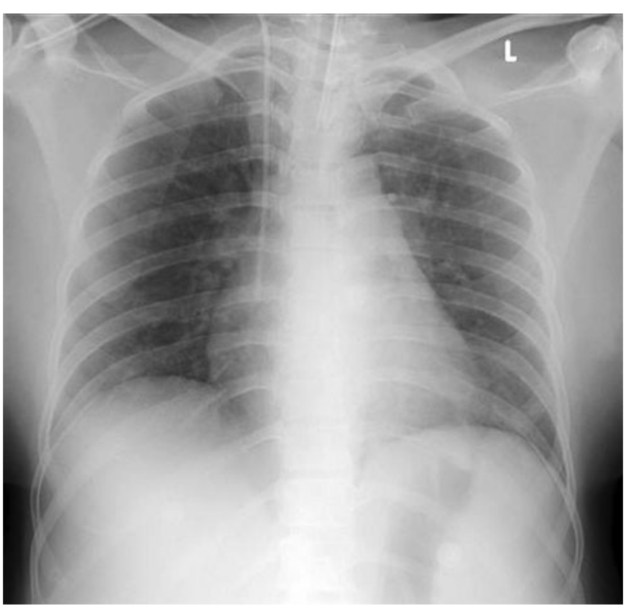


*Fig. 2. A central venous catheter inserted from right internal jugular vein remains on the right side of the trachea and does not cross the carina.*

the trachea well above the carina from left to right and come to lie on the right side of the trachea (Figure 3) unless they are in the artery or are malpositioned where

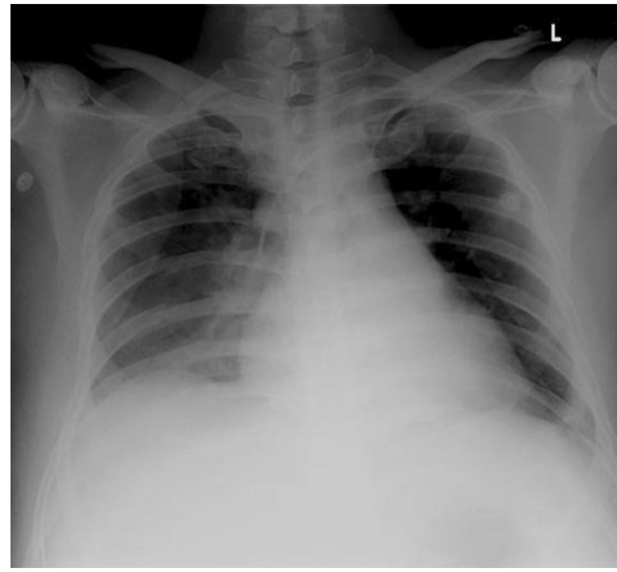


*Fig. 3. A central venous catheter inserted from left subclavian vein crosses the trachea well above the carina through the innominate vein to lie on the right side of the trachea.*

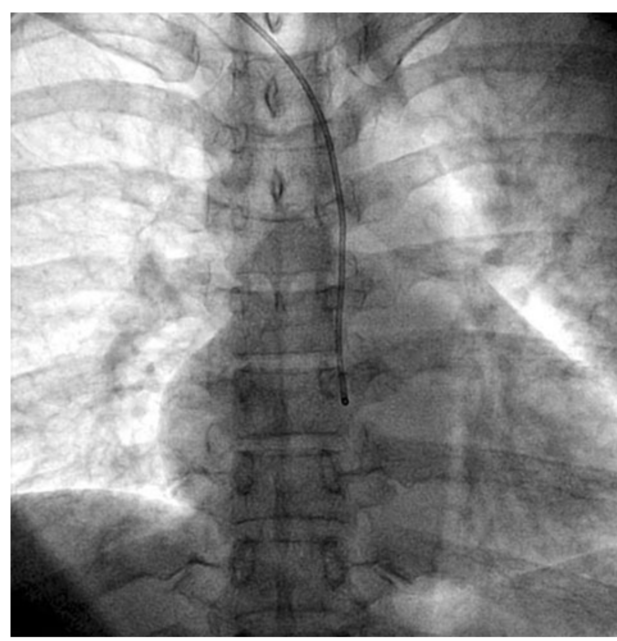

*Fig. 4. An angiocatheter inserted from right radial artery crosses the trachea from right to left well above the carina to come to lie on the left side of the trachea (simulation of accidental arterial placement of CVC from right side).*

CVC travels from left IJV to left SCV or viceversa. Exceptions to this rule would be persistent left sided superior vena cava (Figure 6) or dextrocardia which can mislead the diagnosis, however, fortunately such

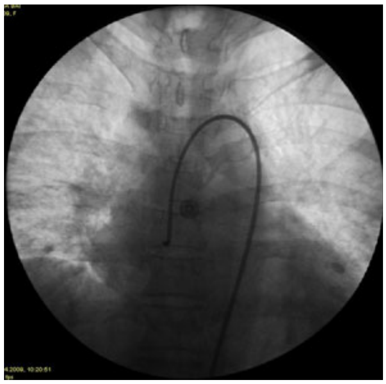

*Fig. 5. An angiocatheter inserted from femoral artery enters ascending aorta and then to descending aorta and always remains on the left side of the trachea (simulation of accidental arterial placement of CVC from left side).*

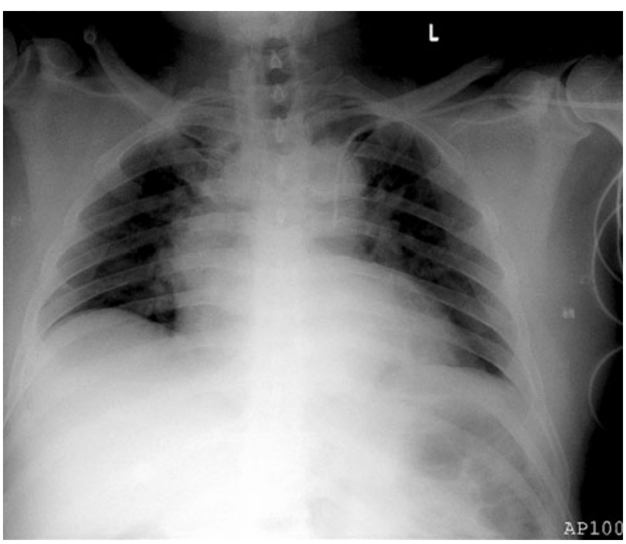


*Fig. 6. A left sided CVC inserted into subclavian vein was found to lie persistently onto left of the tracheobronchial tree. Further evaluation by contrast ECHO revealed a persistent left sided superior vena cava.*

congenital problems are extremely rare (0.3–0.5%) [9]. When the CVC is accidentally placed in the great vessels, it should mimic the course of an angiocatheter inserted into aorta from any of the peripheral artery. An angiocatheter when inserted from right side of the arterial system crosses the trachea well above the carina to left side and remains on the left side of the trachea (Figure 4) and when inserted from left side of the arterial system will continue to remain on the left side of the trachea all through its course (Figure 5). Hence, accidental arterial placement of CVC should be identifiable by its persistent presence on the left side of the trachea while attempting insertion through left IJV/SCV, whereas it crosses the trachea from right to left above the carina if an arterial insertion to occur while attempting insertion through right IJV/SCV. One of the drawbacks of our study was that only one person evaluated the position of the catheters in relation to the tracheobronchial tree. However, we believe this does not affect the outcome of the study as tracheobronchial tree and the CVC should be clearly visible even with the poor quality CXR. Therefore, based on our study results we suggest that an AP view CXR taken after placement of CVC can be useful in determining accidental arterial placement of the CVC. Furthermore, we believe that this might be useful especially in hemodynamically unstable patients such as those who have been revived after cardiac arrest, patients with hypotensive shock on multiple vasopressors. While CVC placement in such patients without the aid of ultrasound could be difficult, identification of venous placement would be even more difficult especially when either a transducer or blood gas analysis facility is not available at hand immediately.

## CONCLUSION

We conclude that an AP view CXR can be a simple, inexpensive and reliable tool to determine accidental arterial placement of the CVC.

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