SHORT COMMUNICATION

Evaluation of routine postoperative chest roentgenogram for determination of the correct position of permanent central venous catheters tip

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Background: Proper placement of central venous catheter (CVC) tip could reduce early and late catheter-related complications. Although the live fluoroscopy is standard of care for placement of the catheter, it is not available in many centers. Therefore, the present study evaluated the sensitivity and specificity of bedside chest X-ray (CXR) for proper positioning of the catheter tip. **Materials and Methods:** A total of 82 adult patients undergoing elective placement of tunneled CVC were enrolled in this study during 2010-2012. The catheter tip position was evaluated by postoperative bedside chest radiographs as well as trans-thoracic echocardiogram as definite diagnostic tool. The catheter position was considered correct if the tip was positioned in the right atrium both in CXR or echocardiography. Finally, CXRs interpreted by expert radiologist. Thus findings were compared by echocardiography. Sensitivity, specificity, accuracy, positive, and negative predictive values were calculated. Data were analyzed using SPSS version 16 (SPSS Inc., Chicago, IL), and $P < 0.05$ considered as significant. **Results:** The patients were 57.37 ± 18.91 years of age, weighed 65.79 ± 15.58 kg and were 166.36 ± 9.91 cm tall. Sensitivity and specificity of CXR for proper catheter tip position were 74.3% and 58.3%, respectively. Positive and negative predictive values were 91.2% and 28%. In addition accuracy, positive likelihood ratio, and negative likelihood ratio were 71.9%, 1.78, and 2.27 respectively. **Conclusion:** Bedside CXR alone does not reliably predict malpositioning after CVC placement.

Key words: Chest X-ray, hemodialysis, tunneled central catheter

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INTRODUCTION

Generally internal jugular veins (IJV) are the preferred sites for inserting long term central venous catheters (CVC). To minimize the risk of early and late catheter-related complications the goal is to place the tip of the catheter within the atrium.[1]

However, central venous catheterization may put the patients in risk. Hemothorax, pneumothorax, hydrothorax, arrhythmias, chylothorax, cardiac tamponade, hematoma, infection, air embolism, great vessel puncture, thrombosis, injury to brachial plexus or phrenic nerve, catheter mal-position, and death are some of catheter-related complications.[2-7] Different studies reported 0.4-20% complication rate due to CVC placement.[8,9] Other investigators revealed that complication rate decreased by increasing operator's experience.[10]

Commonly bedside chest X-ray (CXR) is used to verify the CVC position and possible complications.[11] However identifying superior vena cava (SVC)-right atrium (RA) junction in bedside CXR is challenging.[12] Transthoracic echocardiography (TTE), in comparison, permits the visualization of a CVC tip and its relation to anatomic structures.[13,14] Albeit other investigators used trans-esophageal echocardiography to find catheter tip position,[1] however this technique is invasive and may cause some concerns in end-stage renal disease (ESRD) patients. Therefore, in the present study, TTE served as a reference method.

Although the live fluoroscopy is standard of care for placement of the catheter,[1] it is not available in many centers. Therefore, the present study evaluated the sensitivity and specificity of bedside CXR for proper positioning of the catheter tip.

MATERIALS AND METHODS

This observational study was performed during 2010-2012 in Al Zahra hospital, a referral university

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hospital, Isfahan, Iran, with Ethics Committee of the Isfahan University of Medical Sciences approval (certificate number: 190047). All the patients signed an informed written consent after full informative session about the study purpose and methods. Eighty-two adult patients undergoing elective placement of long-term hemodialysis catheter were enrolled in this study. Patients with morbid obesity (body mass index [BMI] ≥40 kg/m^2), kyphoscoliosis, insertion site infection, chronic obstructive pulmonary disease, previous heart surgery, or coagulopathy were not included. Catheters were inserted under local anesthesia and conscious sedation (by 5 mg intravenous midazolam) as well as heart monitoring. Patients were placed in a Trendelenburg position with the head turned to the left side and mild neck extension. The right IJV was used for catheterization by surface anatomic landmarks. After cannulation of vein, the guide wire was inserted, patient's head and neck was placed in a neutral position. Then subcutaneous tunnel was created, and finally catheter was inserted into right IJV and either fixed to the skin or implanted within the subcutaneous tissue. Catheter insertion was performed by a vascular surgeon and two residents. Portable antero-posterior chest radiograph were obtained in all patients immediately after the procedure in the postanesthesia unit to find out both position of the catheter tip, and possible complications such as pneumothorax, hemothorax, and catheter dislodgment.

Position of catheter was examined by TTE at the same time by an expert cardiologist with no previous knowledge of the experimental design. The catheter position was considered correct if the tip was positioned in the RA or SVC-RA junction. All other positions were judged to be a failure. Failed catheters were re-inserted or withdrawn based on catheter tip position.

All chest roentgenograms analyze by a radiologist who was blinded for study protocol. Other studies showed that the cephalic reflection of pericardium or SVC-RA junction is located 3 cm below the carina, which is easy to find in CXR. The cephalocaudal length of SVC is about 6 cm. Indeed carina placed in mid-SVC length. Hence if the catheter tip seen 3 cm above or below the carina, is located within SVC.[13] Tip of catheter considered intra-atrial when >3 cm distance observed from carina. The atrium begins from 3 cm below the carina and extends down to diaphragm.[14] Tricuspid valve is located just above the diaphragm. Therefore, if catheter shows transverse position in plain film it considered intra-ventricular position.

SPSS version 16.0 software for Windows (SPSS Inc., Chicago, IL) was used for statistical analysis. The sensitivity, specificity, positive predictive value, and negative predictive value of routine postoperative CXR for detecting catheter tip were evaluated using echocardiography as the reference standard. The evaluation indices for the diagnostic tests were as follows:

1. Validity indices, including sensitivity, specificity, predictive values, likelihood ratio, accuracy, and Youden index; and
2. reliability index, including Kappa value. A $P < 0.05$ was considered to be statistically significant.

RESULTS

During the study period, tunneled central venous catheterization was performed on 82 adult patients (54 men, 28 women). The patients were 57.37 ± 18.91 years of age, weighed 65.79 ± 15.58 kg. Height and BMI were 166.36 ± 9.91 cm and 23.64 ± 4.55, respectively.

The data from the two groups were entered into a 4-fold table using a blinded control to calculate the validity and reliability indices for routine CXR. The sensitivity, specificity, accuracy, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, and Youden index for CXR were 74.3%, 58.3%, 71.9%, 91.2%, 28%, 1.78, 2.27, and 0.326, respectively. The reliability index included the kappa value, which was 0.225 [Table 1]. Our data showed no early complications (cardiac tamponade, pneumothorax, hemothorax, catheter malfunction, and catheter-induced arrhythmia) related to the procedure.

DISCUSSION

As a regular intervention in the management of critically ill patients, millions of CVCs are used each year for various medical indications.[15] Proper intraatrial CVC tip position after conventional technique has been reported in 8-47% of the cases.[16-18]

Although improper positioning of the catheter is not very common, it can cause serious postoperative complications such as perforation, pneumothorax, hemothorax, tamponade and arrhythmia.[19] Therefore, it is important to determine whether the catheter is in an acceptable position soon after the intervention. Several imaging and electrophysiologic methods have been used to evaluate the position of the catheter. Bedside CXR, as a less sophisticated imaging procedure, is among the most commonly used imaging

Table 1: Diagnostic values of routine CXR for detecting catheter tip

	Echocardiography		Total
	Successful	Unsuccessful	
CXR			
Successful	52	5	57
Unsuccessful	18	7	25
Total	70	12	82

CXR = Chest X-ray

techniques. However, the validity of this method is still unclear. The main focus of this study was to examine the sensitivity and specificity of routine postoperative CXR for determination of the position of CVC. Although in the literature transesophageal echocardiography is the gold standard measure for identifying catheter tip, however in ESRD patients using this invasive and less available technique is challenging. Therefore, we used TTE for this purpose based on other studies.[13,14,20,21] Present study demonstrated that postoperative CXR is neither a sensitive nor a specific method for detecting CVC malpositioning.

Wirsing *et al*. investigated sensitivity and specificity of bedside CXR in 213 patients who underwent right or left IJV catheterization under electrocardiogram guidance for cardiothoracic surgery. They calculated sensitivity and specificity for both junior and senior radiologists, and found that bedside CXR is not a sensitive method when either junior or senior radiologists read it (40-60%). However, it was specific only when a senior radiologist read it (94%). They concluded that reading of a bedside CXR is not an accurate method to determine the intraatrial position of CVC.[22]

High incidence of falsely positive or negative findings on portable CXR can be attributed to effects of parallax – the influence of differing angles of X-ray beam relative to the patient on the image-and variation in radiographic techniques.[12,22] Due to variation of X-ray beam incident angle, effects of parallax would be especially large in critically ill-patients who are examined by portable X-ray devices. The aforementioned factors may contribute to 20-47% of incorrect intraatrial-classified CVC tips.[12]

On the other hand, bedside CXR has also been employed to detect complications associated with CVC placement. However, previous studies demonstrated that the routine postoperative CXR after CVC placement is not necessary and should be reserved only for patients who develop symptoms.[23]

Bailey *et al*. investigated 358 patients who underwent CVC placement prospectively-retrospectively. They found that complication rate was significantly higher when the operator reported a difficult procedure versus those reported as a straight forward procedure. Therefore, they concluded that CVC placement is a safe procedure in experienced hands; thus, when patients undergo a straightforward procedure with <3 needle passes, CXR can be safely deferred.[24]

Pikwer *et al*. also studied the effectiveness of CXR in the diagnosis of post CVC placement complications in 2230 catheterizations, and concluded that about 50% of the postoperative CXR should be avoided if the clinical conditions observed carefully.[25]

Molgaard *et al*. also studied the necessity of routine CXR in 473 patients who underwent CVC insertion, and found that routine CXR has no value after CVC insertion.[19]

Furthermore, routine postoperative CXR is associated with additional costs as well as risks of radiation exposure.

CONCLUSION

Given the possible errors and technical variations, traditional reading of a bedside CXR alone is not sensitive and specific enough to decide whether a CVC tip is placed properly in the RA. Further investigations on other potentially feasible and helpful modalities are needed to introduce a valid and reliable method to assess the position of CVC postoperatively.

AUTHOR'S CONTRIBUTION

FS and AHDJ were designed the study, AH and JS were performed interpretation of CXRs and echocardiography respectively. AK was the main contributor in manuscript preparation. All authors read and revised the manuscript.

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