Original Article

Practical anatomical landmark for optimal positioning of left-sided long-term central venous catheter (a pilot study)

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Background: Long-term central venous catheter (CVC) insertion in dialysis patients is an accepted method of hemodialysis. The appropriate CVC tip placement may reduce both early and late complications related to catheter and increase patency rate. This study aimed to evaluate a new, simple, and feasible method based on surface anatomy for the proper placement of tunneled CVC in the left internal jugular vein for hemodialysis or chemotherapy. **Materials and Methods:** The study was carried out as a quasi-experimental model at Saint Al-Zahra Education Hospital in 2016. A total of forty patients with an indication of left-sided (upper) long-term CVC insertion were enrolled. The length of catheter to be inserted in the left internal jugular vein was considered as the sum of distance from the insertion point of the needle up to sternal notch plus the total distance between the left and right sternoclavicular joint and half-length of the sternum. The right atrium (RA) or superior vena cava-RA junction was the correct region for inserting the catheter tip. The collected data were analyzed using Fisher's exact test and *t*-test using SPSS (version 22). **Results:** The patients were 63.75 ± 17.96 years of age, weighed 67.33 ± 13.20 kg, and height of 166.92 ± 8.99 cm. Catheters were inserted successfully in 95% of patients (n = 38). No significant relationship was found between the success of new method and age, gender, height, weight, body mass index, and sternum half-length plus the distance between the right and left sternoclavicular joint. **Conclusion:** "The mid – sternal length plus sternoclavicular joints spacing" as a new formula (based on anatomical landmarks) was found practical and safe and could easily be used among adult patients who undergo tunneled CVC in the left internal jugular vein.

Key words: Anatomical landmark, central venous catheters, hemodialysis

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INTRODUCTION

Growing number of patients with chronic renal failure imposes hemodialysis on them to survive. They require a vascular route for sufficient blood flow which includes fistulas, synthetic grafts, and vascular catheters. As the two former methods are still underdeveloped, vascular catheters are commonly used and got special importance.[1]

As in hemodialysis, the correct placement of a central venous catheter (CVC) is related to the tip insertion in a convenient location and various methods have been proposed to determine or estimate the tip correct position. On the other hand, according to different patient anatomies and surgeons' experiences, previous methods were found inaccurate to some extent, especially in positioning the catheter tip in the right place.

Various landmarks,[1-3] formula,[4,5] and complex techniques such as right atrium (RA) electrocardiography[6,7] and transesophageal echocardiography[7,8] have been used to determine venous hemodialysis catheter tip location. As either the advanced sonographic and

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electrocardiographic techniques are not often accessible in operating rooms or they are time-consuming and expensive, chest X-ray (CXR) is preferred for determining proper location of hemodialysis catheter after insertion and also to detect potential consequences such as pneumothorax and hemothorax.[6] Several studies have used anatomic landmarks as a reliable and accessible method for estimating the depth of catheter insertion and reported more than 85% of success rate for their catheterization.[9-11] It has been also reported as a cheap and simple method with high success rate.[12] Regardless of the age, gender, height, weight and surgeon's skill, anatomical landmarks are always available and easily found. In many studies, it has been focused on the importance of applying electrocardiogram and advanced formula for determining the precise location of the catheter tip, and hence, the new methods can also be used to prevent short- and long-term complications.[13,14]

On the other hand, the use of anatomical landmarks should be carried out by experienced physicians, because if the catheter is not correctly applied, it may lead to serious complications such as thrombosis or pneumothorax, and even central venous perforation and bleeding or even death.[14]

Despite one of the most common complications of CVC is related to incorrect insertion, the equipment required for accurate catheter tip placement is not routinely available in most operating rooms. Currently, fluoroscopy is used as an acceptable method for checking of catheter tip location routinely. However, it is not available in all of the medical centers easily. For this reason, we have designed and tested the given method to aim and goals: (1) to minimize need to fluoroscopy equipment to confirm catheter tip location, and (2) to achieve the accurate point for creating exit site (it is very important stage in catheter insertion procedure).[15]

Thus, given the importance of catheterization in patients due to its long-term usage and serious consequences in case of unsuccessful catheterization, it was attempted to evaluate a simple and available method based on surface anatomy for the proper placement of tunneled CVC in the left internal jugular vein.

MATERIALS AND METHODS

Subjects

In this quasi-experimental study, the target population included all patients who had an indication for left-sided CVC and tunneled cuffed catheter insertion for hemodialysis in Saint Al-Zahra Educational Hospital in 2016. Considering the confidence level of 95%, test power of 80%, error level of 0.1, and success rate of equal to 0.88 according to results of the previous study,[10] the sample size was calculated as forty patients.

Patients were selected by convenience random sampling from Saint Al-Zahra Health Center in 2016. They were included in the study in the case of being older than 14 years old, and had an indication for CVC insertion for hemodialysis and other uses and referred to Saint Al-Zahra Hospital Vascular Clinic. Patients were not good candidates for right-sided catheter placement because of (1) right side catheter malfunction without response to intervention, (2) thrombosis and infection of the right side upper central veins, (3) extensive skin scars and previous operation in the right side of the neck and chest, and (4) right upper extremity arteriovenous fistula or arteriovenous graft. They also accepted to participate in this study.

Patients with severe obesity (body mass index [BMI] ≥40 kg/m), clavicle or proximal ribs fracture and kyphoscoliosis, and other deformities, as well as dissatisfied patients, were excluded from the study.

At first, demographic information, including age, sex, height, weight, BMI, and history of having diabetes, hypertension, heart disease, and smoking, were collected from patients and recorded.

Description of technique

Tunneled, cuffed catheter was embedded in the operating room under sterile conditions in all patients through the left internal jugular vein, and it was performed in the same techniques.[10] Catheter length and insertion depth were determined regarding the external anatomical landmarks that are equivalent to the distance of skin incision up to the sternal notch in addition to the total distance between the left and right sternoclavicular joint plus half-length of the sternum [Figure 1].

First, the patient was examined for contraindication comprehensively, and then anatomical landmarks were measured with mentioned formulae and specified by markers on the skin. In addition, sterile gown and gloves, mask and surgical cap, as well as face shield, were worn. The patient was positioned in the Trendelenburg position of 15°, till the vein was filled with blood. A rolled towel or similar object was placed between two scapulae to help identification of patient's external landmarks. The operative field was prepped totally with chlorhexidine and draped with sterile drape, and patient's body was covered.

Next, under conscious sedation (by intravenous midazolam) and heart monitoring, local anesthesia was injected, and the patients were placed in the Trendelenburg position with the head turned to the opposite site and neck extension. When venous access was obtained, the needle was fixated cautiously, and the syringe was exited.

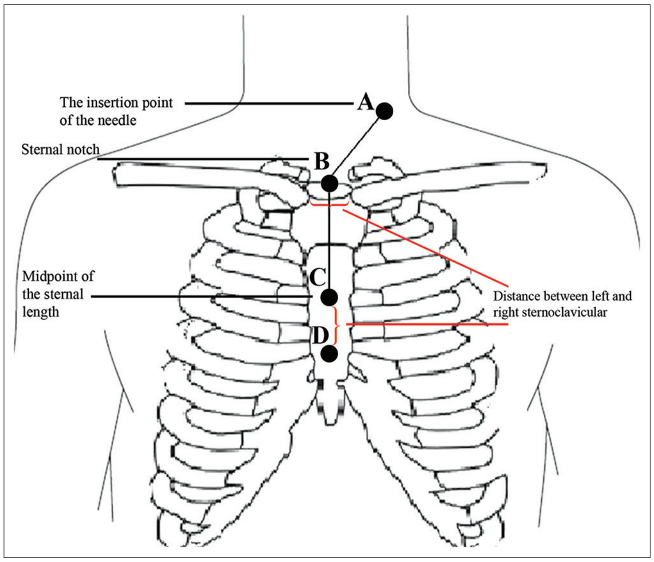

Figure 1: Method for determining the insertion depth of tunneled catheter. Four points are marked on the patient's skin during the catheterization. Point A is the insertion point of the needle. Point B is marked at supra – sterna notch. Point C is marked at the midpoint of the sterna length. Point D is marked at the distance between left and right sternoclavicular. The depth of the catheter is determined by adding the two distances from Point A to Point B and from Point B to Point D

The J-shaped guidewire was advanced through the needle. It should be noted that the wire may easily move without resistance so that it comes out well from the other end of the needle. If ectopic cardiac beats occur on the screen, the wire is pulled back until the ectopic beats disappear. Then, the needle was removed, and the wire was left in place, and control of the wire was maintained. A 1–2-mm incision was made on the skin at the insertion site around the wire to facilitate the passage of dilators. At this time, the catheter was placed on patient's skin (covered with sterile drape), hence, its tip was matched with the previously marked area on the skin and delineated depth of insertion.

Then, the exit site of the catheter was also marked on the anterolateral side of the chest wall by observing the curve appropriately, and the catheter was connected to the tunneler, and was passed through the created subcutaneous tunnel and was brought out just close to the venotomy site and skin incision. Next, dilator over the wire was entered into the vein from the venotomy site.

A gauze pad was used to control bleeding, which usually occurs after dilation. Peel away was inserted into the vein in the path over the guidewire, transducer and guidewire were removed, and the catheter was entered into the vein through the peel-away sheath, and then sheath was removed. Returned blood from both tunneled cuffed catheter lumens was tested and rinsed with heparinized serum. The catheter was then fixed in place with 0–2 nylon suture. After locking lines of the catheter with heparin, the site was covered with a sterile dressing [Figure 2].

Following the insertion of the catheter in the recovery room, CXR was done in semi-sitting position at the end of deep respiration, and possible complications such as pneumothorax or hemothorax were investigated. To check the exact position of the catheter tip, transthoracic echocardiography was performed by the cardiologist who was blinded to our study[16] [Figure 3].

It should be noted that the whole area of the RA is the perfect place to insert the catheter tip. If the catheter tip location was not suitable (malposition), its place would be modified under sterile conditions, and echocardiography should be repeated. All data were recorded in the data collection by a surgical resident for statistical evaluation.

Ethical considerations

The experimental protocols were approved by the Research Ethics Committee of Isfahan University of Medical Sciences (Approval ID: IR.MUI.REC.1395.3.200). The written informed consent was received from patients, who had been informed of the study purpose and methods after the fully informative sessions. The study was designed and implemented in consultation with an academic bioethicist.

Statistical analysis

The collected data were analyzed using SPSS software, version 22 (SPSS, Chicago, IL, USA). Descriptive statistics provided indicators such as mean, standard deviation, frequency, and percentage of frequency. Moreover, tests such as Fisher's exact test and independent sample *t*-test were used in inferential statistics. The statistical significance level in all analyses was considered < 0.05.

RESULTS

In the present study, of forty patients under left-sided upper CVCs placement, 22 patients (55%) were female and 18 (45%) were male with the mean age of 63.75 ± 17.96 years, mean weight of 67.33 ± 13.20 kg, and height of 166.92 ± 8.99 cm. Furthermore, sternum half-length plus the distance between the left and right sternoclavicular joints were 15.33 ± 1.33 cm [Table 1].

Catheters were inserted successfully in 95% of patients (n = 38). Catheter tip positions in the failures were corrected and reevaluated by echocardiography. No early complications (cardiac tamponade, pneumothorax, hemothorax, catheter malfunction, and catheterinduced arrhythmia) related to the tunneled catheter were seen.

No significant relationship was found between the success rate of new method and age, gender, height, weight, body mass index, and sternum half-length plus the sternoclavicular joints spacing [Table 1].

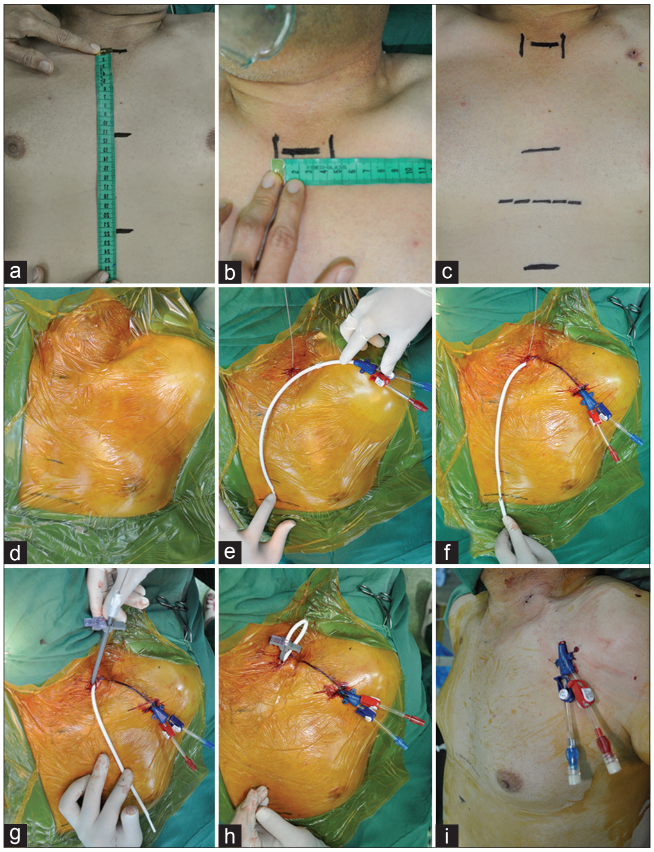

Figure 2: (a-i) Different steps of catheter placemen. (a-c) Measurement of insertion depth, (d) creation of the sterile field, (e) insertion of guide wire, (f) creation of tunnel, (g and h) passing the catheter into the vein, (i) completion of procedure

Table 1: Comparison of demographic characteristics and sternum length according to the results of left-sided superior central venous catheter insertion

Variables	Total (*n*=40)	Successful (*n*=38)	Nonsuccessful (*n*=2)	*P*
Gender, *n* (%)				
Female	22 (55)	21/38 (55.3)	1/2 (50)	0.704
Male	18 (45)	17/38 (44.7)	1/2 (50)	
Age (years)	63.75±17.96	63.47±18.30	69.00±11.31	0.677
Height (cm)	166.92±8.99	167.00±9.17	165.50±6.36	0.822
Weight (kg)	67.33±13.20	67.61±13.48	62.00±4.24	0.565
BMI (kg/m^2)	24.12±3.94	24.19±4.00	22.74±3.29	0.619
Length* (cm)	15.13±1.33	15.14±1.36	14.90±0.56	0.804

*Sternum half-length plus distance between the right and left sternoclavicular joint. BMI=Body mass index

DISCUSSION

Currently, long-term tunneled catheters are used for either hemodialysis or chemotherapy routinely. The catheter tip has been recommended to be placed just at the RA or superior vena cava (SVC-RA) junction or to prevent early (arrhythmia, tricuspid valve damage, cardiac tamponade) or late (thrombosis, infection, and malfunction) complications. Catheter dysfunction or vascular thrombosis and arrhythmias, as well as infection, are among mentioned complications that be related to catheter tip malposition directly.[2,3]

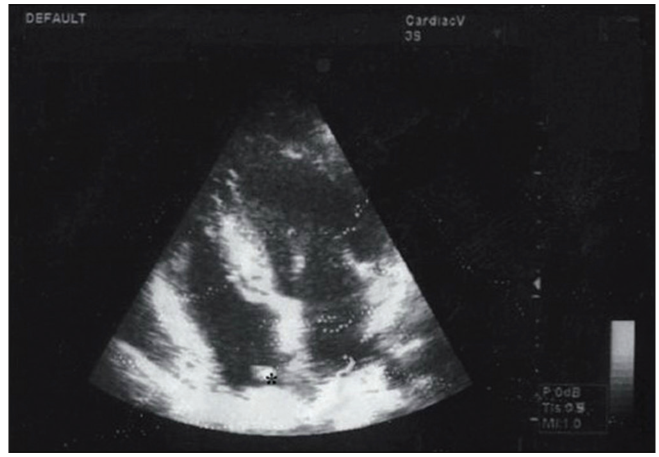

Figure 3: Echocardiogram showed the catheter tip in the upper third of the left atrium (black marker)

Measurement of estimated insertion depth based on the puncture site and the surface anatomical landmark (such as suprasternal notch, xiphoid process, or sternoclavicular prominence) could be more practical and easily identifiable.

In our previously published study, the middle of the sternum almost matches on the RA location and introduced as surface landmark for optimal position of right-sided catheter tip.[10]

Absolutely, we have to extend these formulae to obtain correct catheter tip position in left-sided catheter insertion. Regarding this study and chest anatomy, our idea was formed that the length of the left brachiocephalic vein is almost equal to distance between the right and left sternoclavicular joint anatomically, and hence, we find a new formula for calculating the location of proper insertion of left-sided CVC.

Obviously, in left-sided upper CVC placement, the higher penetration depth is needed to reach its tip to the RA. Because of passage the catheter through the left brachiocephalic vein, in the present study, catheter penetration depth was regarded as distance between the right and left sternoclavicular joints added to sternum half-length, and total length of catheter was calculated as distance from skin incision up to sternal notch plus the given total distance [Figure 1].

Schummer *et al*. studied consequences and malposition cases during routine catheterization. Of 276 patients with catheterization of the left internal jugular vein, 35 cases (12%) needed correction, while in the current study, only 5% needed the corrections.[17]

In the study by Kremser *et al*., ECG was used for the placement of catheter tip in suitable place. In this study, the proper placement of the catheter tip was considered as junction place of SVC and RA. This place is found as the maximum amplitude of *P* wave and finally, proper tip place was approved by CXR. In this study, of 227 catheters placed in the right and left side, 14 cases (6.1%) were mal-positioned that is higher than our study, while it was mentioned in their findings that this is not much suitable method for the right side catheterization.[18] In addition, our measurements indicated that success of this method is not related to age, gender, weight, height, BMI, and sternum half-length plus the distance between the right and left sternoclavicular joint, which the strength of our study was the independence of our method success to the mentioned variables.[10,19]

The other strength of our new method is that it does not need any investigation before the operation, and the procedure is done only based on distances obtained from anatomical landmarks; also there is no need for preoperative CXR, measurement weight, height, or using complex formula.

The study by Czepizak *et al*. suggested that the penetration depth of CVC for its placement inappropriate place is obtained from the division of patient's health by ten. Using this formula, 90% of catheters were placed correctly, and the calculated error of their study was higher than our study.[20]

The other strength of our study was the simple measurement and denoting the anatomical landmarks on the skin of the patient in the supine position and in the operating room rapidly.

In the other work by Lee and Lee, the appropriate place of the catheter was found using anatomical landmarks in CXR. These landmarks include carina and right edges of the transverse process of the first thoracic vertebra, and catheter penetration depth was determined based on these landmarks. As observed, in this study, CXR was needed before the operation which exposes patients to excessive radiation and imposes higher costs to the patient.[1]

In our new method, we did not need any investigation preoperation such as CXR, measurement weight, height, or using complex formula, and the procedure was done only based on distances obtained from anatomical surface landmarks.

Despite CVC under guided ultrasonography is a safe and practical method, and has a beneficial effect on precise cannulation of the veins and reduced cannulation related complications; however, check of the catheter tip location is associated with a lot of limitation (especially air and bone) with this manner.[21-23]

Nowadays, modern operating rooms have been plenished with fluoroscopic equipment that is effective in vascular surgery (including vascular access procedure), orthopedic and urologic interventions. Control of CVC tip place is obtained by fluoroscopy easily.[24] Although, our attention in the project is focused on two subjects: (1) effort to obtain easy, fast, safe (no radiation), and simple way to estimate catheter tip location preoperatively and more important (2) to attain preoperative skin landmark of exit site of long-term catheter. This simple and cost-effective method can be used when there is no access to advanced equipment.[25]

In a nutshell, one of the main concerns of physicians in this area is the simplicity and feasibility of catheterization methods. Besides the importance of catheterization accuracy in dialysis patients due to potential vascular thrombosis as a common complication, it is necessary to pay more attention to find the best calculation method.[26] Using the landmarks can be good substitute for calculation methods, which are both complex and expensive and not available in many parts of the world.

The present study has some limitations such as "relatively the small sample size (due to the rare cases of indicated left-sided catheterization)" and "well-known limitations of transthoracic echocardiography."

The most important strength of the current study is providing a calculation method to accurate left-sided superior CVC insertion that can be so beneficial in deprived areas with no access to the needed equipment such as fluoroscopy.

CONCLUSION

The present study showed that "the midsternal length plus sternoclavicular joints spacing," as a new formula based on anatomical landmarks, can be easily applied as a practical and safe method for optimal positioning of (upper) left-sided long-term CVC, in adult patients.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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