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Original Research Article

An estimation of right and left sided central venous catheter insertion depth using measurement of surface landmarks along the course of central veins - A descriptive observational study

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Abstract

Aim and Objectives: To determine whether the measurement of surface landmarks along the course of central veins can estimate the approximate insertion depths of both right and left sided C.V.C. via the internal jugular veins (I.J.V.) and subclavian veins (S.C.V.).

Methods: Total 150 central venous catheterizations were performed using a triple lumen C.V.C. with Seldinger technique. The anterior approach, using the sternocleidomastoid muscle as a landmark was used for I.J.V. insertion and infraclavicular approach for S.C.V. insertion. Topographical measurement was done by placing the catheter naturally with its own curvature over the draped skin, starting from the insertion point of the needle through ipsilateral clavicular notch and to the insertion point of second right coastal cartilage to the manubriosternal joint. The C.V.C. was then inserted and secured to a depth determined topographically. The position of C.V.C. tip, in relation to the carina, was confirmed and measured on a post procedural full inspiration chest X ray.

Results: The mean (SD) depth of insertion of Right I.J.V., Right S.C.V., Left I.J.V. and Left S.C.V were 12.26 (0.30) cm, 12.86 (0.36) cm, 16.27 (0.22) cm and 16.30 (0.23) cm respectively. The mean (SD) value for vertical distance between C.V.C. tip and carina of Right I.J.V, Right S.C.V., Left I.J.V. and Left S.C.V were 0.38 (0.26) cm, 0.43 (0.27) cm, 0.41 (0.23) cm and 0.55 (0.29) cm respectively. We found no statistically significant difference in incidence of complications and type of C.V.C inserted but statistical significant difference found between incidence of complications and Position of CVC Tip on Post-procedure Chest X-ray.

Conclusion: The approximate insertion depth of a CVC can be estimated using measurement of surface landmarks along the pathway of central veins.

Keywords: Central venous catheter, Internal jugular veins, Subclavian veins, Seldinger technique, Sternocleidomastoid muscle, Infraclavicular approach, manubriosternal joint.

1. Introduction

Central venous catheterization is frequently performed in operation theatres and intensive care units (I.C.U.) to facilitate resuscitation, nutritional support, and long-term vascular access. For the accurate placement of central venous catheter a simple anatomic topographic method is used to decrease serious complications of C.V.C. insertion such as vascular perforation, arrhythmias, and hydrothorax or cardiac tamponade. It is usually accepted that 20cm (left side) or 16cm (right side) length C.V.C. should be used in the majority of adult patients while inserting a catheter via the subclavian or jugular veins [1]. This method is easy but may not be optimal in every patient. Insertion with electrocardiographic guidance or echocardiography are techniques that may assure correct

C.V.C. tip position, but such confirmatory techniques are not routinely used as special equipment for their use is not routinely available [2-3].

To minimize the risk of cardiac tamponade, it has been suggested that the CVC tip should be located above the cephalic limit of the pericardial reflection, not merely above the superior vena cava-RA junction [4]. Of the landmarks easily identifiable on a routine chest radiograph (CRX), the level of the carina has been shown to be near the level of the pericardial reflection in fresh and preserved cadavers and in computerized tomography studies of adult patients [5-7]. The carina has since been studied as an attractive target level for CVC tip position [6-8]. The angle of Louis, the forward prominence formed by the manubriosternal joint, is a surface landmark that shares the same horizontal plane with the tracheal carina. The clavicular notch is an oval articular surface on each side of the sternal manubrium-directed upwards backwards and laterally for articulation with sternal end of the clavicle, and can be identified by palpation. The internal jugular vein (I.J.V.) and the subclavian vein (S.C.V.) lie beneath the ipsilateral clavicular notch [9].

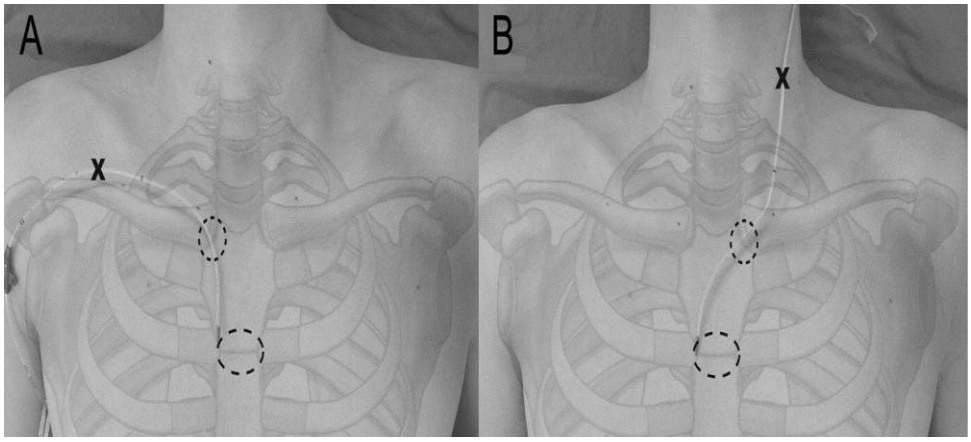
In the literature survey, we observed that there is very few studies are available on determining the approximate insertion depths of both the right and left sided CVC by using measurement of surface landmarks along the pathway of central veins. Therefore, the present study has been envisaged with an intension to determine whether the measurement of surface landmarks along the course of central veins can estimate the approximate insertion depths of both the right and left sided C.V.C.s via the internal jugular veins (I.J.V.) and subclavian veins (S.C.V.).

2. Material and Methods

After obtaining Institutional Ethical Committee approval and patients' written informed consent, this descriptive type of observational study was carried out in total 150 patients of either sex, age between 18–60 years, undergoing elective surgical procedure and I.C.U. patients in whom central venous catheterization was planned. The patients having age below 18 years and above 60 years, bleeding diathesis, patients on anticoagulants, patients with chest deformities, diaphragmatic dysfunction, major vascular anomaly, history of prior clavicle fracture or prior thoracic surgery, having infection at the puncture site were excluded from the study.

In the operational room, non invasive blood pressure, cardioscope, pulseoximeter were attached to the patients and baseline vital parameters such as heart rate, Spo2, blood pressure and mean arterial blood pressure were recorded. In patients who did not have a Peripheral line in them it was taken with an 18G IV cannula. Then patients were placed in Trendlenbergs position (slight head low) with the head turned to the opposite side. After antiseptic skin preparation and sterile draping, central venous catheterization was performed using a triple lumen C.V.C. with the Seldinger technique. The anterior approach, using the sternocleidomastoid muscle as a landmark, was used for I.J.V. insertion, and the infraclavicular approach for S.C.V. insertion. The patients head and neck was placed in the neutral position after the insertion of the guide wire. To determine the adequate depth for catheter insertion, topographical measurement was done by placing the catheter naturally with its own curvature over the draped skin (without direct contact with the skin), starting from the insertion point of the needle through the ipsilateral clavicular notch, and to the insertion point of the second right coastal cartilage to the manubriosternal joint (Figure 1). The C.V.C. was then inserted to the depth determined topographically.

Figure 1: Measurement of adequate depth for catheter insertion



(A) right subclavian vein and (B) left internal jugular vein by placing the catheter with its natural curvature over the skin starting from the insertion point of the needle through the midpoint of the ipsilateral clavicular notch, and to the insertion point of the second right costal cartilage to the manubrIosternal joint. X: insertion point of the needle; circle: clavicular notch; ellipse: manubriosternal joint

The position of the C.V.C. tip, in relation to the carina, was confirmed and measured on a post procedural full inspiration chest X-ray from the Picture Archiving and Communication system (PACS). After, drawing the horizontal line at the level of carina and the C.V.C. tip the vertical distance between the two lines was measured on the chest X-ray. C.V.C. tips positioned above the carina were presented in positive values, and those below the carina were presented in negative values. Incidence of complications i.e. ventricular premature contractions, arterial puncture, arrhythmias or pneumothorax during central venous catheterization was determined. All the collected data were statistically analyzed using standard statistical techniques. A p value less than 0.05 were considered significant.

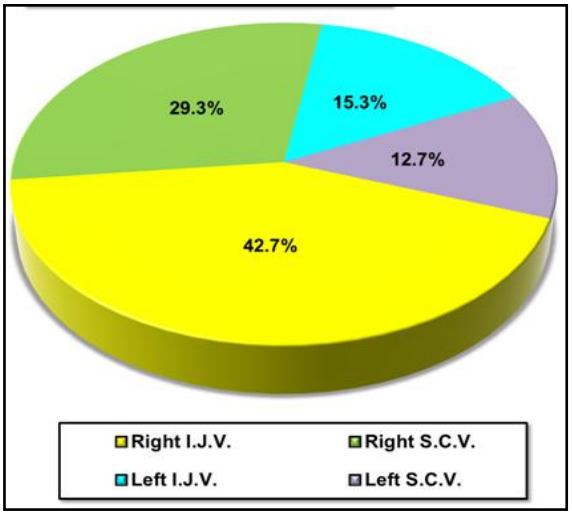
3. Observations and Results

Total 150 cases were enrolled in the study; among them 78 (52%) were males and 72 (48%) were females. Table 1 shows the distribution of cases among the four age groups. Figure 2 shows the distribution of cases according to type of C.V.C. inserted.

Table 1: Distribution of cases according to age groups

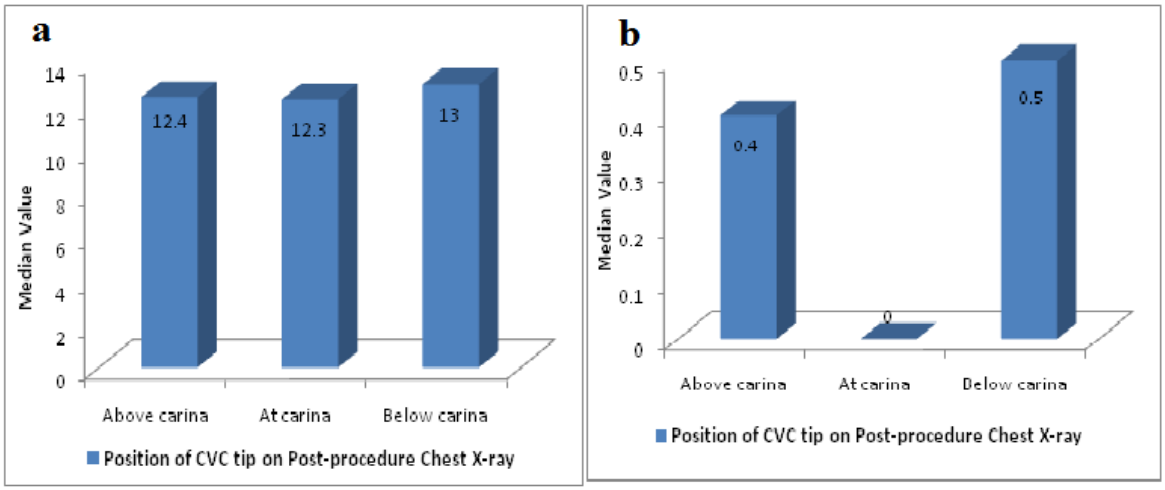
Age (Years)	No.	Percentage
20-29	29 (19.3)	19.3%
30-39	50 (33.3)	33.3%
40-49	36 (24.0)	24.0%
50-59	35 (23.3)	23.3%
Total	150 (100)	100%

Figure 2: Type of CVC inserted among the cases



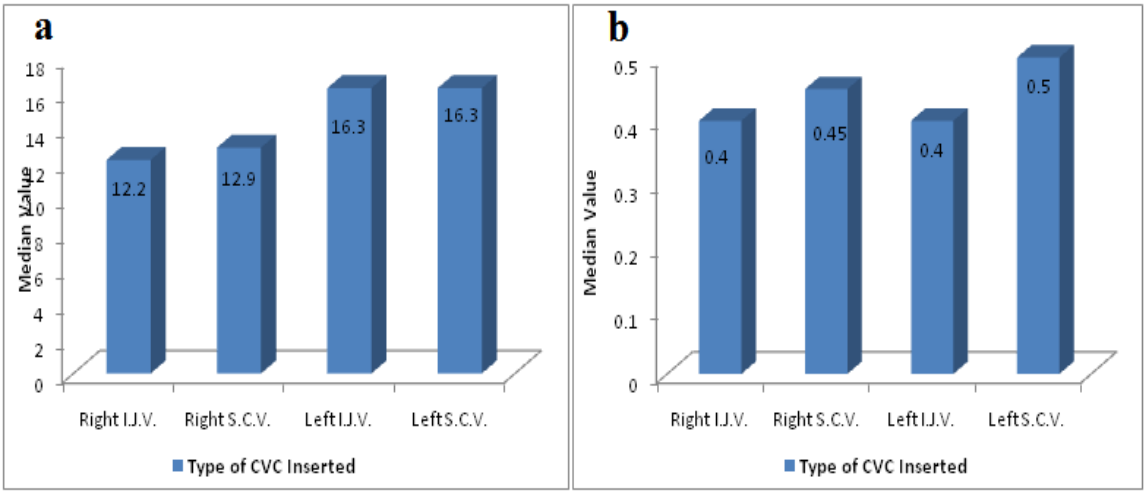
In our study, 60 (40.0%) patients had C.V.C. tip above carina, 24 (16.0%) patients had C.V.C. tip at carina and 66 (44%) patients had C.V.C. tip below carina. The mean (SD) depth of insertion in patients with C.V.C. tip above carina, at carina and below carina was 13.39 (1.82) cm, 12.94 (1.32) cm and 13.95 (1.75) cm respectively and the median value being 12.40cm, 12.30cm and 13.00cm (Figure 3a). The mean value for the vertical distance between the C.V.C. tip and the carina for patients with C.V.C. tip above carina was 0.46±0.13, at carina was 0.00±0.00 and below carina were 0.54±0.25 cm and the median value being 0.40cm, 0.00cm and 0.50 cm respectively (Figure 3b).

Figure 3: a) CVC depth of insertion (cm) and b) Vertical distance between CVC tip and carina (cm) by position of CVC tip on Post-procedure Chest X-ray



The mean (SD) depth of insertion of right I.J.V, right S.C.V., left I.J.V. and left S.C.V was 12.26 (0.30) cm, 12.86 (0.36) cm, 16.27 (0.22) cm and 16.30 (0.23) cm respectively and the median value being 12.2cm, 12.90 cm, 16.30 cm and 16.30 cm respectively (Figure 4a). The mean (SD) value for the vertical distance between the C.V.C. tip and the carina for of right I.J.V, right S.C.V., left I.J.V. and left S.C.V. was 0.38 (0.26) cm, 0.43 (0.27) cm, 0.41(0.23) cm and 0.55 (0.29) cm respectively and the median value being 0.40cm, 0.45cm, 0.40cm, and 0.50cm respectively, (Figure 4b).

Figure 4: a) CVC depth of insertion (cm) and b) Vertical distance between CVC tip and carina (cm) by type of CVC inserted



There were total 24 patients had complications in the study population, among them 21 (14%) had ventricular premature contractions, 3 (2%) patients had carotid artery puncture and 126 (84%) patients had no complication. The incidence of complications in patients with Right I.J.V, Right S.C.V., Left I.J.V .and Left S.C.V. was 12.5% (8 out of 64), 15.9% (7 out of 44), 21.7% (5 out of 18), and 21.1% (4 out of 15) respectively. The incidence was 8.3% (5 out of 60) cases when C.V.C. tip was above carina, 4% (1 out of 24 cases) when C.V.C. tip was at carina and 27.3% (18 out of 66) when C.V.C. tip was below carina. There was no statistically significant difference in incidence of complications and type of C.V.C inserted but statistically significant difference found between incidence of complications and Position of CVC Tip on Post-procedure Chest X-ray. Moreover the incidence of complications was 8.2% (4 out of 49) cases when the C.V.C. tip was below carina but within 0.5cm of the carina and 82.4%(14 out of 17) cases when C.V.C. tip was below but beyond 0.5cm of the carina, ($p<0.05$). Thus it was concluded that the incidence of complications was more when the C.V.C. tip was below but beyond 0.5cm of the level of carina.

4. Discussion

Central venous catheterization (C.V.C.) is a common procedure but catheter misplacement is a frequent complication and can be lethal. Most C.V.C.s is inserted at a recommended mean depth of 15 cm from the skin puncture site. Location of the tip of a central venous catheter (C.V.C.) within the pericardium has been associated with potentially lethal cardiac tamponade and it is a serious complication of central venous catheter (C.V.C.) insertion. Current guidelines strongly advise that the C.V.C. tip should be located in the superior vena cava (SVC) and outside the pericardial sac. This may be difficult to verify as the exact location of the pericardium cannot be seen on a normal chest X-ray. The carina is an alternative radiographic marker for correct C.V.C. placement, suggested on the basis of studies of embalmed cadavers.

Considering the results of previous studies [6,7,10], we took the carina as the target position for the CVC tip and thus CVC tip placement was considered accurate if it was positioned above or at or below but within 0.5cm of the carina. The carina is located in the centre of the thorax. Therefore image distortion and measurement errors by parallax effect are less important, if we use the carina in CXR as a landmark. Many studies [1,11] revealed that when C.V.C.s are inserted to a depth derived by adding the length between needle insertion point and clavicular notch and the vertical length between clavicular notch and carina, the C.V.C. tip can be reliably placed near the carina level. Kim *et al* [12] in their study estimated the right and left sided central venous catheter insertion depth using measurement of surface landmarks along the course of central veins.

After considering the results of the previous studies, we found that that the CVC tip could be inserted to a location near the carina level when the CVC is inserted via the right IJV, left IJV, right SCV, or left SCV to a catheter depth measured by the topographical method. There are no gold standards in estimating the exact CVC insertion depth. A prior study done in 1993 by McGee *et al* [1] found an average insertion depth of 16.5 cm to the atrial–caval junction; however, internal jugular and subclavian approaches from both the left and right sides were included. A depth of 16.5 cm will clearly be too deep in many patients, especially if the right internal jugular or right subclavian approach is used. Moreover, this depth does not consider patient height, which may impact final catheter tip location. Right atrial electrocardiogram or

transesophageal echocardiography- guided CVC placement is of value, but these techniques involve additional equipment and cost, and are thus not used routinely. Although topographic landmarks including the right third intercostal space and angle of Louis were used for positioning the CVC to an adequate depth in other studies, those were only for the right IJV. The greatest advantage of the technique introduced in this study is that it can be used for measuring appropriate insertion depth in left-sided CVC approaches. Other benefits are that it does not require extra cost or devices.

In our study, the percentage of incidence of complications was 17.2% in age group 20 to 29, 22.0% in age group 30 to 39, 11.1% in the age group 40 to 49 and 11.4%% in age group 50 to 59 years. In females the incidence of complications was 13.9% (10 out of 72) and in males it was 17.9% (14 out of 78). The comparison of incidence of complications in different age groups as well as among sexes was not significant. So the incidence of complications was not related to the age and sex of the patients. There was no statistically significant difference in incidence of complications and type of C.V.C inserted in the study population but statistically significant difference found between incidence of complications and Position of CVC Tip on Post-procedure Chest X-ray. Also it was observed that the incidence of complications was more when the C.V.C. tip was below but beyond 0.5cm of the level of carina and in our study only 18 out of 150 patients had C.V.C. tip below but beyond 0.5cm of the level of carina. The present study was compared with other studies with respect to incidence of complication [6, 13 and 14]. There are more arterial punctures but less catheter malpositions with the internal jugular compared with the subclavian access. There is no evidence of any difference in the incidence of hemothorax or pneumothorax and vessel occlusion. Data on bloodstream infection are scarce.

There are some limitations of the study which includes- 1. Only radiologic definition of the carina was used to evaluate CVC tip positions, 2. There is greater and variable parallax effect of the portable antero-posterior CXR in the supine position, which was used to check the position of CVC tips. This effect is exaggerated on the periphery of CXRs. However because the carina and SVC are situated at the same depth in the centre of the thorax, this effect may be negligible.

5. Conclusion

From the observations of present study, we concluded that the CVC tip could be inserted to a location near the carina level when the CVC is inserted via the right IJV, left IJV, right SCV, or left SCV to a catheter depth measured by the topographical method with no additional costs. The incidence of complications was more when the C.V.C. tip was below but beyond 0.5cm of the level of carina, so we concluded that measurement of surface landmarks along the course of central veins is useful in reducing the complications associated with central venous catheterization and over insertion of guide wire is associated with increased risk of complications

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