Original Article

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Correlation of Surface Landmarks Based Insertion Length of Right Subclavian Central Venous Catheter with Post Insertion Location of Catheter Tip

Jatin Kumar Khatodkar[1], Arvind Kumar Rathiya[2], Sudhakar Dwivedi[3]

[1]Senior Resident, Department of Anaesthesia, Shyam Shah Medical College, Rewa, Madhya Pradesh, India, [2]Assistant Professor, Department of Anaesthesia, Shyam Shah Medical College, Rewa, Madhya Pradesh, India, [3]Professor, Department of Anaesthesia, Shyam Shah Medical College, Rewa, Madhya Pradesh, India

Abstract

Background: Subclavian central venous catheterisation (CVC) is done in critically ill patients requiring long-term central venous access. There is no gold standard for evaluating depth of insertion for catheter. In this study we correlated desired length of central venous catheter based on surface landmarks.

Objectives: We conducted this study with two objectives, first is to estimate the appropriate insertion length of right subclavian central venous catheter using topographical measurements and other is to observe and quantitate the side effects which occur (if any) during central venous cannulation.

Materials and Methods: After obtaining informed written consent from the patient's relatives, fifty patient were enrolled for central venous catheterizations via the right subclavian vein (SCV). The infraclavicular approach was used. Topographical measurement based on surface landmarks (insertion point of the needle, through the ipsilateral clavicular notch to just below the insertion point of the second right costal cartilage to the manubriosternal joint) was performed by placing the catheter with its own curvature over the draped skin . The central venous catheter (CVCs) was inserted and secured to a depth determined topographically. The location of CVCs tip around the carina was observed on the post procedure chest X-ray.

Results: The average insertion length in male was 13.2 cm and in female was 11.9 cm. In 95.1% of female patients and 89.6% of male patients, the tip was at or above the level of carina (≤1cm). It was considered correct if the tip was just above or at the level of the carina in the right-sided catheters.

Conclusion: It is concluded from the study that CVC insertion depth can be estimated using the topographical measurement with the CVCs itself. Moreover, this method requires no additional cost and/or time-consuming procedures.

Key words: Central venous catheter tip, Topographic method, Right subclavian central venous catheterisation

INTRODUCTION

Central venous catheterization (CVC) is common practice among surgeons, anesthesiologists, and emergency room physicians during the preparations for major surgical procedures such as open-heart surgery as well as for intensive care monitoring and rapid restoration of blood volume. They provide long-term venous access.[1]

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Central venous lines are inserted through major veins such as the subclavian, internal jugular, or femoral veins. The safe and successful performance of a CVC requires a specific knowledge of anatomy in addition to a working knowledge.

The subclavian vein (SCV) has a caliber of 1–2 cm in adults and is thought to be held open by its surrounding tissues, even in severe circulatory collapse.[2] This route may be preferred in trauma patients with a suspected cervical spine injury. This route is best avoided in patients requiring long-term renal replacement as there is a significant risk

Corresponding Author: Arvind Kumar Rathiya, F-9/2 New doctors colony Rewa, Rewa, Madhya Pradesh, India. Phone: +91-8959949669. E-mail: arvind.rathiya@gmail.com

of venous stenosis, which causes problems for existing or future arteriovenous fistulae. It is also best to avoid in patients with abnormal clotting or bleeding diathesis. Serious, immediate complications are uncommon but occur more frequently than other routes. Pneumothorax is one of the most common major complications with an overall incidence of 1–2% this figure increases to 10% if multiple attempts are made. Extravasation injury may result from CVCs lying so proximal that one or more of the catheter openings lie outside the vessel lumen, but such incidence is non-lethal.

Various techniques have been developed to ensure correct placement of CVCs. Although X-ray or fluoroscopy is often used, while insertion with electrocardiographic guidance and echocardiography guided techniques are that may assure correct CVC tip position, but such confirmatory techniques are not used routinely.[3]

Optimal positioning of the tip of a CVC is a complex and controversial subject. Misplacement of CVC tip can rarely cause erosion of the catheter through the right atrium (RA) or right ventricle, leading to haemothorax, hydrothorax, or cardiac tamponade and can be fatal. It is, hence, recommended to locate the tip in the superior vena cava, outside the pericardium to avoid cardiac tamponade.[4] There is ongoing controversy as to whether CVC tips should always lie above the pericardial reflection.[5] Cadaver studies[6] and computerized tomography in adults have shown the carina to be above the level of pericardium. The pericardium cannot be seen on a chest X-ray that is routinely done to check the position of the catheter tip. However, carina can be easily identified on a chest X-ray and can be used as a reference point for optimal position of CVC tip. For CVC tips lying below the pericardial reflection, there is a small but potentially fatal risk of pericardial tamponade if the CVC tip erodes through the vessel wall. Other problems of catheter placement in the RA include arrhythmias, placement in the coronary sinus, and tricuspid valve damage. Vessel wall erosion also seen when the CVC tip lies above the pericardial reflection usually causing hydrothorax or hydromediastinum from the extravasated fluid, but this is less likely to have a fatal outcome.

The carina is a reliable landmark to guide appropriate and safe positioning of the CVC tip above the pericardial reflection and to minimize the risk of cardiac tamponade.[7] The angle of Louis, the forward prominence formed by the manubriosternal joint is a surface anatomical landmark that shares the same horizontal plane with the tracheal carina.[8]

The present study evaluates the ideal CVC tip position merely by the help of landmarks rather than by post-procedure of chest X-ray. It is cheap, easy, and avoids unnecessary exposure to radiation. Post-procedural X-ray is done only to verify whether the landmark-guided catheter insertion leads to correct catheter tip positioning in superior vena cava or not. If it is below the carina level repositioning is done.

METHODS

This study is carried out in patients admitted to the Department of Surgery from January 2015 to December 2016 at N.S.C.B. Medical College, Jabalpur, In whom subclavian CVC was deemed necessary were recruited into the study after approval from Ethics Committee. Informed consent was obtained from the patient's relative. Patient is requiring emergency CVC insertion (shock), requiring emergency surgeries (perforation peritonitis and blunt trauma abdomen) were included in this study. Patient refusal, pediatric patient, child <18 years, pregnancy, systemic sepsis, deranged coagulation, local skin infection, connective tissue disorder, gross anatomical deformities of neck and chest (barrel chest and pigeon chest) were excluded from the study. The right SCV was cannulated using a Triple Lumen CVC set (Meditech™, Innovative Health Solution, New Delhi, India) as per the institutional protocol for CVC insertions.

After antiseptic skin preparation and sterile draping, CVC was performed with the Seldinger technique. Infraclavicular approach was used for SCV catheterization. After insertion of Guidewire, the patient's head and neck were placed in the neutral position.[9] Earlier to determine the adequate depth for catheter insertion, we performed topographical measurement 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 to the insertion point of the second right costal cartilage to the manubriosternal joint [Figure 1]. The CVC was then inserted and secured to the depth determined topographically.[10]

After the insertion of CVC, the position of CVC tip, in relation to the carina, was confirmed and measured by post-operative full inspiration chest radiograph (CXR). Results are divided into three groups - first CVC tips positioned above the carina level, second at the level of carina, and third group were those below the carina [Figure 2]. CVC tip beyond 0.5 cm below the carina was repositioned.

All the records are rechecked for their completeness and consistencies before collection. Nonnumeric entries are coded into nominal/ordinal distribution before analysis. Categorical variables are summarized in frequency and percent distribution and Chi-square or Fisher's exact test is performed as appropriate. ANOVA is used for assessment of relative size of variance among group means. Continuous variable is analyzed using mean ± standard deviation (SD) or median with interquartile range as appropriate. Matched test of analysis is performed to estimate the level of concordance. Statistical analysis is done with SPSS for window.

RESULTS

Table 1 shows number and percentage of males and females selected for the study among total participants. There were no catheterization failures during the study period.

Table 2 shows catheter tip position with respect to carina for all the participants. It shows number of times tip was below, at the level or above the carina.

Table 3 shows catheter tip position with respect to corresponding vertebral level for all the participants. It shows number of times tip was at 4th, 5th, or 6th vertebrae. In 80% cases, tip was at level of the 5th thoracic vertebra.

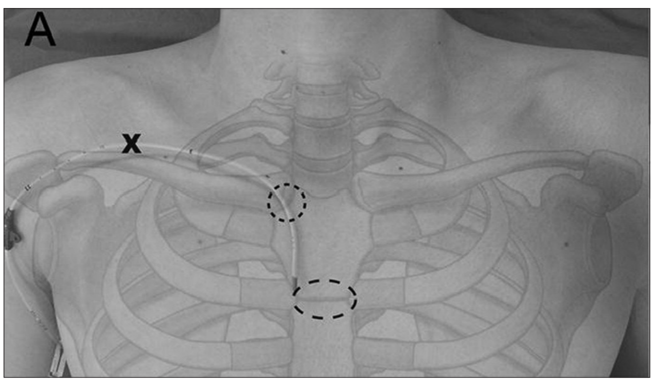

Figure 1: Topographical landmarks of subclavian vein

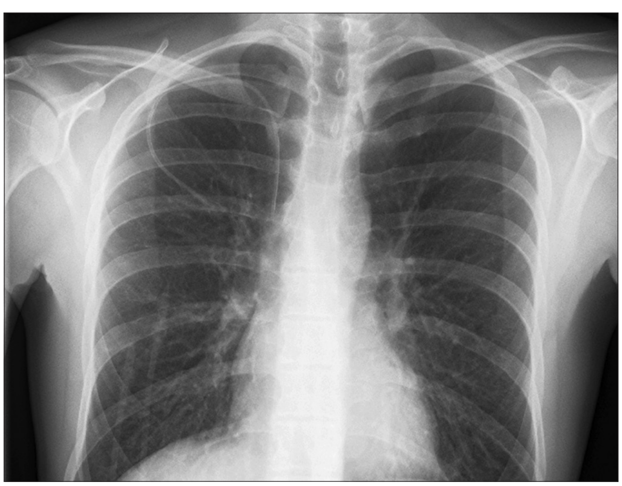

Figure 2: X-ray chest showing catheter and catheter tip

Table 4 shows catheter tip position with respect to corresponding intercostal space for all the participants. It shows number of times tip was at 4th, 5th, or 6th intercostal space. In 84% cases, tip was at the level of 5th intercostal space.

Table 5 shows mean topographical length and age of participants with standard deviation. Where mean value of age is 37.84 ± 11.456 years (SD) and mean value of topographical length is 12.672 ± 0.7817 cm (SD).

Table 6 shows sex-wise distribution of age and topographical length. Where mean age for females is 36.05 ± 10.082 years

Table 1: Sex-wise distribution

Sex	Frequency (%)
Female	21 (42.0)
Male	29 (58.0)
Total	50 (100.0)

Table 2: Catheter tip position with respect to carina

Tip position	Frequency (%)
Below the carina	4 (8.0)
At the level of carina	35 (70.0)
Above the carina	11 (22.0)
Total	50 (100.0)

Table 3: Catheter tip position with respect to corresponding vertebral level

Corresponding vertebral level	Frequency (%)
4th	3 (6.0)
5th	40 (80.0)
6th	7 (14.0)
Total	50 (100.0)

Table 4: Catheter tip position with respect to corresponding intercostal space

Corresponding intercostal space	Frequency (%)
4th	4 (8.0)
5th	42 (84.0)
6th	4 (8.0)
Total	50 (100.0)

Table 5: Topographical length with respect to age of participants

Statistical parameters	Age	Topographical length (cm)
Mean	37.84	12.672
SD	11.456	0.7817
Minimum	20	11.0
Maximum	63	14.0

SD: Standard deviation

standard deviation (SD) and mean age for males is 39.14 ± 12.366 years (SD). The mean topographical length for females is 11.943 ± 0.4915 cm (SD) and mean topographical length for males is 13.200 ± 0.4575 cm (SD).

Table 7 shows sex-wise frequency and percentage of catheter tip position with respect to carina. In females, 95.2% (85.7 + 9.5) case belongs to at the level or just above to the carina while in males this value is 89.6% (58.6 + 31).

Table 8 shows mean value of catheter length (cm) corresponding to carina levels. This mean value at the level of carina is 12.6 cm.

Table 9 Shows statistical analysis of topographical length between the groups (i.e. at level of carina, above the carina and below the carina) and within the group. This is a result of one-way ANOVA for topographical length. It is statistically significant between the groups.

Table 10 shows statistical significance of one level topographical length with respect to other two levels. This statistical significant difference was due to the difference in length between below the carina and at the level of carina and below and above the carina.

Table 11 shows mean value of ages corresponding to carina levels. This relation is nonsignificant.

Table 12 Shows Result of one-way ANOVA for age. The observed age (years) is statistically insignificant, which means age is not a factor for topographical length.

Table 13 shows statistical significance of mean age of participants with different carina levels. This difference was statistically nonsignificant.

Table 6: Sex wise distribution of age and topographical length

Sex	Age	Topographical length (cm)
Female		
n	21	21
Mean	36.05	11.943
SD	10.082	0.4915
Minimum	22	11.0
Maximum	55	13.0
Male		
n	29	29
Mean	39.14	13.200
SD	12.366	0.4575
Minimum	20	12.5
Maximum	63	14.0

SD: Standard deviation

Table 7: Sex wise frequency and percentage of catheter tip position with respect to carina

Characteristics	Frequency (%)
Female	
Below the carina	1 (4.8)
At the level of carina	18 (85.7)
Above the carina	2 (9.5)
Total	21 (100.0)
Male	
Below the carina	3 (10.3)
At the level of carina	17 (58.6)
Above the carina	9 (31.0)
Total	29 (100.0)

Table 8: Mean value of catheter length corresponding to carina levels

Tip level	*n*	Mean±SD
Below the carina	4	13.750±0.5000
At the level of carina	35	12.626±0.7543
Above the carina	11	12.427±0.6680

SD: Standard deviation

Table 9: Statistical significance of topographical length

Source of variation	Sum of squares	df	Mean square	F	*P* value
Between groups	5.382	2	2.691	5.150	0.009
Within groups	24.559	47	0.523		
Total	29.941	49			

Table 10: Statistical comparison between different groups

Tip position	Tip position	*P* value
Below the carina	At the level of carina	0.015
	Above the carina	0.009
At the level of carina	Below the carina	0.015
	Above the carina	1.000
Above the carina	Below the carina	0.009
	At the level of carina	1.000

Table 11: Mean value of ages corresponding to carina levels

Tip level	*n*	Mean±SD
Below the carina	4	47.50±12.014
At the level of carina	35	38.29±11.105
Above the carina	11	32.91±10.756
Total	50	37.84±11.456

SD: Standard deviation

Table 12: Result of ANOVA for age

Source of variation	Sum of squares	Df	Mean square	F	*P* value
Between groups	647.668	2	323.834	2.632	0.083
Within groups	5783.052	47	123.044		
Total	6430.720	49			

Table 14 shows that there was no association between level of carina and sex.

Table 15 shows descriptive statistics about catheter tip position and topographical length at different levels of carina, separately for males and female.

DISCUSSION

Desired localization of CVC tip has been always a controversial topic. 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.[8]

Only transesophageal echocardiography can accurately detect a CVC tip in relation to superior vena cava (SVC) and RA,[11,12] but its availability as a bedside tool is limited to major hospitals.

A recent study conducted by Vinay and Tejesh in 2016, suggests the superiority of the topographical method over the formula method given by Peres in 1990.[13] We incorporated a post-procedure chest X-ray (CXR) that confirms the position of the catheter tip[14] can also detect malpositions, pneumothorax, and kinking. The carina is radiologically identifiable in about 96% of all chest x-rays (CXRs) at the interspace between the fourth and fifth thoracic vertebrae.[15] Carina is an ideal radiological landmark for tip of CVC catheter.

In our study, the average insertion length in male was 13.2 cm (12.5 cm to 14 cm) while the average length of catheter insertion in female was 11.9 (11–13 cm) which corresponds to positioning 80% in 5th posterior intercostal space and 84% in 5th thoracic vertebrae. In 95.1% of female patients and 89.6% of male patients, the tip was at or above the level of carina (≤1 cm). It was considered correct if the tip was ≤ 1 cm above and ≤ 0.5 cm below from carina level. Based on the CXRs the catheters were repositioned which were beyond the range. Our range encompasses 92% cases of our study which strongly signifies our method.

A study by Kim *et al.*,[10] who estimated the desired length of right and left-sided CVC using surface landmarks. They showed that mean tip position of right-sided CVC inserted in SCV was 0.9 cm above the carina. Another study shown almost similar but the placement of tip was 0.2 cm below the carina.[9] These both studies are giving the similar results as our. One more study states the similar conclusion, but observed length was more than our topographical length this may be due to ethnic variation.[16]

Some other derived formula[13] while other used technique (tailored technique)[17] to improve tip position. Some found electrocardiographic method is better than fluoroscopy method while others were in favor of echocardiographic method.[18] Our study result is not absolute perfect, but they are very close to perfection without using expensive, rarely available devices. No complication is seen in our study.

CONCLUSION

It can be concluded from the study that appropriate length of CVC of right SCV is correlated with surface

Table 13: Relation of mean age of participants with different carina levels

Tip position	Tip position	*P* value
Below the carina	At the level of carina	0.367
	Above the carina	0.087
At the level of carina	Below the carina	0.367
	Above the carina	0.502
Above the carina	Below the carina	0.087
	At the level of carina	0.502

Table 14: Statistical association between level of carina and sex

Tip position	Sex		Total	Pearson Chi-square	Df	*P* value
	F	M				
Below the carina	1	3	4			
At the level of carina	18	17	35	4.314	2	0.116
Above the carina	2	9	11			
Total	21	29	50			

Table 15: Descriptive statistics about catheter tip position and topographical length at different levels of carina

Sex	Tip position (topographical length) (cm)	*n*	Minimum	Maximum	Mean±SD
Male	Below the carina	1	13.0	13.0	13.0±0.0000
	At the level of carina	18	11.5	12.8	11.978±0.3639
	Above the carina	2	11.0	11.2	11.100±0.1414
Female	Below the carina	3	14.0	14.0	14.000±0.0000
	At the level of carina	17	12.9	13.9	13.312±0.3100
	Above the carina	9	12.5	12.9	12.722±0.1302

SD: Standard deviation

landmarks, and the approximate CVC insertion depth can be estimated using the topographical measurement with the CVC itself, along with the pathway of the central veins. Moreover, this method requires no additional cost and/or time-consuming procedures and radiation exposure was minimal.

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