Research Article

Vertebral levels of great vessels in mediastinum and their role in vascular interventions

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Received November 14, 2014. Accepted December 3, 2014

Abstract

Background: The interventional procedures such as central venous catheterization demand better knowledge of anatomy of mediastinal vessels. The vertebral body provides a useful and radiographically visible landmark for accurate central catheter tip placement.

Objective: To study the vertebral levels of formation and termination of superior vena cava (SVC) and the vertebral level of origin of brachiocephalic trunk, left common carotid artery, and left subclavian artery in Indian subjects, and to describe their role in vascular interventions.

Materials and Methods: The CT chest images of 48 patients were studied and vertebral levels of earlier mentioned vessels were measured.

Results: The vertebral level of formation of SVC was found to be at the level of T3, T4, and T5 in 22.91%, 62.50%, and 14.58% cases, respectively, whereas that of the termination of SVC was found to be at the level of T5, T6, T7, and T8 in 10.41%, 56.25%, 29.16%, and 4.16% cases, respectively. The left common carotid artery, left subclavian artery, and the brachiocephalic trunk were found at T3, T4, and T5 in 27.08%, 60.41%, and 12.50% cases, respectively.

Conclusion: The comprehensive data of vertebral levels will help clinicians in understanding the vascular levels for diagnostic and therapeutic purposes, especially in Indian subjects.

KEY WORDS: Superior vena cava, central venous catheter, catheter tip placement, mediastinal vasculature, Indian subjects

Introduction

The great vessels in mediastinum include the ascending, the descending, and the arch of aorta, left common carotid artery, left subclavian artery, brachiocephalic trunk, and superior vena cava (SVC).[1] The anatomy as seen in the cadaver does not always reflect accurately the situation in life because formalin fixation causes tissue hardening and shrinkage. Here comes the role of imaging techniques such as CT and MRI that have the ability to depict in vivo cross-sectional anatomy and pathology.[2,3] CT has better spatial resolution and shorter imaging time than MRI, besides being less expensive and more widely available; thus, CT remains the best imaging modality to study the mediastinal vasculature.[4–7]

Central venous catheter (CVC) insertion is a routine procedure in intensive care units (ICUs) to administer drugs or intravenous fluids and also to measure central venous pressure.[8–10] The CVC tip has been classically positioned in the lower third of the SVC, just above the superior vena cava–right atrium (SVC-RA) junction to prevent complications.[8–15] Placement of catheter tips above or near the cephalad origin of the SVC with the infusion of hypertonic or irritative solutions risks thrombosis from endothelial damage, embolism, and stenosis of the brachiocephalic veins or catheter erosion into the mediastinum leading to hydrothorax or hydromediastinum. Improper positioning of CVC or misplacement with tip resting within the right atrium results in lethal right atrial perforation that can rapidly progress to cardiac tamponade and arrhythmias.[16–18]

Access this article online	
Website: http://www.ijmsph.com	Quick Response Code:
DOI: 10.5455/ijmsph.2015.1411201492	

Anteroposterior chest radiography is used to ensure that the catheter tip is properly positioned in the SVC. However, to exactly identify the SVC–RA junction is difficult with low-quality portable chest radiographs in critically ill patients.[19–21] Previous investigators have recommended the use of various radiographic landmarks for identifying the cephalad and caudal boundaries of the SVC relevant to CVC positioning. The vertebral body provides a useful and radiographically visible landmark for accurate central catheter tip placement. After reviewing the literature thoroughly, it was found that even though the vascular anatomy of the mediastinum has a wide range of clinical implications and applications, there is dearth of literature about living anatomy of mediastinal vessels in Indian subjects. Fewer studies on this part have added up to the inherent complexity of mediastinal vascular anatomy, ultimately resulting in diagnostic difficulties. Thus, this study was conducted to study the reliable radiological landmark for the great vessels of mediastinum that will help in various vascular interventions in this region.

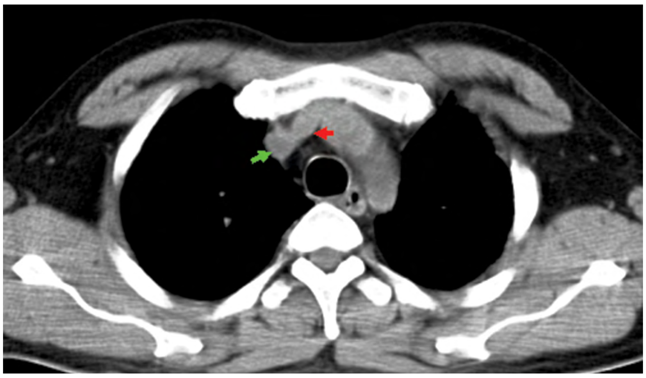

Figure 1: Illustration showing formation of superior vena cava. The left brachiocephalic vein (red arrow) is seen crossing from left to right. It unites with right brachiocephalic vein (green arrow) to form superior vena cava.

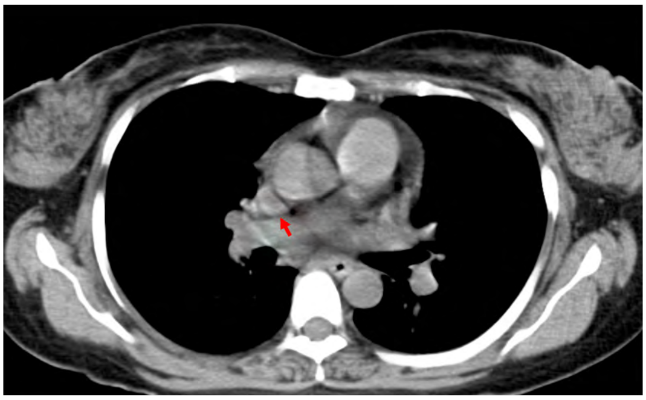

Figure 2: Illustration showing termination of superior vena cava (red arrow).

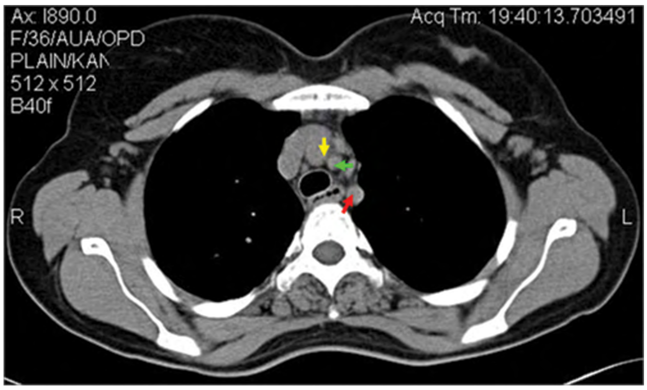

Figure 3: Illustration showing CT chest at the vertebral level of origin of brachiocephalic trunk (yellow arrow), left common carotid artery (green arrow) and left subclavian artery (red arrow).

Materials and Methods

The CT chest images of 48 patients (30 males and 18 females) investigated in a corporation and a government hospital were studied using Somatom, four-row CT scanner (Siemens).

Only the patients of age group 18–60 years with normal mediastinal report were included in the study. Those with any space-occupying lesion of mediastinum or any lung disease, coronary heart disease, hypertension, chronic pulmonary and renal disease, diabetes, and deep vein thrombosis were excluded.

It was a prospective study undertaken with permission from institutional ethics committee. The patient's informed consent was taken to participate in the study. The patient was put in a supine position with both arms abducted and was instructed to hold the breath in full inspiration. Thin sections (5 mm) were taken in axial plane. The data obtained were analyzed in a craniocaudal sequence at the workstation of reporting room. The following parameters were then studied and their vertebral levels were noted in a master chart as per the pro forma:

- Vertebral level of formation of SVC [Figure 1]
- Vertebral level of termination of SVC [Figure 2]
- Vertebral level of origin of brachiocephalic trunk, left common carotid artery, and left subclavian artery [Figure 3]

The crossing point between the SVC and the innominate vein was considered as the level of formation of the SVC, and the SVC-RA junction was considered as the level of termination of SVC. Then, these points were related to the level of the thoracic vertebra as a radiographic landmark. The intervertebral disk was included with the preceding vertebra. For example, the disk between T4/5 was included with T4 vertebra. The estimation of vertebral level of ascending, arch, and descending thoracic aorta was not included in the study due to lack of any clinical significance attached to it.

All these measurements were statistically analyzed by calculating the mean ($\bar{x}$) and standard deviation (SD) using SPSS software, version 22.0.

Table 1: The vertebral level of formation of superior vena cava

Vertebral level	Number of cases	%
T3 & above	11	22.91
T4	30	62.50
T5 & below	7	14.58

Table 2: The vertebral level of termination of superior vena cava

Vertebral level	Number of cases	%
T5	5	10.41
T6	27	56.25
T7	14	29.16
T8	2	4.16

Table 3: The vertebral level of origin of left common carotid artery, left subclavian artery and brachiocephalic trunk

Vertebral level	Number of cases	%
T3	13	27.08
T4	29	60.41
T5	6	12.50

Results

The study is pertaining to estimation of the vertebral levels of various vessels of mediastinum on normal CT chest images. The following observations were made:

- Vertebral level of formation of superior vena cava was measured and the findings were as shown in Table 1. The SVC was formed at the level of T4 vertebra in majority of cases (30 cases; 62.50%).
- Vertebral level of termination of SVC was measured and the findings were as shown in Table 2. The SVC terminated into right atrium at the level of T6 vertebra in majority of cases (27 cases; 56.25%); the next common level was T7 vertebra.
- Vertebral level of origin of left common carotid artery, left subclavian artery, and brachiocephalic trunk were measured and the findings were as shown in Table 3. These vessels originated from the arch of aorta at T4 level in majority of cases (29 cases; 60.41%).

Discussion

The anatomy of the great vessels of mediastinum is exceedingly complex, therefore a detailed study is very important. As the new diagnostic modalities such as CT and MRI have established their place in our diagnostic armamentarium, they have required us to be knowledgeable, especially about sectional anatomy as never before. The knowledge of structural relationship of great vessels of mediastinum not only has diagnostic implications but therapeutic use also.

The importance of knowing the vertebral level of SVC is to check for the positioning of the tip of catheter of central venous line on the chest radiograph in ICU patients. Optimal positioning of the tip of a CVC is a complex and controversial subject. A review of the scientific literature on this topic shows strong opinions and conflicting clinical practices. Greenall et al.[22] proposed that the caudal margins of the clavicles correspond with SVC origin. Na et al.[11] proposed that the sternal head of a right clavicle and the nipples can also be used as an external marker for placement of CVC in children. However, Aslamy et al.[12] stated that the use of these structures as radiographic landmarks can lead to substantial errors in CVC tip positioning due to the effect of parallax as these skeletal structures are not located in the same anatomic plane as the SVC. They proposed that an anatomic structure located in proximity to the SVC would be a better radiographic landmark. Defalque and Campbell[23] stated that, when viewed on a standard chest radiograph, the ideal position for a catheter tip is between the fifth and sixth thoracic vertebrae. Rutherford et al.[24] reported the angle between the right main stem bronchus and the trachea as a radiographic landmark for identifying the cephalad origin of the SVC. However, the use of right tracheobronchial angle is probably not applicable to actual clinical practice because even radiologists find it difficult to identify this landmark particularly on limited quality anteroposterior chest radiographs taken in ICUs and also not useful for left-sided CVC, which is more prone for complications.[13] Schuster et al.[25], Mahlon and Yoon,[26] and Caruso et al.[27] proposed that the carina was a reliable, simple radiographic marker for the correct placement of a CVC, but this suggestion was based on the examination of embalmed cadavers.

Arai et al.[28] in their study of 65 Japanese children (2–96 months) found that in approximately 90% of the cases the formation of the SVC was situated above the level of T4/5 interspace. In this study, the SVC was found to form at the level of T3 in 22.91% cases, at T4 in 62.50%, and at T5 in 14.58%. In the present study, the disk between T4-5 was included in T4 vertebra. Thus, in the present study 85.41% cases were above T4-5 interspace, which closely resembles the work of Arai et al.[28]

Connolly et al.[29] in their study on 56 Canadian children found that the vertebral level of termination of SVC passed through T6 or the interspace above or below in 92.5% cases. Baskin et al.[30] in their study of 100 adolescents (12–28 years) from Pittsburgh found that the T7 or T8 is the vertebral level of the SVC-RA junction. In this study, the vertebral level of termination of SVC was found to pass through T5 in 10.41% cases, T6 in 56.25, T7 in 29.16, and T8 in 4.16% cases. The study on the vertebral levels of origin of left common carotid artery, left subclavian artery, and brachiocephalic trunk was not found in literature, but these levels are important for vascular interventions. In this study, the left common carotid artery, left subclavian artery, and the brachiocephalic trunk were found to originate from the arch of aorta at T3 in 27.08% cases, at T4 in 60.41%, and at T5 in 12.50%.

The position of the thoracic viscera is, however, affected by posture. In this study, measurements were taken with the patient in supine position; the standard position for taking CT chest and also bedside X-ray chest in ICU patients. This position raises the level of thoracic viscera, but this effect would be counteracted by the fact that all the scans were taken in full inspiration. This takes the heart along with the great vessels and the tracheal bifurcation at a lower level than described in cadavers; thus, the levels described in anatomy books and levels seen in clinical practice in living subjects are different. Hence, this study was an attempt to study anatomy of the great vessels of mediastinum with the help of CT in Indian subjects. Despite many differences in materials, method, and number of investigated cases, some of the data of this study were quite similar to those reported earlier. This study provides specific data on the vertebral levels of great vessels of mediastinum in Indian subjects, which can be of diagnostic and therapeutic use.

Conclusion

A quantitative assessment of the vertebral levels of great vessels of the mediastinum has been presented that will help the clinicians for diagnostic and therapeutic purposes, especially in Indian subjects. Further studies with larger sample size were needed to rationalize the present findings.

References

1. Standring S. *Gray's Anatomy: The Anatomical Basis of Clinical Practice*, 40th edn. Churchill Livingstone, Elsevier, 2008. pp. 939–41.
2. Ellis H, Logan BM, Dixon AK. *Human Sectional Anatomy: Atlas of Body Sections, CT and MRI Images*, 3rd edn. London: Hodder Arnold, 2007. pp. viii–xiii, 106–127.
3. Lee JK, Sagel SS, Stanley RJ, Heiken JP. *Computed Body Tomography with MRI Correlation*, 3rd edn, Vol 1. Philadelphia, PA: Lippincott-Raven, 1998. pp. 1–9, 202–220.
4. Heitzman ER. *The Mediastinum: Radiologic Correlations with Anatomy and Pathology*, 2nd edn. New York: Springer, 1988. pp. 1–5.
5. Crowe JK, Brown LR, Muhm JR. Computed tomography of the mediastinum. Radiology 1978;128(1):75–87.
6. McLoud TC, Wittenberg J, Ferrucci JT. Computed tomography of the thorax and standard radiographic evaluation of the chest: a comparative study. J Comput Assist Tomogr 1979;3(2):170–80.
7. Jost RG, Sagel SS, Stanley RJ, Levitt RG. Computed tomography of the thorax. Radiology 1978;126(1):125–36.
8. Yoon SZ, Shin JH, Hahn S, Oh AY, Kim HS, Kim SD, et al. Usefulness of the carina as a radiographic landmark for central venous catheter placement in paediatric patients. Br J Anaesth 2005;95:514–7.
9. Albrecht K, Nave H, Breitmeier D, Panning B, Tröger D. Applied anatomy of the superior vena cava—the carina as a landmark to guide central venous catheter placement. Br J Anaesth 2004;92:75–7.
10. Vesely TM. Central venous catheter tip position: A continuing controversy. J Vasc Interv Radiol 2003;14:527–34.
11. Na HS, Kim JT, Kim HS, Bahk JH, Kim CS, Kim SD. Practical anatomic landmarks for determining the insertion depth of central venous catheter in paediatric patients. Br J Anaesth 2009;102:820–3.
12. Aslamy Z, Dewald CL, Heffner JE. MRI of central venous anatomy: implications for central venous catheter insertion. Chest 1998;114:820–6.
13. Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. Br J Anaesth 2006;96:335–40.
14. McGee WT, Ackerman BL, Rouben LR, Prasad VM, Bandi V, Mallory DL. Accurate placement of central venous catheters: a prospective, randomized, multicenter trial. Crit Care Med 1993;21:1118–23.
15. Racadio JM, Doellman DA, Johnson ND, Bean JA, Jacobs BR. Pediatric peripherally inserted central catheters: complication rates related to catheter tip location. Pediatrics 2001;107:E28.
16. Ridge CA, Litmanovich D, Molinari F, Bankier AA, Eisenberg RL. Radiographic evaluation of central venous catheter position: anatomic correlation using gated coronary computed tomographic angiography. J Thorac Imag 2013;28(2):129–33.
17. Kowalski CM, Kaufman JA, Rivitz SM, Geller SC, Waltman AC. Migration of central venous catheters: implications for initial catheter tip positioning. J Vasc Interv Radiol 1997;8:443–7.
18. Fletcher SJ, Bodenham AR. Safe placement of central venous catheters: where should the tip of the catheter lie? Br J Anaesth 2000;85:188–9.
19. James L, Bledsoe L, Hadaway LC. A retrospective look at tip location and complications of peripherally inserted central catheter lines. J Intraven Nurs 1993;16:104–9.
20. Duntley P, Siever J, Korwes ML, Harpel K, Heffner JE. Vascular erosion by central venous catheters. Clinical features and outcome.. Chest 1992;101:1633–8.
21. Kremser J, Kleeman F, Reinhart K, Schummer W. Optimized method for correct left-sided central venous catheter placement under electrocardiographic guidance. Br J Anaesth 2011;107:567–72.
22. Greenall MJ, Blewtt RW, McMahon MJ. Cardiac tamponade and central venous catheters. Br Med J 1975;2:595–59.
23. Defalque RJ, Campbell C. Cardiac tamponade from central venous catheters. Anesthesiology 1979;50:249–52.
24. Rutherford JS, Merry AF, Occleshaw CJ. Depth of central venous catheterization: an audit of practice in cardiac surgical unit. Anesth Intensive Care 1994;22:267–71.
25. Schuster M, Nave H, Piepenbrock S, Pabst R, Panning B. The carina as a landmark in central venous catheter placement. Br J Anaesth 2000;85:192–4.
26. Mahlon MA, Yoon HC. CT angiography of the superior vena cava: normative values and implications for central venous catheter position. J Vasc Interv Radiol 2007;18:1106–10.
27. Caruso LJ, Gravenstein N, Layon AJ, Peters K, Gabrielli A. A better landmark for positioning a central venous catheter. J Clin Monit 2002;17:331–4.
28. Arai T, Yamashita M. Cephalad origin of the superior vena cava and the level of the central venous catheter tip on chest radiographs. Paediatr Anaesth 2005;15(1):47–9.
29. Connolly B, Mawson JB, MacDonald CE, Chait P, Mikailian P. Fluoroscopic landmark for svc-ra junction for central venous catheter placement in children. Pediatr Radiol 2000;30(10):692–5.
30. Baskin KM, Jimenez RM, Cahill AM, Jawad AF, Towbin RB. Cavoatrial junction and central venous anatomy: implications for central venous access tip position. J Vasc Interv Radiol 2008;19:359–65.

How to cite this article: Syed NP, Ali AS, Syed IS, Bhuiyan PSS. Vertebral levels of great vessels in mediastinum and their role in vascular interventions. Int J Med Sci Public Health 2015;4:450-453

Source of Support: Nil, **Conflict of Interest:** None declared.