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ORIGINAL ARTICLE

Location of the Internal Mammary Arteries in Relation to the Lateral Border of the Sternum: A Key to Avoid Injury during Computed Tomography-Guided Biopsy of Anterior Mediastinal Masses

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ABSTRACT

Introduction: *Accurate knowledge of the location of the internal mammary arteries (IMAs) in relation to the lateral border of the sternum is important in preventing haemorrhagic complications during biopsy of anterior mediastinal masses using an anterior parasternal approach. This study aimed to document the location of the IMAs in relation to the sternum and their course to guide parasternal transthoracic interventions.*

Methods: *The shortest distance between each IMA and the sternum midway between the main pulmonary artery and the aortic arch was measured on axial sections of contrast-enhanced chest computed tomography of 150 adult patients.*

Results: *The mean distance of the right IMA from the lateral border of the sternum was 11.7 ± 2.51 mm and that of the left IMA was 10.88 ± 2.41 mm.*

Conclusion: *Our study established the position of the IMAs in relation to the sternum's lateral border in the Indian population. This knowledge is useful in planning percutaneous anterior mediastinal biopsies without injuring the IMA. We recommend a parasternal approach with a safe window of 11.3 mm between the lateralmost margin of the sternum and the medial margin of the IMA for percutaneous transthoracic anterior mediastinal procedures.*

Key Words: *Image-guided biopsy; Mammary arteries; Needles; Supine position*

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This study was approved by our Institutional Review Board (Ref: 12734). The need for consent was waived off in view of the retrospective nature of the study.

中文摘要

內乳動脈相對於胸骨外側緣的位置:計算機斷層掃描引導前縱隔腫塊活檢過程中避免損傷的關鍵

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引言：準確了解內乳動脈（IMA）相對於胸骨外側緣的位置對於預防前胸骨旁入路對前縱隔腫塊進行活檢時出現出血併發症非常重要。本研究旨在記錄IMA相對於胸骨位置及其路線，以指導胸骨旁經胸介入。

方法：在150名成人患者的胸部計算機斷層掃描增強掃描的軸向切面圖像上，測量主肺動脈和主動脈弓中間的胸骨與每個IMA之間的最短距離。

結果：右側IMA距胸骨外側緣的平均距離為11.7 ± 2.51 mm，左側IMA平均距離為10.88 ± 2.41 mm。

結論：本研究確定印度人口中IMA相對於胸骨外側緣的位置。這些知識有助於在不損傷IMA的情況下規劃經皮前縱隔活檢。對於經皮經胸前縱隔手術，我們推薦胸骨最外側邊緣和IMA內側邊緣之間的安全窗為11.3 mm的胸骨旁入路。

INTRODUCTION

Biopsy of anterior mediastinal masses using a parasternal approach under both computed tomographic (CT) and ultrasonic guidance is widely practised.[1,2] CT-guided percutaneous biopsy of anterior mediastinal masses is considered a safe diagnostic procedure with a high diagnostic yield.[3-7] The course of the left internal mammary artery (LIMA) and the right internal mammary artery (RIMA) adjacent to the sternum makes them susceptible to iatrogenic injury during anterior parasternal transthoracic procedures, which can lead to life-threatening haemorrhage.[8] Knowledge of the location of the IMAs in relation to the lateral border of the sternum is key in planning biopsy of anterior mediastinal masses using the parasternal approach.

Anatomical Considerations: Does the Location Matter?

As the IMAs (usually the LIMA) are the primary conduit used for coronary artery bypass grafts, there are many cadaveric studies that have generated information on their anatomy.[9-11]

The IMA originates from the first part of the subclavian artery and descends along the posterior aspect of the first to sixth costal cartilages. Medial to the artery, there are two internal mammary veins (IMVs), which variably unite and drain into the brachiocephalic vein.[12] The IMA and IMV are located approximately 1.3 cm from the lateral edge of the sternum on either side. Usually, the IMA is situated lateral to the IMV (Figure 1). However, studies have shown that the position of these vessels can be variable and the lateral border to sternum to artery distance can range from 0.42 to 1.66 cm for the IMV and from 0.98 to 2.42 cm for the IMA.[12-14] Differences in the points of measurement across studies (e.g., midpoint of an IMA to the lateral border of the sternum or medial border of an IMA to the lateral border of the sternum) or different craniocaudal levels of measurement can

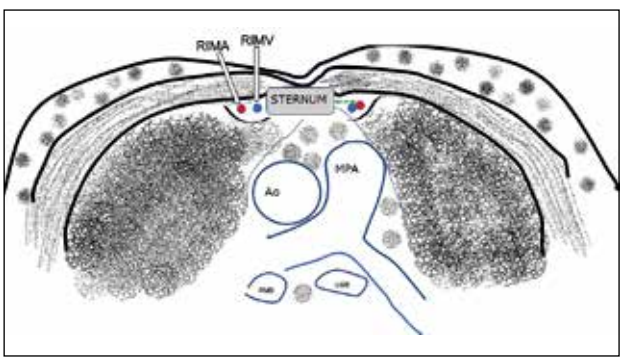

Figure 1. Diagrammatic representation of the anatomical relationship between the sternum and internal mammary vessels. There is a potential safe window (green arrow) between the internal mammary artery and the sternum.
Abbreviations: Ao = aorta; LMB = left mainstem bronchus; MPA = main pulmonary artery; RIMA = right internal mammary artery; RIMV = right internal mammary vein; RMB = right mainstem bronchus.

contribute to the wide range of variations in the distance from the lateral border of the sternum to the IMA.

Most of the studies contributing to the knowledge of the anatomy of the internal mammary vessels are cadaveric. The IMAs are easily demonstrated on CT.

This study aimed to document the shortest distance between the IMAs and the sternum, and variations in the number of IMAs, to prevent injury of these vessels during percutaneous transthoracic procedures.

METHODS

The study was performed in a tertiary care referral hospital. This study was approved by our Institutional Review Board (IRB Ref: 12734). The need for consent was waived in view of the retrospective nature of the study. We performed a retrospective observational study of 175 consecutive patients, who underwent contrast-enhanced CT of the thorax for diverse indications such as evaluation of lung opacities discovered on chest radiography, primary or metastatic disease, or suspected pulmonary infection/inflammatory conditions. Patients aged <18 years or with conditions that distort the normal anatomy, such as space-occupying lesions, major trauma, malunited fractures, or congenital thoracic anomalies were excluded. Twenty-five patients were excluded from the study, based on the above criteria.

Technical Information

Computed Tomography Acquisition

Contrast-enhanced axial sections of the thorax in the arterial phase were obtained on a 64-slice (GE Discovery CT 750 HD scanner; GE Healthcare, Milwaukee [WI], United States) or on a 32-slice CT scanner (Philips Incisive CT; Philips Healthcare, Best, the Netherlands) with a section thickness of 2.5 mm and an interslice gap of 2.5 mm.

Measurement Methodology

The number of arteries visualised on either side of the sternum was noted. The shortest distance between the most medial IMA and the lateral border of the sternum was measured at a level between the aortic arch and the main pulmonary artery, which approximately corresponds to the level of the tracheal bifurcation. Electronic callipers were used to measure the shortest distance between the sternum and the medial margin of each IMA on either side on relevant magnified axial sections. Measurement at the level of the costal cartilages was avoided (Figure 2).

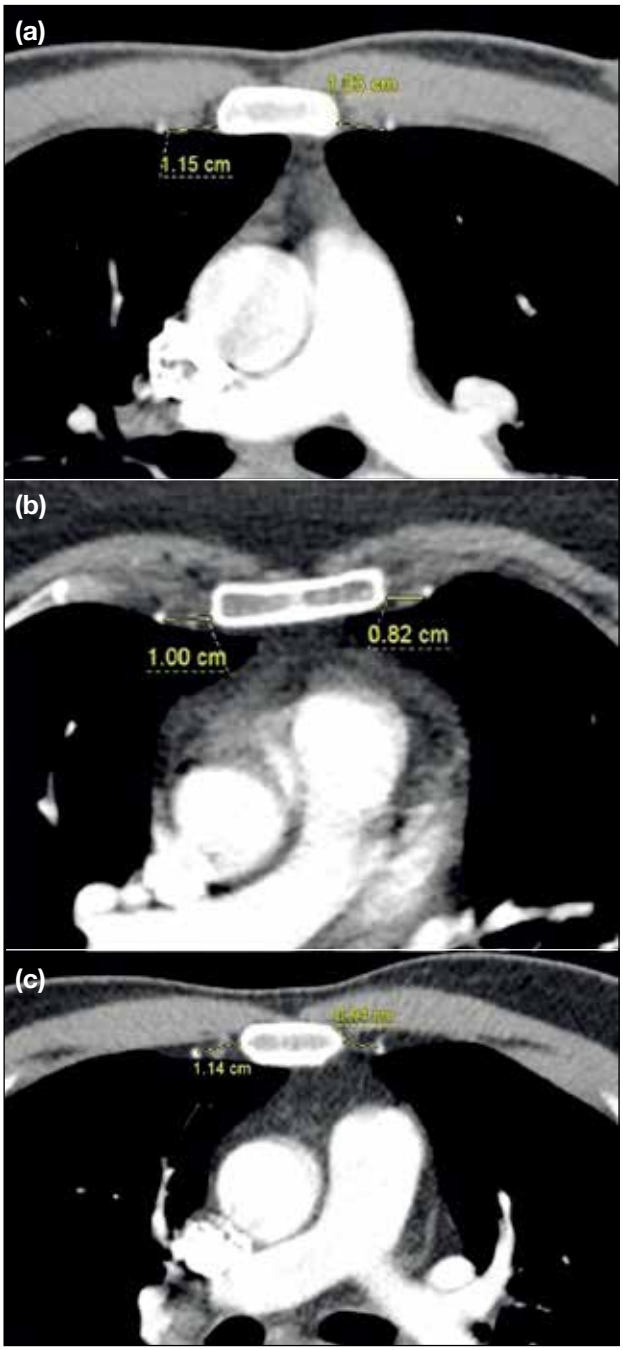

Figure 2. Axial sections of the thorax at the level of the main pulmonary artery. The area of interest is zoomed and the shortest distance between the medial border of the internal mammary artery (IMA) and the lateral border of the sternum is measured by using electronic callipers. In (a) and (b), the shortest distance is measured from the IMA to the posterior aspect of the sternum while in (c), the shortest distance is to the posterior aspect of the mid-level of the sternum.

Statistical Analysis

Descriptive statistics were used such as mean ± standard deviation for continuous variables. Number

and proportion were used for categorical variables. An independent Student's *t* test was used to identify significant differences in the IMA distance to the sternum between sides and between sexes. p value < 0.05 was considered significant. The analysis was carried out using SPSS (version 21.0; IBM Corp, Armonk [NY], United States).

RESULTS

There were 150 patients (300 sides) included for evaluation of which 87 (58%) were men and 63 (42%) were women. The patients were age 18 to 83 years (mean age 48.4 ± 15.7; men: 49.7 ± 17.1; women: 46.6 ± 13.4).

A single IMA was noted on each side in all patients. The mean distance between the IMA from the lateral border of the sternum was 11.3 ± 2.49) mm. There was no significant difference between the mean IMA distance of men and that of women (p = 0.232).

The mean distance from the RIMA to the sternum was 11.7 ± 2.51 mm (range, 2.8-18.0) and from the LIMA to the sternum was 10.88 ± 2.41 mm (range, 5.2-16.9) [p = 0.003]. There was a significant difference among men (p = 0.009) but not among women (p = 0.125) in IMA distance to sternum between the two sides.

The mean distances between the IMA and sternum were 11.09 ± 2.79 mm in men and 11.45 ± 2.25 mm in women. The mean distance from the RIMA to the sternum was 11.89 ± 2.24 mm (range, 5.9-17.1) for men and 11.47 ± 2.85 mm (range, 3.8-18.0) for women (p = 0.309). The mean distance from the LIMA to the sternum was 11 ± 2.18 mm (range, 5.9-16.9) for men and 10.7 ± 2.69 mm (range, 5.2-16.2) for women (p = 0.472).

We did not encounter any anatomical variants of the IMA in our study.

DISCUSSION

Knowledge of the location of the IMAs helps to guide the planning of the procedure, ensuring the trajectory of the needle is such that the IMA is not along the needle path. Inadvertent puncture of the IMA can occasionally result in substantial extrapleural and pleural haemorrhage and is potentially fatal.[8] The need to preserve the IMA also lies in the fact that it is the most preferred vessel for coronary artery bypass grafting.[11]

Although there are cadaveric studies that describe the distance between the IMA and the lateral margin of the sternum, there are few imaging-based studies available. Glassberg et al[14] in their study recommended that in order to avoid IMA injury while performing parasternal percutaneous transthoracic procedures, a more lateral approach (2.5 cm from the sternal border) should be adopted. They described the existence of a safe window between the sternal border and the internal mammary vessels and advocated its use only for procedures performed under image guidance. However, the authors did not specify the measurement technique, whether it is measured from the anterior or posterior margin of the sternum. Also, the study included patients between 5 years and 96 years, which could skew the results as the younger population have smaller measurements given their smaller chests. Dursun et al[1] measured the distances between the IMA and the sternum at three different levels (manubrium, midsternal corpus, and distal sternal corpus) and found that the distance increased caudally.[1,14] However, these were done on coronal reformatted images.

Karaman et al,[15] in their study on 164 patients with CT angiography, measured the mean distance between the lateral margin of the sternum and midpoint of the RIMA and LIMA (13.0 mm and 12.4 mm, respectively). However, we need the shortest distance between the sternum and the medial margin of the IMA to facilitate needle insertion without injury to the IMA. Iguchi et al[16] reported a mean distance of 7.3 ± 2.4 mm between the IMA and the lateral edge of the sternum, based on their experience with biopsy of 42 anterior mediastinal lesions.

Our study revealed a mean distance of 11.3 ± 2.49 mm between the lateralmost margin of the sternum and the medial margin of the IMA. There exists a safe window of 11.3 mm between them, which would be sufficient to accommodate a coaxial needle under CT guidance (Figure 3). The needle, when advanced close to the sternum, allows the use of the sternum as a pivot guiding further advancement, and also avoids the pleural reflection, which lies more laterally, thereby preventing complications such as pneumothorax and pleural haemorrhage.

The knowledge of the relationship between the IMAs and the lateral margin of sternum helps to plan safe access to anterior mediastinal pathologies without injury to the adjacent IMA and the pleural reflection, thereby avoiding potentially life-threatening mediastinal and/or pleural haemorrhage as well as pneumothorax.

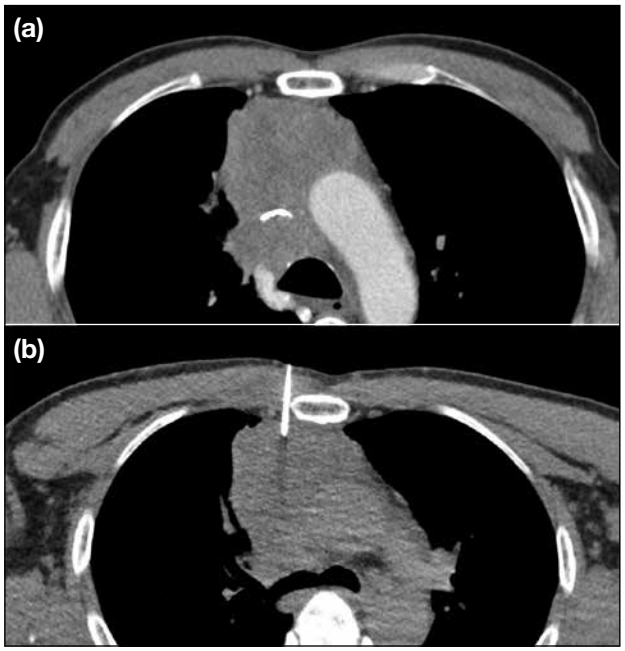

Figure 3. (a) Axial section of the thorax at the level of the aortic arch in a patient with an anterior mediastinal mass lesion, showing the right internal mammary artery lying between the point of entry on the skin and the mass lesion, putting it at a higher risk of injury. The safe approach is through the window between the sternum and the internal mammary artery as seen in (b).

Although the IMA can be identified on the non-contrast planning CT, it may not always be possible to do so, particularly in case of a large anterior mediastinal mass reaching up to the chest wall, wherein the IMA may not be visually separated from the mass. This study establishes the position of the IMAs in relation to the sternum's lateral border and assures us that there will, most often be adequate space available to pass a biopsy needle.

There are no major limitations in this study. The distance between the IMAs and the sternum was measured at one specific level. One needs to be aware that the location of needle insertion for biopsy of a mediastinal lesion depends on several factors, including the size of the mediastinal mass, its location, intervening costal cartilage, and any lung tissue in between. These factors may limit a fixed location of entry of the biopsy needle.

This distance may vary slightly at different levels. We did not encounter any anatomical variants in the number of IMAs and hence the data are not applicable to patients with anatomical variants. It is important to be aware that the IMV lies medial to the IMA. To the extent possible, injury to the IMV is preferably avoided, though it is not known to cause significant or life-threatening haemorrhage.

In conclusion, this study establishes that there exists a safe window of 11.3 mm between the IMA and the lateral margin of the sternum for planning percutaneous anterior mediastinal biopsies. With this background of knowledge, the recommended route while planning an image-guided biopsy for an anterior mediastinal lesion is therefore medial to the IMA, which will avoid inadvertent injury to the artery and prevent entry of the pleural space, avoiding pleural haemorrhage and pneumothorax. Although the safe window is established as 11.3 mm, the least distance we encountered in our study was 5.9 mm in men and 3.8 mm in women. Nevertheless, this study emphasises the existence of a window between the IMA and the sternum, wide enough to let a needle pass through. One will look at the IMAs and IMVs anyway before biopsy. However, the information obtained by this study provides confidence regarding the potential available space between the sternal border and the IMA.

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