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Surface landmarks and Surface projections of thorax - A Brief Review

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ABSTRACT
Introduction: Surface anatomy is fundamental for comprehending topographical anatomy, assessing patients, deciphering diagnostic imaging, and carrying out surgical or interventional operations like positioning of central venous catheters and endotracheal tube. Clinically significant surface landmarks exhibit a great deal of variability between and within modern anatomical texts. The surface anatomy of the thorax will be reviewed in this article, with a focus on its clinical significance.
Aim: to review the variations and similarities in thoracic surface anatomy between current standard thoracic surface anatomy knowledge (central veins, cardiac apex, diaphragmatic openings, and structures in relation to the sternal angle).
Conclusion: the main conclusion reached was that to teach accurate information about surface anatomy, medical, dental, and other health profession students, as well as those pursuing postgraduate studies in the medical sciences, should be taught about potential ranges of variation. The variations in the surface landmarks of thorax will throw light for cardiothoracic surgeons.
Keywords: Surface anatomy; Thorax; Sternal angle; Cardiac apex, Tracheal bifurcation.

Introduction

Surface anatomy is essential for understanding basic topographical anatomy, examining patients, interpreting diagnostic images, and performing surgery or interventional procedure[1,2] Traditional understanding of human surface anatomy, however, is mostly based on cadaver research, which can be distorted by postmortem changes, ageing, disease, comorbidity, and embalming[3].

Most traditional anatomical studies were performed before the introduction of modern cross-sectional imaging, but their descriptions have been reiterated in multiple editions of anatomical and clinical texts with little consideration of their accuracy and therefore their utility. There are numerous inconsistencies in clinically important surface markings among and within contemporary anatomical texts[4].

The normal development of the thoracic structure is an essential for the neonatal spontaneous breathing during the embryonic and fetal period, so the prenatal diagnosis of the fetal thoracic structure and its deformities are immensely important[5]. Additionally, adult thoracic surface anatomy serves as a reference for making incisions in surgical procedures and the placement of catheters and positioning of endotracheal tubes[6 7]. In recent years, several studies using modern imaging techniques in living subjects have challenged the validity of traditional surface landmarks. This article will review the surface anatomy of the thorax, emphasizing its clinical significance[8].

The information available in standard textbooks is derived from work done on embalmed cadavers and it has many limitations because cadaveric studies do not consider the changes incurred during the embalming process, or the effects of air in the thoracic cavity, which would influence the position of thoracic structures[4].

Standard anatomy textbooks state that the cardiac apex is located approximately 9 cm lateral to the midline, frequently at the level of the fifth or sixth ribs on the left side of the intercostal space[9–12]. Contrary to popular belief, the trachea bifurcates below the sternal angle and at the level of the upper part of the sixth thoracic vertebrae. The concavity of the arch is in level with the upper half of the fifth thoracic vertebra (range 2.8 cm superior to 4.8 cm inferior), and it rests about 1 cm inferior to the sternal plane. The formation of the left and right brachiocephalic veins occurs behind the sternoclavicular joints. At the level of the right third costal cartilage, SVC enter the right atrium[10–13]. The esophagus crosses the diaphragm at the level of the tenth thoracic vertebra, the inferior vena cava crosses it at the level of the disc between the eighth and ninth thoracic vertebrae, and the aorta crosses it at the level of the lower border of the twelfth thoracic vertebra and the adjacent disc, which is slightly to the left of the midline[10–12].

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Review

Recently, several international studies have been published that have focused on population specific surface anatomy in living subjects by utilizing modern imaging techniques such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound scanning[8,14,15].

In computed tomography-based study in adult population determined that the position of the cardiac apex, formation of the brachiocephalic veins, and vertebral levels of the sternal angle, xiphisterna joint, and aortic hiatus were consistent with commonly accepted surface markings although there was a wide range of normal variation. In contrast, common surface markings were markedly inaccurate for the following: the position of the tracheal bifurcation, aortic arch, and azygos vein termination (below the plane of the sternal angle at T5-T6 vertebral level in most individuals); the lower border of the lung (adjacent to T12 vertebra posteriorly); and the level at which the inferior vena cava and esophagus traverse the diaphragm (T11 in most). The trachea usually bifurcates at the level of the seventh cervical vertebra (range C5 to T1); SVC termination varied more between the sexes and age groups; SVC and right atrial junction was at the level from the right third intercostal space to the fifth costal cartilage and was higher levels in women and younger adults[7,8].

Anatomical planes are commonly used as reference points by anatomy students, and the vertebral level and contents of these planes are usually included in modern anatomical literature [10–12,16,17]. It is challenging to pinpoint the exact origin of this plane because it changed after cadaver cross-sectional anatomy was introduced[4]. The sternal angle usually lies at the level of T4 to upper T5 intervertebral disc which is consistent with most textbook descriptions[18] and the tracheal bifurcation, convexity of aortic arch, azygos vein/SVC junction, and pulmonary bifurcation all usually below the plane[4].

A cross sectional study was conducted by reviewing computerized tomography (CT) images of 77 children aged from four days to 12 years. It stated that in pediatrics the sternal angle is an accurate surface landmark for the azygos vein-superior vena cava junction in all age groups. However, the aortic arch (except in the 0–1-year group), the bifurcation of the pulmonary trunk and the tracheal bifurcation in those aged 15-18 years were not within this plane. The left brachiocephalic vein was located behind the ipsilateral sternoclavicular joint except in the 1-3 years group, and the right was behind it in children older than 6 years. The apex of heart was at the 5th intercostal space level in the 0-1- and 12-18-years groups; however, it was higher in the other groups. The lower borders of the lungs were at the sixth costal cartilage level in the midclavicular line, eighth intercostal space level in the midaxillary line, and T12 adjacent to the vertebral column in the 15-18 years group; the lower borders were at higher levels in younger children[9].

Another study in adolescent population (aged 12–18 years) using CT scans was conducted. The results showed that the brachiocephalic vein (left and right) formed mostly posterior to the sternoclavicular joint. The superior vena cava formed close to the second costal cartilage, ±16.3 mm to the right of the midline. The apex of the heart was in relation to the fifth intercostal space; ±78.6 mm to the left of the midline. The caval hiatus was in relation to T9 and T10; the esophageal hiatus was at T10, whereas the aortic hiatus was at T11. The sternal angle plane was in relation to the upper half of T5, which was also where the bifurcations of the trachea and pulmonary trunk were observed. The SVC/azygos vein junction and the concavity of the aortic arch were observed to be more than 10 mm superior to this plane[19].

A study was conducted in three hundred computed tomography (CT) of children and were divided into three age groups: 0–3 years, 4–7 years, and 8–11 years. In childhood, the ipsilateral medial clavicular head was frequently the site for the brachiocephalic vein (BCV) formation. Superior vena cava (SVC) formation was most frequently found at the second costal cartilage (CC) in the youngest group; however, as the child developed, it shifted to the first costal cartilage (CC)/first intercostal space (ICS). When the child grew, the SVC/right atrial junction migrated to the third CC/third ICS from its original location at the fourth CC in the youngest group[20].

Conclusion

According to the studies mentioned above, both similarities and differences are present between current surface anatomical knowledge and the findings that are reported. The main conclusion drawn was for accurate information regarding surface anatomy to be taught, possible ranges of variation should be incorporated into the education of medical, dental, and other health professions students, as well as in the medical sciences, at both undergraduate and postgraduate level. The variations in the surface projection of thorax will add additional knowledge for cardiothoracic surgeons.

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