Introduction

In the last 50 years since the first pacemaker was implanted, technology has improved dramatically, and these devices have saved or improved the quality of countless lives. Pacemakers treat slow heart rhythms by increasing the heart rate or by coordinating the heart's contraction for some heart failure patients ***(Wood et al., 2002)***.

Implantable cardioverter defibrillators stop dangerous rapid heart rhythms by delivering an electric shock ***(Reiffel et al., 2002).***

As the range of applications widens, the number of patients with cardiac devices continues to increase. Approximately 400 000 devices are implanted each year in the United States, and there >3 million patients with implanted cardiac devices currently ***(Reiffel et al., 2002).***

Simultaneously, we have observed an increase in the number of systems that need to be explanted due to different causes: the infection of the generator casing or the electrodes, the presence of bacterial endocarditis, the dysfunction of these electrodes, the need to implant more complex systems and the presence of secondary tricuspid insufficiency ***(Brodman et al., 1992).***

The retrieval of the endovenous electrodes is not always a simple procedure. Sometimes the progressive development of fibrous adhesions that are formed in time around the electrodes along their route in the vascular territory, as well as in the atrioventricular endocardium, leads to the extraction through open surgery and with the help of extracorporeal circulation a necessity ***(Byrd et al., 1992).***

Due to this difficulty, to ensure patient safety, the Heart Rhythm Society has published guidelines for safe lead removal or extraction. These guidelines outline the indications for lead extraction, physician qualifications and training, and the tools and techniques used in the procedure ***(Wilkoff et al., 2009)***.

Lead extraction has undergone an explosive evolution since its inception with limited technology and therapeutic options.

Early techniques involved simple manual traction, which frequently proved ineffective for chronically implanted leads and carried a high risk for myocardial avulsion, tamponade, and death ***(Rettig et al., 1979)***.

Telescoping mechanical non powered sheaths were developed in the 1980s to aid in the extraction of chronically implanted leads utilizing the principles of counterpressure and countertraction ***(Byrd et al., 1991)***. Locking stylets were developed in 1990 to reinforce the lead, transmit the extraction force to the tip of the lead, reduce the risk for lead disruption, and increase the likelihood of complete lead removal ***(Goode et al., 1991)***.

Powered sheaths employ a source of energy to make the dissection of encapsulating fibrous tissue easier and more efficient, thus enabling the advancement of the sheath along the lead with reduced traction and counterpressure forces ***(Bongiorni et al., 2005; Smith et al., 2008).***

One such powered sheath, the Excimer Laser System, Electrosurgical Dissection Sheath. However, disruption of calcified binding sites remained difficult with both systems. The most recent addition to the armamentarium of lead extraction tools provides a solution. The Evolution and Evolution Shortie Mechanical Dilator Sheath) are 'hand-powered' mechanical sheaths that consist of a flexible, braided stainless steel sheath with a stainless steel spiral-cut dissection tip. The sheath is attached to a trigger activation handle that rotates the sheath and allows the threaded metal end to bore through calcified and dense adhesions ***(Dello et al., 2005).***

The recently presented 2009 Heart Rhythm Society Expert Consensus on Transvenous Lead Extraction provides several recommendations to help the specialty of lead extraction evolve. The document creates standard definitions, recommends guidelines for safe lead extraction, identifies indications for extraction, and emphasizes the importance of reporting outcomes ***(Wilkoff et al., 2009).*** However, standardized reporting of outcomes will become essential. Data collection will serve to advance our collective knowledge and allow us to draw conclusions regarding the safety and complications of these techniques.

Aim of the Study

To present and analyse the experience of Ain Shams University hospitals in the field of percutaneous lead extraction among patients referred for percutaneous lead extraction in the period between April 2011 and April 2014.

Chapter one

Anatomical Consideration for Lead Implantation and Extractin

Lead extraction is the gold standard for treatment of CIED related infection and the management of lead malfunction ***(Wilkoff et al., 2009).***

A thorough knowledge of the anatomic structures of the neck, upper extremities, and thorax is essential for both cardiac pacing and extraction (**figure 1).** The precise location and orientation of the internal jugular, innominate, subclavian, and cephalic veins are important for safe venous access. Their anatomic relations to other structures is crucial to avoiding complications ***(Netter, 1992)***.

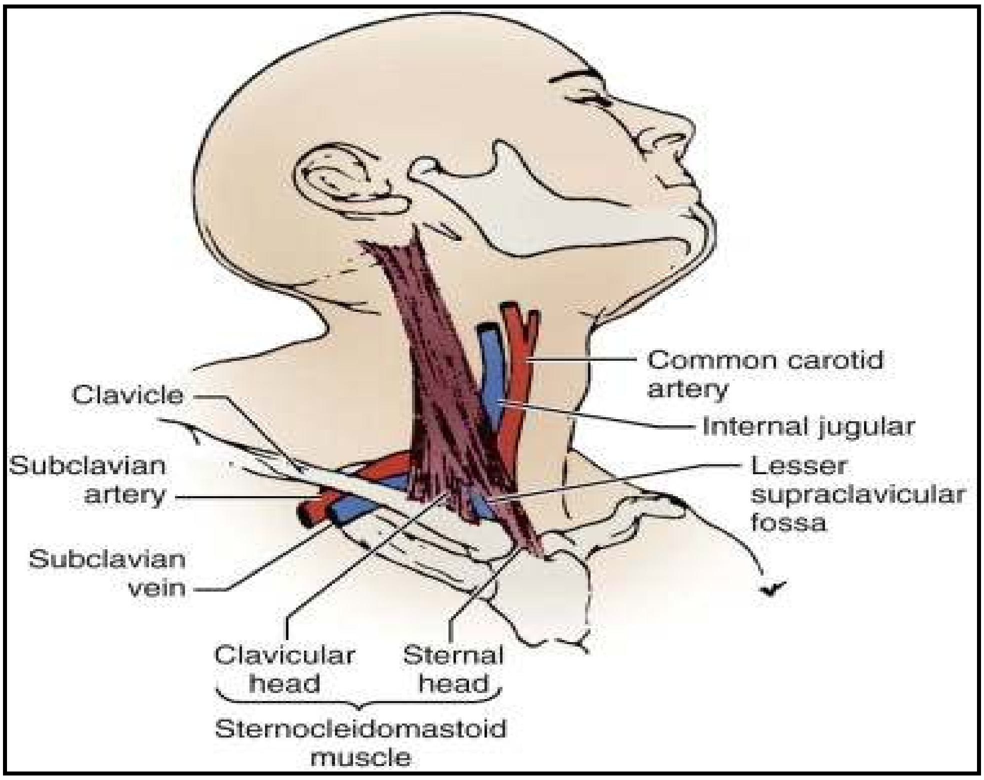

Figure (1): Anatomic relationship of the vascular structures in the neck and superior mediastinum ***(Ellenbogen et al., 2011).***

The venous anatomy of interest, from a cardiac pacing and extraction point of view, starts peripherally with the *axillary vein*. This large venous structure represents the continuation of the basilic vein and starts at the lower border of the teres major tendon and latissimus dorsi muscle ***(Gray et al., 1974).*** The axillary vein terminates immediately beneath the clavicle at the outer border of the first rib, where it becomes the subclavian vein. The axillary vein is covered anteriorly by the pectoralis minor and pectoralis major muscles and the costocoracoid membrane. The axillary vein is anterior and medial to the axillary artery, which it partially overlaps. At the level of the coracoid process, the axillary vein is covered only by the clavicular head of the pectoralis major muscle **(figure 2).** At this juncture, the axillary vein receives the more superficial cephalic vein ***(Gray et al., 1974).***

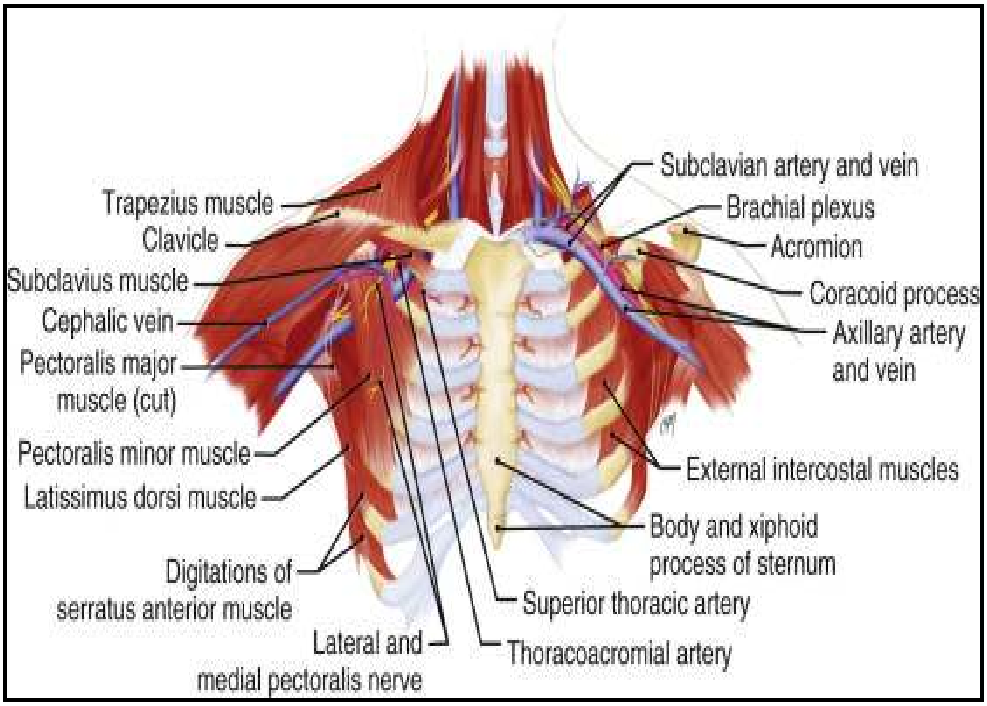

Figure (2): Detailed anatomy of the anterolateral chest demonstrating the axillary vein with the pectoralis major and pectoralis minor muscles removed ***(Ellenbogen et al., 2011).***

The *cephalic vein* terminates in the deeper axillary vein at the level of the coracoid process beneath the pectoralis major muscle. The cephalic vein often used for pacemaker venous access is classified as a “superficial vein of the upper extremity.” This vein, which actually commences near the antecubital fossa, travels along the outer border of the biceps muscle and enters the *deltopectoral groove,* an anatomic structure formed by the deltoid muscle and clavicular head of the pectoralis major **(figure 3)**. The cephalic vein traverses the deltopectoral groove and superiorly pierces the costocoracoid membrane, crossing the axillary artery and terminating in the axillary vein just below the clavicle at the level of the coracoid process ***(Gray et al., 1974).***

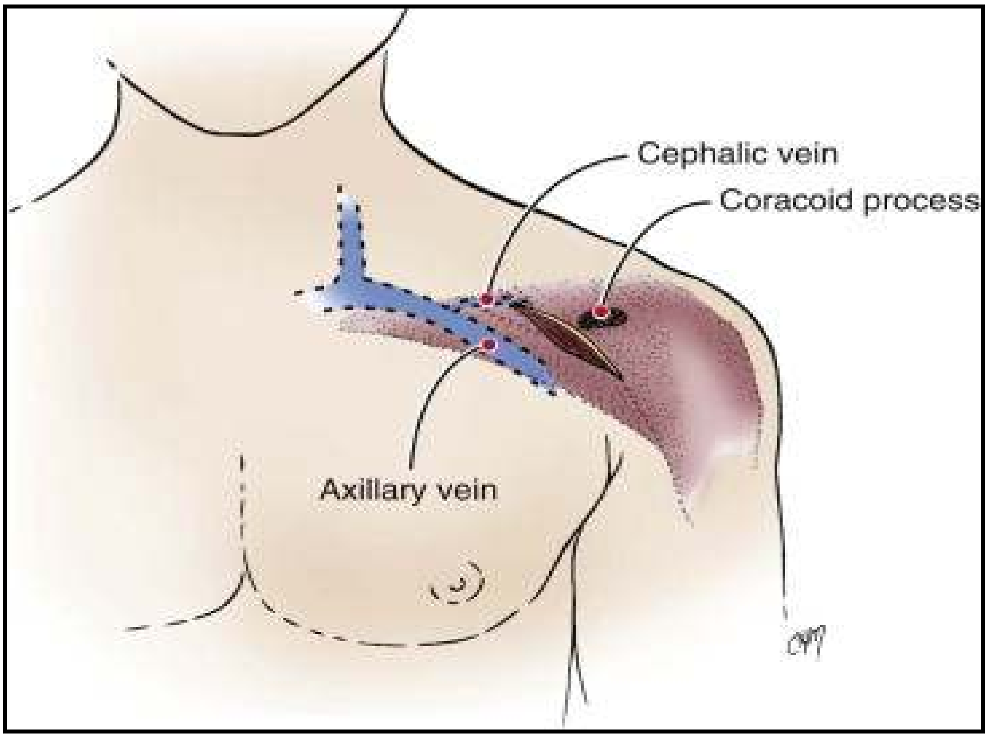

Figure (3): Anatomy of deltopectoral groove ***(Ellenbogen et al., 2011).***

The subclavian *vein* is a continuation of the axillary vein. The subclavian vein extends from the outer border of the first rib to the inner end of the clavicle, where it joins with the internal jugular vein to form the brachiocephalic trunk or innominate vein. The subclavian vein is just inferior to the clavicle and subclavius muscle. The *subclavian artery* is located posterior and superior to the vein. These two structures are separated internally by the scalenus anticus muscle and phrenic nerve. Inferiorly, the subclavian vein is associated with a depression in the first rib and on the pleura **(figure 4)** ***(Gray et al., 1974).***

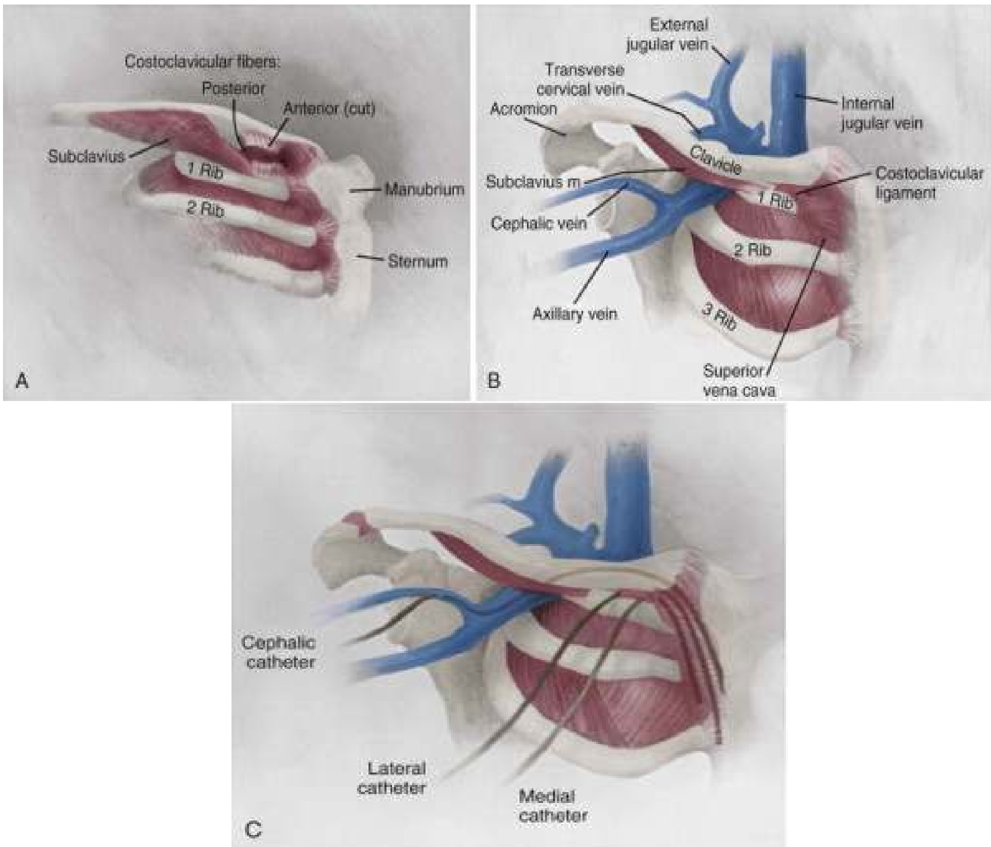

Figure (4): A, Musculoskeletal anatomy of the infraclavicular space. **B,** Relationship of the venous structures to clavicle, first rib, and costoclavicular ligaments. **C,** Course of leads through the venous structures shows how the pacemaker electrode can become entrapped ***(Jacobs et al., 1993).***

The internal and external jugular veins have also been used for pacemaker venous access. The *external jugular vein* is a superficial vein of the neck that receives blood from the exterior cranium and face. This vein starts in the substance of the parotid gland, at the angle of the jaw, and runs perpendicular down the neck to the middle of the clavicle. In this course, the external jugular crosses the sternocleidomastoid muscle and runs parallel to its posterior border. At the attachment of the sternocleidomastoid to the clavicle, the external jugular vein perforates the deep fascia and terminates in the subclavian vein just anterior to the scalenus anticus muscle. The external jugular is separated from the sternocleidomastoid muscle by a layer of deep cervical fascia. Superficially, it is covered by the platysma muscle, superficial fascia, and skin ***(Gray et al., 1974).***

The external jugular vein can vary in size and may even be duplicated. Because of its superficial orientation, the external jugular vein is less frequently used for cardiac pacing venous access ***(Ellenbogen et al., 2011).***

The *internal jugular vein* is an unusual site for pacemaker venous access. Because of its larger size and deeper and more protected orientation, however, the internal jugular vein is used more frequently than the external jugular vein. The internal jugular vein starts just external to the jugular foramen at the base of the skull. It drains blood from the interior of the cranium as well as superficial parts of the head and neck. This vein is oriented vertically as it runs down the side of the neck. Superiorly, the internal jugular is lateral to the internal carotid and inferolateral to the common carotid. At the base of the neck, the internal jugular vein joins the subclavian vein to form the innominate vein. The internal jugular vein is large and lies in the *cervical triangle,* defined by the (1) lateral border of the omohyoid muscle, (2) inferior border of the digastric muscle, and (3) medial border of the sternocleidomastoid muscle. The superficial cervical fascia and platysma muscle cover the internal jugular vein, which is easily identified just lateral to the easily palpable external carotid artery **(figure 5)** ***(Gray et al., 1974).***

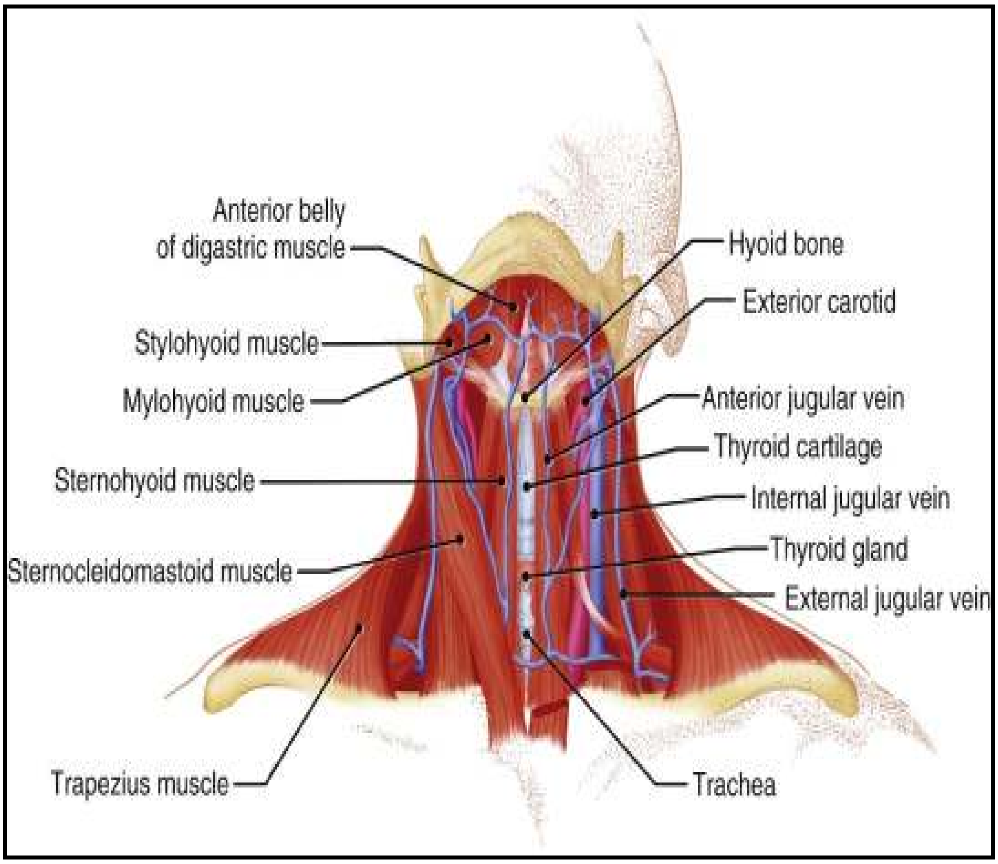

Figure (5): Detailed anatomy of the neck demonstrating the relationship of venous anatomy to the superficial and deep structures ***(Ellenbogen et al., 2011).***

From a venous access perspective, the location of the subclavian vein may vary from a normal lateral course to an extremely anterior or posterior orientation in elderly patients. *Byrd* ***(Byrd, 1974)*** has described the subclavian venous anatomy of two distinct deformities, both of which make venous access more difficult and hazardous. The first deformity involves a posteriorly displaced clavicle **(figure 6).** This is usually seen in patients with chronic lung disease and anteroposterior chest enlargement. Such patients can be identified from the presence of a horizontal deltopectoral groove and the posteriorly displaced clavicle. The second deformity is an anteriorly displaced clavicle **(figure 7).** Which is found occasionally, especially in elderly women. In this situation, the clavicle is anteriorly bowed or actually displaced anteriorly. It is important that the implanting physician recognize such variations so as to avoid complications such as pneumothorax and hemopneumothorax when using the percutaneous approach.

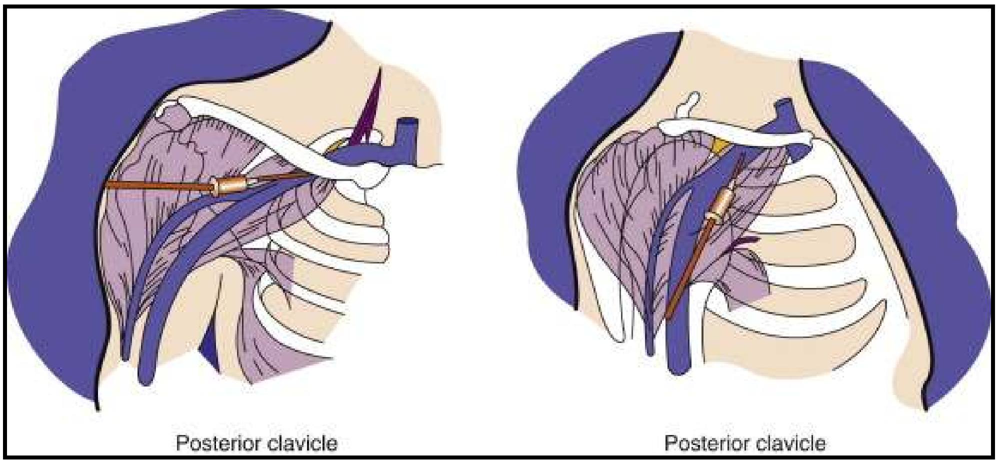

Figure (6): Posterior displacement of clavicle. The deltopectoral groove is in a horizontal rather than an oblique position ***(Byrd, 1974).***

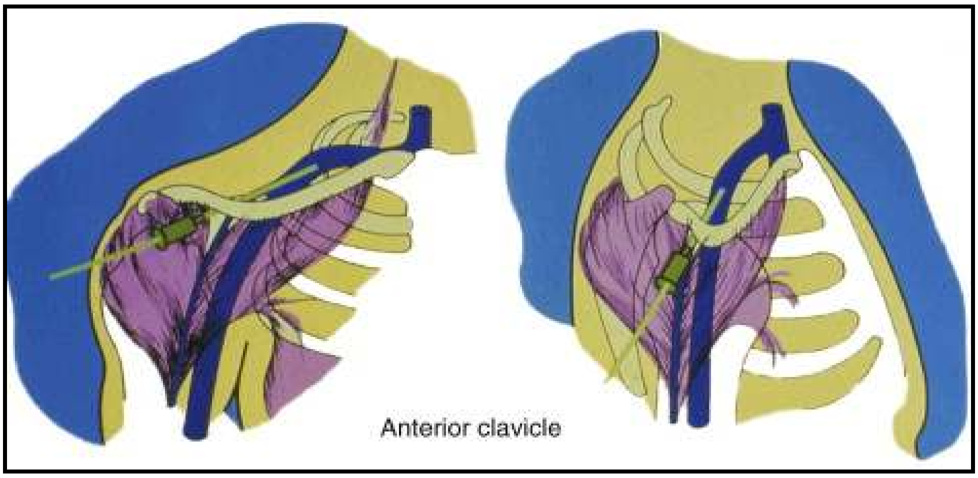

Figure (7): Anterior displacement of clavicle. The deltopectoral groove is nearly vertical ***(Byrd, 1974).***

It is assumed that the implanting and extracting physician is also completely familiar with the anatomy of the heart and great vessels, however, their spatial orientation is at times confusing, particularly with respect to the right atrium (RA) and right ventricle (RV). In the frontal plane, the border of the right side of the heart is formed by the RA. The border of the left side of the heart is composed of the left ventricle. Importantly, the RV is located anteriorly (**figure 8**) and is triangular. The apex of the RV is the generally accepted initial "target" for ventricular lead placement, although its location can vary. Its normal location, distinctly to the left of midline, depends on the rotation of the heart, which is affected by various pathologic and anatomic conditions. At times, the apex may be located directly anterior to or even to the right of midline. A lack of appreciation of these variations can lead to considerable difficulty in electrode placement ***(Netter, 1981).***

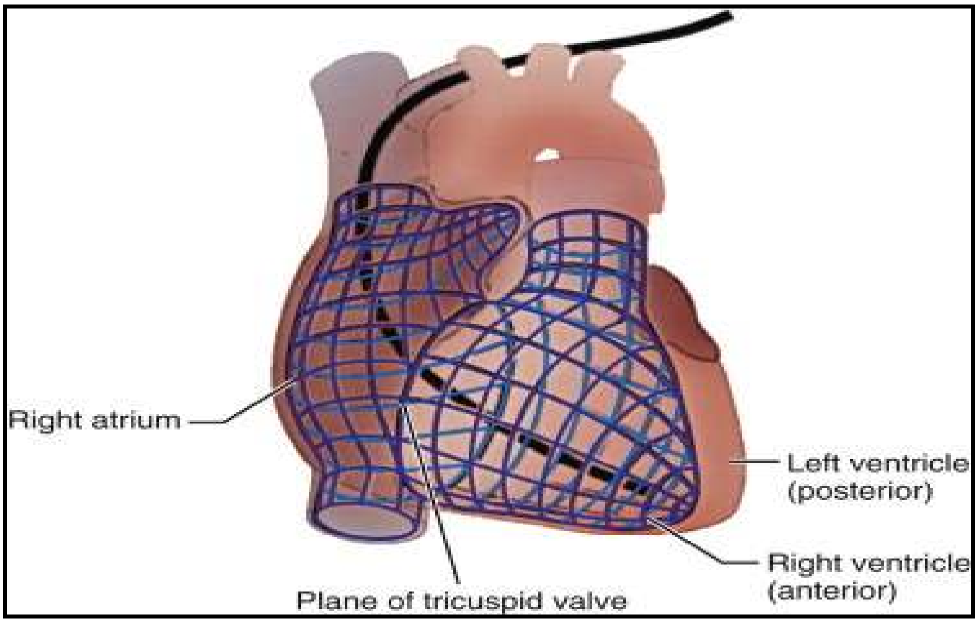

Figure (8): Spatial orientation of the right ventricle as an anterior structure in relationship to the left or posterior ventricle or coronary sinus, which is also posterior ***(Netter, 1981).***

The choice of site for pacemaker implantation is also occasionally important anatomically**.** This decision is typically made most appropriately on the basis of the patient's dominant hand, occupation, recreational activities, and medical conditions. The decision should not be made according to the dominant hand of the implanting physician ***(Netter, 1981).***

However, some fundamental differences exist between the anatomy of the right and left sides, which can be frustrating when passing a pacemaker lead. It seems to be easier for many right-handed implanters to work on the right side of the patient, and vice versa, but from a surgical point of view, lead manipulation from the right can be a frustrating experience. When entering the central venous circulation from the left upper limb, the pacemaker lead tracks along a smooth arc to the RV. There are generally no sharp angles or bends (**figure 9, A)**. Conversely, when approaching from the right, the electrode is forced to negotiate a sharp angle or bend at the junction of the right subclavian and internal jugular veins, where the innominate vein is formed (**figure 9, B)**. This acute angulation can make the manipulation of the pacemaker electrode difficult when a curved stylet is fully inserted. Another anatomic pitfall occurs when there is a persistent left SVC, making passage to the heart from the left more difficult and, if there is no right SVC, makes passage from the right impossible ***(Netter, 1981).***

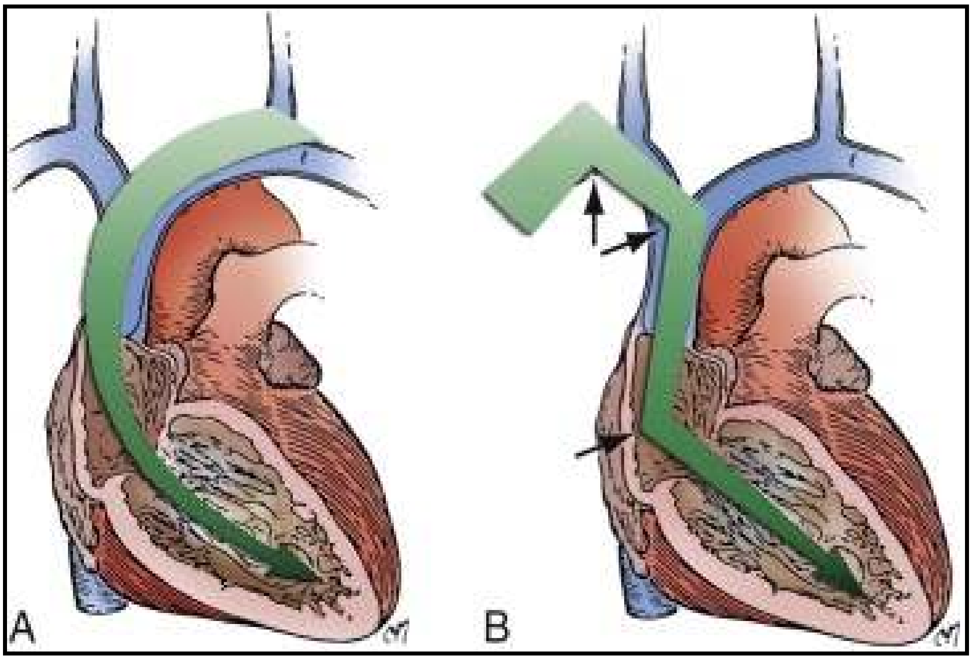

Figure (9): A, Smooth course of a lead entering from the left side. **B**, Acute angulation of the lead course when the lead enters the venous system from the right ***(Netter, 1981).***