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Cardiac Pacemaker: A Cadaveric Case Report

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Abstract:

Introduction: The Patients whose hearts beat is too slowly or too quickly may benefit from artificial cardiac pacemakers. In recent years, the utilization of this medical technology has grown. To perform the surgery, a solid understanding of anatomy is required. **Materials and Method**: A cardiac pacemaker was observed during routine dissection of a male cadaver. The pulse generator was present in the right infraclavicular region. Leads were tracked till it pierced the wall of a vein. Thoracotomy was done and the heart was removed with the pacemaker in-situ. Composite structure was radiographed to ascertain the position of the tip of leads followed by dissection. **Observation:** Leads entered the right subclavian vein, traversed through right brachiocephalic trunk, superior vena cava, right atrium and finally the tip resting in the right ventricle. **Discussion:** A pacemaker retrieved from cadaver can be reused. Non-removal of pacemaker before cremation can cause bursting of the equipment and a major catastrophe. **Conclusion:** A thorough knowledge of anatomy is necessary for a successful implantation. **Key words**: Pacemaker, cadaver, clinical anatomy, cardiovascular system.

Introduction

Electronic devices known as permanent cardiac pacemakers use insulated wire leads to deliver electrical impulses. The pulse generator has a lithium-iodide battery housed in a stainless-steel casing. Due to the short path of the right subclavian vein to the heart, the pulse generator is implanted beneath the skin of the infraclavicular area, primarily on the right side. The ventricular trabeculae, often of the right ventricle, are attached to the leads from the pulse generator. Demand type pacemakers are most frequently utilized for individuals whose heartbeats are either too sluggish or would stop beating entirely without electrical stimulation. Additionally, implantable cardio fibrillatory are used for patients whose heartbeats are too rapid. With the increasing use of this modern equipment in medical science, the students of anatomy need to be

equipped with the desired knowledge to understand the anatomical basis of emergency medicine and surgical procedures. Findings of medical equipment in cadaver assist us to learned anatomy with a realistic approach to the particular area of human body where the equipment is introduced and kept in situ. It is noteworthy that clinical anatomy makes the anatomy more interesting. The present case report, a pacemaker in cadaver, is used as a new perspective for clinical anatomy.

Materials and methods

During the routine abdominal dissection in the Department of Rachana Shareera, S.D.M College of Ayurveda Hassan. In a male cadaver of about 60 years, a pulse generator was discovered in the right pectoral region just below the clavicle. Leads from the pulse generator were tracked by meticulous dissection till a vein is pierced. Thoracotomy & hemi- section of sternum were done. Fibrous pericardium was incised and the heart removed with the pacemaker in-situ. The heart, along with pacemaker, was documented to ascertain the tip of the leads. Finally, the heart was dissected to expose the passage of the leads.

Observation / Cadaver with Pacemaker/ Case Study

Pulse generator was lodged inside a pouch of superficial fascia of right pectoral region just below the right clavicle (Fig 1). Two leads were observed inside the tissue pouch. Both the leads pierced the right subclavian vein adjacent to one another just above right first rib. To track the leads, the sternum was sawed and removed along with costal cartilages and was reflected upwards (Fig no. 2). The fibrous pericardium and the outer (parietal) layer of serous pericardium were incised vertically in line with superior vena cava. The heart with the pacemaker in-situ was removed along with the great vessels (Fig3,4).

After ascertaining the position of the leads, the anterior walls of the right atrium and ventricles were incised . It was observed that one of the leads ,after entering the right atrium of the heart was seen fixed at the level of Sino arterial node present in the junction between entry of Superior Vena cava and upper end of Crista terminalis (Fig5). Another lead was seen passing via Right Atrioventricular orifice into right ventricle and was seen fixed with Anterior papillary muscles and was related with moderator band and associated with Right bundle of His and Purkinje Fibres passing through Chordae Tendinae .(Fig 6&5)

Figure no.1

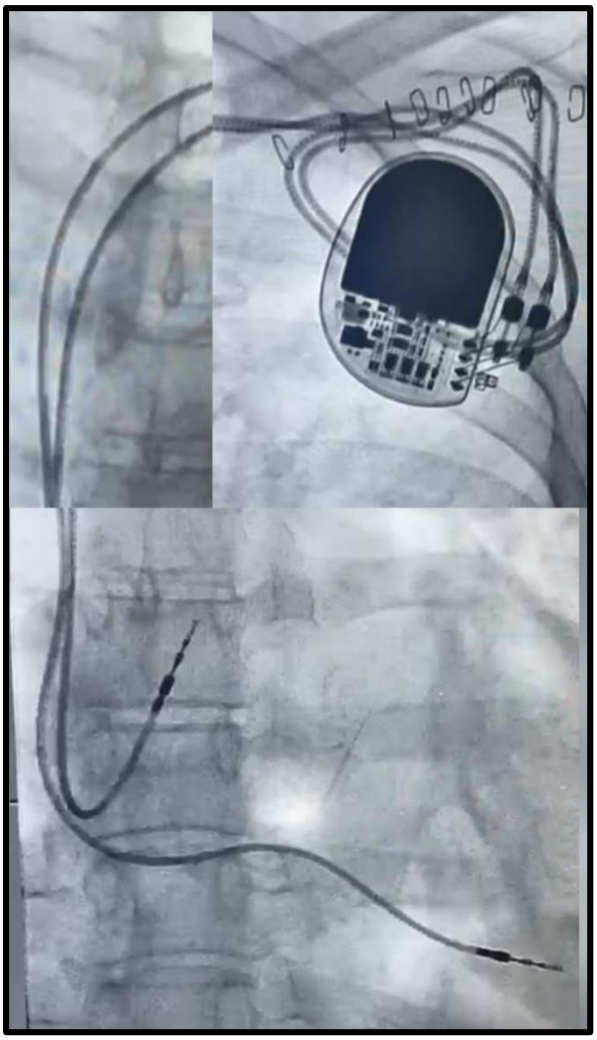
Figure no.2

Figure no.3

Figure no.4

Figure no.5

Figure no.6



X-ray image of a live person, whose heart beat was below 40 beats per minute. Here, the Pacemaker is introduced in left infraclavicular fossa, and the leads are passing through left subclavian, left brachiocephalic and then through superior vena cava. One lead is connecting with SA node and the other has entered the right ventricle and disconnected with moderator band.

Discussion

The Clinical anatomy is taught by citing examples, by showing photographs, illustrations or by medical images. The present trend to utilize clinical imaging to assist conceptualize anatomical structures, effectively transforms anatomy into a different entity. New imaging technologies like ultrasonography, 3D visualization, multiaxial computerized image reconstruction, multiplanar magnetic resonance imaging have improved our understanding of anatomical structural organization. In medical course, cadaver is the first patient and the study of anatomy is never fulfilling without it. Hands on cadaver teaching is the first step towards interpretation of 3D structural organization of body. In the present context of pacemaker in a cadaver, teaching of clinical anatomy can be embarked from the general anatomy of skin, superficial fascia, superficial vein, deep fascia, muscles, deep veins and artery and finally the anatomy of heart and its covering, thus completing the major portion of cardiovascular system in a short period of time. The procedure could be explained in the following way:

The importance of superficial fascia in the pectoral fascia is emphasized as it houses the pulse generator in a pocket created in the superficial fascia, which otherwise is a neglected structure in the dissection as a fatty layer. The deep fascia called the pectoral fascia of the region lies posterior to the equipment. The deltoid fascia lies laterally covering the deltoid muscles. The cephalic vein lies in the deltopectoral groove and pierces the clavipectoral fascia to drain into axillary vein.

This superficial vein is chosen by the cardiac surgeons[1] to introduce the leads or deep veins like subclavian vein.[2] Preference of right or left subclavian vein for introduction of lead depends upon the cardiothoracic surgeon. They opine that left subclavian vein is preferred because of a simpler anatomic position of the subclavian vein as well as easier organization of work in case only a cardiologist performs an operation without the help of a surgeon. However, in case of right-sided implantation of a cardiac pacemaker, the position of an electrode is in the form of letter “S”, which means that the electrode bends in two contralateral curves which are in contrast to left- sided implantation where the electrode has only one curve on its path from the generator to the peak of the heart. These two curves of the electrodes give better stability and fewer number of post-operative dislocations.3

In the present case, we observed introduction of leads in the right subclavian vein. This right-sided procedure, from anatomical point of view, would be easier and less time consuming because the right subclavian vein is shorter than the left subclavian vein. Subclavian veins are the continuation of axillary veins. They extend from the outer border of the first ribs of respective sides to the medial border of scalenus anterior, where they are joined by internal jugular vein to form the right and left brachiocephalic veins. It then unites with the right and left brachiocephalic vein to form the superior vena cava. The right subclavian vein is short compared to left subclavian vein and continue further as Right Brachiocephalic vein which is short compared to left Brachiocephalic vein and is in line with Superior Vena Cava.

While sawing the sternum, in the present case, the attachment of fibrous pericardium to the posterior surface of the sternum by the superior and inferior sterno pericardial ligament were observed.

Pericardium is the covering of the heart.[4]The attachment of the fibrous pericardium at the roots of great vessels was observed and its reflection as Visceral Pericardium along with its Pericardial Cavity was also observed in due context with the relations of leads and position. Upon opening of the chambers of the heart, orientation of the right heart, left heart, the valves chordae tendinea and trabeculae carnae were observed with special reference of Pacemaker and documented.

Importance of the trabeculae carnae in the present context is the trapping of the tip of the leads. The electrode tip of the non-functioning lead was found adherent to the endocardium. Old leads get adhered to the endocardium or myocardium hence posing a risk of injury and death if lead is extracted. Therefore, only the pulse generator is replaced or removed but the non-functioning electrode lead is not extracted. Normally, the life span of a pulse generator is 10 years. After this period the pulse generator is to be replaced by a new one, either of the previous company or another company.

Pacemakers are silver dollar sized battery- powered devices surgically implanted under the skin in the upper chest. Pacemakers fit in a surgically created pocket which may create slight visible bulge beneath the skin. It helps the heart beat in rhythm by sending electrical impulses to the heart. The heart has its own natural pacemaker called the SA node. The SA node is composed of specialised Cardiac cells that generate their own electrical impulse enabling the SA node to regulate the Heart's rhythm.

Cardiac excitation normally begins in the **sinoatrial (SA) node,** located in the right atrial wall just inferior and lateral to the opening of the superior vena cava. SA node cells do not have a stable resting potential. Rather, they repeatedly depolarize to threshold spontaneously. The spontaneous depolarization is a **pacemaker potential.**[5]

When the pacemaker potential reaches threshold, it triggers an action potential. Each action potential from the SA node propagates throughout both atria via gap junctions in the intercalated discs of atrial muscle fibers. Following the action potential, the atria contract. By conducting along atrial muscle fibers, the action potential reaches the **atrioventricular (AV) node,** located in the interatrial septum, just anterior to the opening of the coronary sinus. From the AV node, the action potential enters the **atrioventricular (AV) bundle** (also known as the **bundle of His**). This bundle is the only site where action potentials can conduct from the atria to the ventricles. (Elsewhere, the fibrous skeleton of the heart electrically insulates the atria from the (ventricles).[5]

After propagating along the AV bundle, the action potential enters both the **right** and **left bundle branches.** The bundle branches extend through the interventricular septum toward the apex of the heart. Finally, the large-diameter **Purkinje fibres** rapidly conduct the action potential beginning at the apex of the heart upward to the remainder of the ventricular myocardium. Then the ventricles contract, pushing the blood upward toward the semilunar valves.[5]

Who needs Pacemaker

- Bradycardia- When your Heart beats too slowly i.e less than 50 beats per minute with other symptoms like dizziness or fainting.
- Tachycardia- When your Heart beats too fast i.e more than 100 beats per minute at rest.
- Clinical condition like weakness of heart caused by Heart Attack, Heart Block, Heart failure etc.[6]

Types of Pacemaker

- **Single Chamber Pacemaker**- It sends the signals to either upper or lower chamber of the heart.
- **Dual Chamber Pacemaker**- It sends signals to both the upper and lower chambers of heart with the help of two leads respectively.
- **Biventricular Pacemaker**- This system paces both the lower heart chambers and is primarily for those with Heart failure.
- **Automated Implanted Cardioverter defibrillators**- AICDS combine a Pacemaker and a Defibrillator. The Defibrillator portion will provide a sudden jolt of electricity if the hearts rhythm becomes dangerous. "Defibrillators have pacing capacity, but not all pacemakers are defibrillators."[6]

How a Pacemaker Works

All the pacemaker contains a pulse generator, which is the battery component of a pacemaker. A pulse generator contains the electrical circuity and a lithium battery that creates the impulses that stimulate the heart. There are few options for the pacemaker system:

- **Transvenous -** Thin, flexible, wires called leads, are threaded through a vein into the heart. There , they deliver electrical impulses.
- **Epicardial -** These leads are attached to the outer surface of the Heart. This system is much less common less than the transvenous option.
- **Leadless -** This newer system is where the pacemaker can be implanted directly into the Heart. This system combines the pulse generator and electrodes into one.

Conclusion

The integration of clinical anatomy with cadaveric dissection provides an invaluable platform for bridging the gap between theoretical knowledge and clinical practice. In the present case of a cadaver with a cardiac pacemaker, the study journey began from the superficial anatomical layers and progressed to the deep internal cardiovascular structures, effectively covering a wide range of clinically relevant anatomy in a short duration. The presence of the pacemaker and leads offered a unique opportunity to understand the anatomical considerations involved in pacemaker implantation. The superficial fascia, often overlooked during routine dissection, gained clinical importance as the site for housing the pulse generator. The deltopectoral groove, housing the cephalic vein, demonstrated its practical relevance as a preferred site for venous access. Detailed examination of venous anatomy, especially the subclavian vein, underscored the surgeon's choice in selecting the optimal side for lead placement balancing ease of access, lead path configuration, and postoperative stability.

Furthermore, the dissection of the pericardium and heart emphasized the importance of structural relationships such as the sternopericardial ligaments**,** attachments at the roots of great vessels, and the organization of heart chambers and valves**.** Special emphasis on trabeculae carneae revealed their role in anchoring old pacemaker leads, explaining why such leads, once fibrotically adhered, are not extracted due to

the high risk of myocardial injury or fatal complications. This case study reinforces the importance of cadaver as a dynamic teaching tool in clinical anatomy. It not only provides spatial orientation and tactile experience, but also imparts a deeper understanding of procedural anatomy, clinical decision-making, and anatomical variations encountered during surgical interventions.

The use of such clinically embedded examples in dissection labs transforms traditional anatomical learning into an applied, patient-oriented, and diagnostically insightful process. In conclusion, the cadaver with a cardiac pacemaker serves as a model of integrated learning, blending gross anatomy with surgical relevance, imaging interpretation, and procedural understanding. It highlights the indispensable value of cadaver-based education in nurturing safe, competent, and anatomically informed healthcare professionals. The pacemaker implantation procedure depends completely on anatomical structure of the cardiovascular system hence a good knowledge is essential for a successful surgery. It is assumed that such cases of medical equipment in cadaver could be a new perspective for teaching clinical anatomy.

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