
Anatomical correlate of permanent cardiac pacemaker

S R Mishra*, P Sinha, K Sushobhana, R Singh, S Singh and J Passey

Department of Anatomy, G.S.V.M. Medical College, Kanpur, Uttar Pradesh, India

***Correspondence Info:**

Prof. S R Mishra

Professor,

Department of Anatomy,

G.S.V.M. Medical College, Kanpur

Uttar Pradesh, India

E-mail: dr.suniti@yahoo.co.in

Abstract

An incidental and interesting heart with artificial permanent cardiac pacemaker was seen in a cadaver during the routine dissection in the Anatomy department of GSVM Medical College, Kanpur, Uttar Pradesh, India. The case is reported for the academic interest of readers. Artificial Pacemaker is a device that provides electrical stimulation to cause cardiac contraction when intrinsic cardiac electrical activity is slow or absent. A pacemaker is composed of two parts, the pacing electrodes, or leads, which are wires that are inserted directly into the heart, and a pacemaker generator.

In the cadaver the pacemaker was implanted subcutaneously in the right Pectoral region inferior to the Clavicle. The lead was inserted into the heart through the Right Subclavian Vein. The terminal end of Lead was found in the apex of Right Ventricle. The size of the heart was measured with a vernier calliper. The cardiomegaly was found.

Keywords: Artificial Pacemaker, heart, Pacemaker, right atrium, Rt ventricle, SA Node

1.Introduction

During the past few years the cardiovascular disease has emerged as one of the leading cause of adult death. Arrhythmia is one of the cardiac diseases which can lead to cardiac failure and death. The heart beat is normally initiated by an electrical discharge from the sinoatrial node (SA node). Cardiac arrhythmia is a disturbance of the electrical rhythm of heart and may result in tachycardia or bradycardia. An artificial permanent cardiac pacemaker is indicated for cardiac pacing to prevent cardiac failure.

During the routine dissection in the dissection hall of the Anatomy department in GSVM Medical College, Kanpur, Uttar Pradesh, an artificial Permanent Cardiac Pacemaker implant was found in a male adult cadaver. The exact age of the cadaver was not known but appeared to be about 68-70 yrs.

Artificial pacemakers are electronic devices used primarily to control cardiac rate in patients in whom the intrinsic heart rate is inadequate for a normal life style. These devices automatically and rhythmically provide electrical impulses to stimulate the heart.[1] The Pacemakers stimulate cardiac

depolarization, sense intrinsic cardiac function and respond to increased metabolic demand by providing rate responsive pacing. Permanent cardiac pacing remains the only effective treatment for chronic, symptomatic bradycardia.[2] The late 1950's – early 1960's witnessed several important achievements in the field of cardiac pacing. Three landmark are the first battery-operated wearable pacemaker(1957), the first totally implantable pacemaker (1958) and the first long-term correction of heart block with a self-contained, implantable pacemaker (1960). These events had far-reaching consequences and opened up the field to the future. Pacemaker and lead technology continued to develop rapidly to make these devices reliable, automatic and flexible in the therapy they provide. The therapeutic end-point shifted from saving life to enhancing its quality and simplifying follow-up. Electrotherapy has become socially accepted and its indications are extending also to non-cardiac pathology: Parkinson's Disease, pain-control, drug delivery [3].

2. Case finding

In the cadaver the Pacemaker Generator was placed in right pectoral region in the subclavicular region. (Fig-1) The leads passed through right subclavian vein and Superior Venacava to the right atrium. The pericardial fat and epicardium were removed from the surface of the heart. The size of the heart was measured-

- Maximum transverse diameter in normal anatomical position.
- Maximum antero-posterior diameter in normal anatomical position
- Measurement from centre of base to apex (also called as heart height /heart length)

All the measurements (in cms) were taken with a stainless steel metric Vernier caliper with 0.1mm precision. On gross examination the heart was enlarged. The maximum Anteroposterior diameter in the normal anatomical position was 12.6 cm and the maximum transverse diameter was 9.7 cm. Measurement from centre of base to apex (also called as heart height /heart length) was 12.5 cm. The right side of heart was opened. In the dissection, the right atrium was opened from inferior venacaval opening to the tip of right atrial appendage. An incision was made along the anterior atrioventricular groove of the heart and was extended to the right ventricular apex. The lead was seen in Right atrium passing through the tricuspid valve into the right ventricle. Here the electrode was firmly fixed to the trabeculae carneae in the ventricular wall and placed in contact with the endocardium. The pacemaker was a single chamber type-SSI i.e single chamber paced, sensed and inhibited: VVI and consisted of only one lead which was inserted in Right ventricle.

The interatrial septum, the tricuspid valve and the interventricular septum were normal.

Figure 1: Permanent Cardiac Pacemaker generator inserted in Right subclavicular region



Figure 2: Permanent Cardiac Pacemaker generator with lead passing through Superior Venacava



Figure 3: Permanent Cardiac Pacemaker lead inserted at the apex of right ventricle



3. Discussion

In a normal heart the SA node is located at the junction of the superior vena cava with the Right atrium. The AV node is located in the right posterior portion of the interatrial septum. There are three bundle of atrial fibres that contain Purkinje type fibers and connect SA node to AV Node. AV node is normally the only conducting pathway between the atria and ventricles. It is continuous with the bundle of his, which gives off a left bundle branch at the top of the interventricular septum and continues as the right bundle branch. The left bundle branch divides into an anterior fascicle and a posterior fascicle. The branches and fascicle run subendocardially on either side of septum and come in contact to purkinje system whose fibres spread to all parts of the ventricular myocardium.[4]

SA Node controls the rate of contraction for the entire heart muscle because its cells have the quickest rate of spontaneous depolarization, thus they initiate action potentials the quickest. Cells in the SA node spontaneously depolarize, ultimately resulting in contraction, approximately 100 times per minute. This intrinsic rate is regulated by the autonomic nervous system so that the average resting cardiac rate in adult humans is about 70 beats per minute. Because the sinoatrial node is responsible for the rest of the heart's electrical activity, it is sometimes called the primary pacemaker. The cells of the AV node normally discharge at about 40-60 beats per minute, and are called the secondary pacemaker. Further down the electrical conducting system of the heart is the Bundle of His. The left and right branches of this bundle, and the Purkinje fibres, also produce a spontaneous action potential at a rate of 30-40 beats per minute, so if the SA and AV node both do not function these cells can become pacemakers. It is important to realize that these cells initiate action potentials and contraction at a much lower rate than the primary or secondary pacemaker cells. These results in cardiac arrhythmia, giving rise to premature ventricular contractions, also called ventricular escape beat.

In such cases of Atrioventricular conduction block an artificial permanent pacemaker is indicated. Permanent pacemakers are small, flat, metal devices that contain a battery, a pulse generator, and programmable electronics that allows adjustment of pacing and memory function. The pacing electrodes can be placed via subclavian or cephalic veins into the right ventricle (usually at the apex), the right atrial appendage or for AV sequential (dual chamber) pacing, both.[5]

Thus Artificial pacemakers, classified according to the number of chambers involved and their basic operating mechanism:

A. Single chamber pacemaker - In this type, only one pacing lead is placed into a chamber of the heart, either the atrium or the ventricle. Atrial pacing is appropriate for patients with sinoatrial disease without AV Block.

Ventricular Pacing is suitable for patients with continuous AF and bradycardia. Single Chamber -VVI lead lies in right ventricle. The electrode is indicated in AV conduction disease. The permanent pacemaker is indicated in Mobitz type II second or third degree AV heart block because of the risk of asystole and sudden death. Pacing improves prognosis.[5]

B. Dual chamber pacemaker - Here, wires are placed in two chambers of the heart. One lead paces the atrium and one paces the ventricle. This type more

closely resembles the natural pacing of the heart by assisting the heart in coordinating the function between the atria and ventricles, typically in pts with nonfibrillating atria and intact AV conduction.

C. Biventricular pacing (or cardiac resynchronization therapy) often utilizes a 3-lead pacemaker that stimulates both the septal and lateral walls of the left ventricle to contract simultaneously, as well as the right atrium to coordinate atrial and ventricular contractions.

In the present cadaver the ventricular pacing was evident. The lead was inserted at the apex of right ventricle. The various parts of the pacemaker, including the casing, microelectronics, and the leads, are all made with biocompatible materials. Typically, the casing of the pacemaker generator is made of titanium or a titanium alloy which holds the lithium batteries. The lead is also made of a metal alloy –titanium and it is insulated by a polymer such as polyurethane. The fixator mechanism which holds the tip of the lead fixed to the heart is made up of Nickel cobalt alloy. [6] The reliability of the leads of the entire pacemaker system is vital as the risks of failure include: loss of pacing due to the deterioration of the polymeric insulator in the physiological environment; thromboembolism due to inadequate blood compatibility of the insulator; tissue reactions at the electrode/tissue interface; general foreign body rejection phenomena; perforation of the leads; and excessive stress applied by sutures causing abrasion and stress cracking.[7]

On Gross examination there was cardiomegaly as compared to the previous studies.[8,9] The maximum Anteroposterior diameter was 12.6 cm as against the normal reported in an average adult human heart 6cm anteroposteriorly[8]. The maximum transeverse diameter was 9.7 cm as against the 8-9 cm as reported in previous studies[9]. Measurement from centre of base to apex (also called as heart height /heart length) was 12.5 cm which is slightly greater than the normal reported 12cm[8]. A single chamber pacemaker VVI was inserted in right ventricle. The interatrial septum, the tricuspid valve and the interventricular septum were normal. The case possibly had atrio-ventricular conduction defect. The arrhythmia resulted in cardiac failure and consequentially cardiac hypertrophy occurred as a compensatory mechanism in cardiac failure. The exact age of the cadaver was not known but appeared to be about 68-70 yrs. The insertion of artificial pacemaker might have facilitated him some longevity, yet death could have resulted from cardiac failure because of associated structural cardiac disease or as a result of some complication of

permanent pacing like pneumothorax, cardiac tamponade or infection.

Such incidental finding of a artificial cardiac pacemaker even in a cadaver is an indicator of the modern era of advancement in medical sciences indeed!

Acknowledgement

The study is not funded by any agency. We acknowledge our thanks to the working staff in the Dissection hall that have supported us in our study.

References

- [1] Das G, Carlblom D Artificial cardiac pacemakers, *Int J Clin Pharmacol Ther Toxicol*. 1990 May; 28(5):177-89.
- [2] Trohman RG, Kim MH, Pinski SL Cardiac pacing: the state of the art. *Lancet*. 2004 Nov 6-12; 364(9446):1701-19.
- [3] Aquilina O, A brief history of cardiac pacing, Images. *Paediatr Cardiol*. 2006 Apr-Jun; 8(2): 17-81.
- [4] Ganong William F., Origin of the Heart beat & the electrical activity of the heart Review of Medical Physiology, Appleton & Lange publication 17 edition 498-514.
- [5] Newby DE, Grubb NR, Bradbury A, Cardiovascular Disease Davidson's principles and practice of Medicine, Churchill Livingstone Elsevier publication, 21st Edition 2010:521-64.
- [6] Jeffrey K, Many Paths to the Pacemaker, Invention and technology, Spring 1997 pp 28-39.
- [7] Bruck SD, Mueller EP Materials aspects of implantable cardiac pacemaker leads. *Med Prog Technol*. 1988; 13(3):149-60.
- [8] Johnson D. Heart. In Standring S, Ellis H, Healy JC, Johnson D, Williams A, Collins P, et al editors. Gray's Anatomy. The Anatomical Basis of Clinical Practice. 39th ed. London: Elsevier Churchill Livingstone; 2005: 995-1027.
- [9] Garg S, Singh P, Sharma A, Gupta G. A gross comparative anatomical study of hearts in human cadavers and pigs. *Int J Med and Dent Sci* 2013; 2(2):170-176.

Competing interests: none declared

Conflict of interests: none declared