# Pacemakers-"An Infernal Machine that Interferes with the will of God"

The term "artificial pacemaker" was coined by Hyman in 1930s when he was experimenting with electrical stimulation to create cardiac mechanical activity using a needle electrode passed into a patient's right atrium through the intercostal space. He was accused of creating "an infernal machine that interferes with the will of God."[1] Dr Lillehei and colleagues at the University of Minnesota used insulated wire placed on the myocardium for post operative pacing using external alternating current power generators. However, a three hour power failure in Minneapolis caused tragic death of a baby who was pacing dependent.[1] Lillehei consulted Earl Bakken, an electrical engineer, for the development of a battery powered device to prevent such occurrences. He used transistors to create electrical impulse that could pace the heart instead of a speaker. He named his company as Medtronic.[2] The first fully implantable pacemaker was placed in 1960s by Senning and Elmqvist in a patient with Stokes-Adams syncopal attacks.[1,2] The patient underwent 20 pulse generator changes in his lifetime and outlived both surgeon and engineer.

Pacemaker, implantable cardioverter defibrillator, and resynchronization therapy are collectively named as cardiac implantable electronic devices (CIED). More than 1 million CIEDs are implanted every year. A basic understanding of CIEDs and their function, troubleshooting, and management at the time of surgery or radiological imaging are important for cardiac anesthesiologist to improve the standard of patient care.

Pacemakers are generally classified into single chamber, dual chamber, or multiple chambers (biventricular pacing). Pacing can be done using either unipolar or bipolar leads. The advantage of the bipolar lead is its reduced susceptibility to electromagnetic interference.[3] Single chamber pacemaker has only one lead designed to stimulate one chamber of the heart. Right atrial pacing is performed for sinus node dysfunction. However, since 3–5% of these patients eventually develop AV node dysfunction, majority of the pacemakers implanted are dual chamber pacemakers for this condition.[2] Isolated ventricular pacing is performed only in chronic atrial fibrillation with slow ventricular rate. So majority of the currently implanted pacemakers are dual chambered. That means, they have right atrial lead and right ventricular (RV) lead. In dual chamber mode, there is sequential depolarization of the RV, then the inter-ventricular septum, and lastly the lateral wall of the left ventricle (LV) gets activated. This creates a typical left bundle branch block pattern in ECG. Similarly, if LV is paced, it creates a right bundle branch block in ECG.

Early complications of pacemaker insertion include hematoma, seroma, and wound infection at pacemaker insertion site.[4] Other complications are related to transvenous pacing leads. This includes left sided pneumothorax, cardiac perforation, and lead malposition. Transvenous lead can be placed inadvertently into the arterial system or into the middle cardiac vein through the coronary sinus or into the LV through patent foramen ovale (PFO).[2] Post operatively, a lateral chest X-ray, oblique imaging with right anterior oblique or left anterior oblique imaging, echocardiography, or computerized tomography are helpful to confirm correct placement of lead. Right bundle branch morphology during pacing should alert the clinician about the possibility of LV lead. LV lead placement can occur through a PFO or by perforation of inter-ventricular septum. Rarely, a RV septal lead can also give rise to right bundle branch morphology.[5,6] LV lead left inside can lead to thromboembolic complication and mitral valve regurgitation. Severe mitral valve regurgitation occurs because of leaflet perforation or very rarely due to inflammation and fibrosis of sub-valvular apparatus. LV lead placed within two weeks can be easily removed. However, those left after one year is difficult to remove without surgery.[4] Long term anticoagulation is recommended in such cases if the patient does not have any obvious abnormalities of the mitral valve. In cases between two weeks and one year, recommendation is to treat the patient "case by case".[5]

At the time of cardiac surgery, it is important to reprogram the pacemaker to asynchronous mode (VOO), otherwise electromagnetic interference from diathermy may be sensed as own rhythm and the pulse generator may stop pacing.[3,7] If the patient is pacing dependent, it may lead to asystole. Newer generation pacemakers are MRI "conditional". That means, patients can be safely taken for MRI, but it is advised to interrogate the pacemaker after MRI protocol. Old generations of pacemakers (legacy system) are contraindications for MRI. However, many hospitals allow MRI with strict institutional protocol where the heart rate is continuously monitored for any electro-magnetic interference and asystole. Currently, almost all patients with legacy system are safely imaged at centers with such dedicated program and protocol.[2]

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