Pacemaker and Other Implantable Devices

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Introduction

In surgery settings, it is common to encounter patients with cardiac implantable electronic devices (CIEDs). These devices perform many functions, including bradycardia pacing, arrhythmias monitoring, cardiac resynchronization in case of heart failure, and defibrillation and anti-tachycardia pacing in case of tachyarrhythmias. CIEDs have been used for many years. During this time, the clinical efficacy has been proven in terms of improvement of quality of life and decrease of morbidity and mortality.

Although the devices available nowadays are complex, the vast majority of procedures can be safely performed in patients who carry them. Safe surgical planning requires familiarity with these devices. The anesthesiology must be aware of possible complications and be able to coordinate a multidisciplinary approach to ensure a safe management of patients with CIEDs during the perioperative period, in order to decrease the possibility of adverse events.

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Types of Cardiac Implantable Electronic Devices

Cardiac rhythm management devices include pacemakers (PM), implantable cardioverter defibrillators (ICDs), cardiac resynchronization devices (CRDs) and implantable loop recorders (ILR) Table 1.

Pacemakers

These devices produce and deliver electrical impulses to stimulate the heart. They are indicated in patients with different types of bradyarrhythmia. The permanent forms of bradyarrhythmia are caused by an intrinsic disease of the sinus node or AV conduction system. There is a strong consensus that patients with symptomatic sinus node disease will benefit from cardiac pacing for symptom relief. Also, permanent cardiac pacing is indicated in patients with third or second degree type 2 AV block to improve mortality.

Table 1 Types of cardiac implantable devices and their functions. CRT- P: Cardiac resynchronization therapy with pacing, CRT-D: Cardiac resynchronization therapy with defibrillator, S-ICD: Subcutaneous implantable cardioverter defibrillator

Device	Function	
Pacemaker	Bradycardia pacing Rhythm monitoring	Transvenous or leadless pacing
Defibrillator	Bradycardia pacing Defibrillation Antitachycardia pacing Rhythm monitoring	Fast pacing to terminate the arrhythmia (not in S-ICD) Shock delivery to restore normal heart rhythm
Cardiac resynchronization therapy	Cardiac resynchronization Bradycardia pacing (CRT-P/ CRT-D) Defibrillation (CRT-D) Rhythm monitoring	Biventricular pacing to improve systolic function in electrical desynchronize heart (wide QRS)
Implantable loop recorder	Rhythm monitoring (no therapies)	Detects bradycardia, pauses and tachycardia

Some patients may be entirely dependent on their PM and have no underlying rhythm, while others may only pace intermittently.

The chamber of the heart where the pacing electrodes sit may also vary from single lead in one chamber to three leads in cardiac resynchronization therapy (CRT).

Depending on the indication and the patient's underlying rhythm, the PM may be programmed in different ways. The nomenclature uses three to five letters. The first letter refers to the chamber paced (A—atrium, V—ventricle, D—dual), the second to the chamber sensed, and the third to the response to a sensed event (O—none, I—inhibit, T—trigger, D—dual). A fourth letter (R) is often used if the pacemaker has rate-modulation capability, whereby the PM increases the patient's heart rate with exercise. A fifth letter relates to the presence and location of multisite pacing.

By applying a magnet, pacemakers automatically reprogram in asynchronous mode of pacing (AOO, VOO, DOO), which means 'neglecting' impulses that are being sensed and deliver pacing at a programmed magnetic rate.

Defibrillators

They produce and provide fast pacing or shock to interrupt tachyarrhythmias.

These devices are indicated in prevention of sudden death due to malignant arrhythmias in populations at risk. The first detection mode is cardiac heart rate (instead cardiac frequency). However, they also have another screening method to classify cardiac arrhythmias in supraventricular or ventricular origin, such as stability of the rhythm, sudden onset of the episode and morphology comparable to normal QRS.

In the interrogation of the device, the programmed anti-tachycardia therapy, rhythm disorders presented by the patient, as well as the therapies received (whether appropriate or inappropriate), are evaluated.

Patients who receive a single shock should communicate with the cardiology service by telephone. In case of receiving multiple shocks, the scenario must be treated as a medical emergency. These patients must be admitted with access to an external defibrillator, being necessary to assess reversible causes such as metabolic or electrolyte abnormalities. Electrical storm is defined as the presence of 3 or more episodes of arrhythmias requiring the intervention of the device in a 24 h period. Ventricular arrhythmia storm leading to heart failure is the most frequent cause of multiple shocks.

Nevertheless, in some situations, the shocks are inappropriate. The most common causes of inappropriate shocks are supraventricular tachycardias, including atrial fibrillation. Another less frequent cause is complex detection other than QRS. Electromagnetic interference is also a reason for inappropriate therapies. In these cases, we can avoid therapies by approaching a magnet. The use of magnet in patients with ICDs inhibits the detection and therapy of ventricular arrhythmias

(antitachycardia and shock function), but does not inhibit the antibradycardia pacing function. However, most patients do not need pacing.

Loop Recorders

These devices only function is to monitor for cardiac arrhythmias. They are implanted as a diagnostic tool, but do not provide cardiac therapies.

Cardiac Devices Complications

Concerns regarding potential device-related complications should be discussed with the implanting physician Tables 2 and 3.

Cardiac Devices Malfunctions

When a patient carrying a CIED is attending the preanesthesia consultation, anesthesiologist should determine the likelihood of that symptoms being related to a device malfunction.

Undersensing

It occurs when the device cannot detect the intrinsic cardiac activity. The conditions that can cause this are ischemia, new branch block, hydroelectrolytic disorders,

Table 2 Pocket complications

Pocket complications	
Hematoma	It may be due to residual bleeding. More frequent in patients on treatment with antiplatelets or anticoagulants. 1 to 2% of cases require evacuation. Never perform needle puncture
Infection	It causes local inflammation and fluctuation. Can lead to endocarditis and sepsis. Prolonged antibiotic therapy and complete removal of the device may be required
Pacemaker migration	The main cause is the bad fixation of the device. It causes pain and can cause erosion, requiring surgical debridement and relocation. Syndrome of Twiddler: It is the rotation of the generator with possible displacement of the electrodes

Table 3 Electrodes complications

Electrodes complications	
Pneumothorax/ Hemothorax	It can manifest immediately or in the days following the implant. The symptoms consist of breathlessness, pain, and subcutaneous emphysema. The incidence is 1.6–2.6%. In severe cases a pleural drainage must be implanted
Venous thrombosis	Produced by venous endothelial injury, cause pain and inflammation of the ipsilateral arm. May also produce superior vena cava syndrome. Nevertheless, asymptomatic thrombosis is common. The ultrasound confirms the diagnosis and treatment is anticoagulation
Tricuspid insuficiency	Symptoms depend on the degree of valve failure. It is usually accompanied by right heart failure
Cardiac perforation	Pericardial commitment can occur during electrode placement, but also in days following the implant. Electrode implant in coronary sinus may cause cardiac perforation. The incorrect position of the lead is observed in the ECG as a right bundle branch block, since the stimulation takes place in the left ventricle. It may cause diaphragmatic stimulation

ventricular extrasystoles or supraventricular arrhythmias. Displacement or electrode rupture are also a possible cause for undersensing; however, these conditions are usually associated to capture problems too.

Oversensing

It is due to improper device inhibition. There are signals that should not be detected that can cause stimulation failures. The T wave, noise from electromagnetic fields or skeletal muscle activity can be misinterpreted as intrinsic activity, inhibiting the device stimulation function. Emergency treatment consists on the application of a magnet, this will set the device on asynchronous stimulation (stimulating at fixed heart rate). This maneuver should be performed on monitored patients.

Stimulation Failure

It may be due to the lack of stimulus generation or the inability to capture. The first case can be caused by damage or depletion of the battery of the generator. The second scenario occurs when the impulse is insufficient to effectively depolarize the myocardium. Cable displacement or rupture and cardiac perforation should be ruled out. Electrolyte abnormalities could also affect the threshold for capturing. PM dependent patients may require external temporal stimulation.

Pacemaker Mediated Tachycardia

PM-mediated tachycardia may occur secondary to a closed loop reentry produced in bicameral pacesmakers. The mechanism consist on the use of the electrode as an aterograde route and the normal electric system as a retrograde route.

It can be produced by a ventricular extrasystole, or by atrial over or under sensing. Retrograde P waves can be detected in the twelve leads electrocardiogram (ECG). Current devices have algorithms to prevent or terminate PM mediated tachycardia, a widely used option is the prolongation of the post atrial refractory period.

Pacemaker Syndrome

It is caused by the loss of atrioventricular synchrony. This syndrome is observed mostly in single-chamber PM. The atrial contraction is lost, hence, a decrease in cardiac output and blood pressure occur. Patients usually show signs of hypoperfusion (fatigue, confusion, headache, dyspnea, and syncope).

Electromagnetic Interference

The most frequent sources of interference are large magnets such as resonances, speakers, airport security arches. In the operating room, the surgical electrocautery unit and other electronic procedural equipment can behave as intraoperative electromagnetic interference (EMI). These may alter the stimulation, leading to an inhibition by oversensing. Permanent damage of the device is rare, although it may occur during exposure to high sources of energy, such as external defibrillation and electrocautery.

Surgical Planning

Before Surgery

The purpose of preoperative planning is to gather information on the CIED and patient conditions. The clinical and physical exam should include a review of vital signs, cardiovascular examination and the complete inspection of the implant area.

The ECG is the first diagnostic tool. On its analysis, the intrinsic rhythm, the position of the stimulation electrode and the correct functioning of the device can be assessed. The ECG of a patient carrying a CIED must be interpreted with caution,

since the new automatic pacemaker`s algorithms can be mistaken and identified as malfunction.

Radiologically we can determine which CIED type is implanted. On chest x-ray, ICD electrodes are clearly differentiated from PM electrodes by visible thickness, which corresponds to the high energy delivery part of the electrode.

In some cases, a complete interrogation of the device is mandatory. This is performed by the implant physician. It will give us crucial information, through the record of arrhythmias or malfunctions.

It is also necessary to determine the type, model, and manufacturer of the CIED, since each device has its own programmer. Usually, patients carry a card with identification and information regarding the device and electrodes. Some CIED even have telemonitoring, so the patient may have sent information through the website to the center where the implant was performed and subsequent monitored. Implant date, battery status, programming data and parameters of electrodes should be checked.

Immediate preoperative interrogations are not likely necessary in patients who are compliant with routine periodic interrogations by their pacemaker physician, nevertheless it is consider a good practice to do it (Table 4).

During Surgery

In addition to the usual care during surgery, there are a few specific requirements for patients with CIEDs. Continuous monitoring of heart rhythm and availability of external defibrillator with transcutaneous pacing and self-adhesive electrodes are essential. A magnet must also be available in the operating room.

Electromagnetic interference during surgery is frequent. The American Society of Anesthesiologist (ASA) Task Force states that electromagnetic interference could be minimized by different actions. These include positioning the cautery tool and current return pad away from the implant area; avoiding proximity of the cautery's

Table 4 Check list before surgery

Before surgery	
Patient interrogation and physical examination	Vital signs, cardiovascular exam, and implant area inspection
Check X-Ray and ECG	Normal positioning of device and cardiac rhythm assessment
Device type and brand, implant date and last follow-up	Information about device
Location of the device and surgery area	Possible interference surgery area—implant area
Type of the surgery	Emergency or programmed

Table 5 Check list during surgery

During surgery	
Pacemaker dependence	Does the patient still have intrinsic rhythm?
Arrhythmia density	Does the patient have arrhythmias and need therapy?
Electromagnetic interference	It is possible to minimizes electrical noises?

electrical field to the pulse generator and leads; using short, intermittent, and irregular bursts at the lowest feasible energy levels and using bipolar electrocautery whenever possible.

To prevent interferences during surgery, the behavior of a CIED can be temporarily altered with magnet application or permanently altered with a manufacturer-specific programming device.

Magnet application, apart from being simple and for most patients safe, it is also the preferred way of perioperative care, as it avoids repeated, incorrect, or incomplete reprogramming. This technique improves workflows in the perioperative period.

Absolute indications for CIED testing or reprogramming before surgery are suspicion of device malfunction, PM dependent patients with surgery performed in the area of the CIED (impossibility of magnet application) and patients with an ICD dependent on anti-bradycardia pacing (Table 5).

After Surgery

It is necessary to monitor patients until the function of the CIED is recovered. If the CIED has been reprogrammed preoperatively, monitoring is mandatory until new CIED testing and reprogramming to the previous mode is performed. If the CIED has not been reprogrammed, postoperative interrogation is indicated only in clinical situations where there is a suspicion that the device function may had been altered (Table 6).

Table 6 Check list after surgery

Afther surgery	
Check normal device function	If the CIED was reprogramed before surgery
Check ECG	Electrical normality

Conclusions

The recent advances in CIEDs function have greatly improved survival and the quality of life of patients. The preoperative assessment is mandatory to detect device complications or malfunctions. Surgical planning includes device last follow up and minimize of electrical interferences. With few exceptions, magnet application is the preferred way of perioperative care, as it avoids repeated, incorrect or incomplete reprogramming of the devices.

Recommended Readings

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