temporary epicardial pacemakers [created by Paul Young 05/01/08]

daily checks

1. assessment of underlying rhythm:
- The need for ongoing pacing should be regularly reassessed. This is best done by turning down the pacing rate and allowing the endogenous rhythm to appear.

2. test sensitivity:
- The 'sensitivity' (as numerically represented on the pacing generator) is the minimum current that the pacemaker is able to sense. A lower number thus corresponds to a greater sensitivity.
(i) the pacemaker rate should be set below the endogenous rate (if present), and placed in VVI, AAI or DDD modes.
(ii) sensitivity number is increased (making the pacemaker less sensitive) until the sense indicator stops flashing.
(iii) Pacing should then occur asynchronously in the chamber being tested.
(iv) Sensitivity number is then turned down (making the pacemaker more sensitive) until the sense indicator flashes with each endogenous depolarisation (in time with the P or R wave on the surface ECG). The number at which this first occurs is the pacing threshold.
(v) Most institutional protocols recommend leaving the pacing generator set at half the pacing threshold, to allow for detection of abnormally small signals, and for the possibility that perilead fibrosis over the course of the day will reduce the current transmitted to the pacemaker
NB: If there is no endogenous rhythm, it is impossible to determine the pacemaker sensitivity, in which case the sensitivity is typically set to 2 mV.

3. test the capture threshold:
- The capture threshold is the minimum pacemaker output required to stimulate an action potential in the myocardium. The capture threshold should not be checked if there is no underlying rhythm (which will have been established in the first step of these checks), for fear of losing and not being able to regain capture.
(i) If it is safe to check the pacing threshold, the pacemaker rate should be set above the patient's endogenous rate, such that the chamber of interest is being consistently paced
(ii) The pacemaker energy output is then reduced until a QRS complex no longer follows each pacing spike. This is the capture threshold.
(iv) Typically, the output is left at twice the threshold, again to allow a margin of safety. However, if the threshold is > 10 mA, the margin of safety is set to a lesser value, so as not to accelerate fibrosis at the lead / myocardium interface.

commonly used models

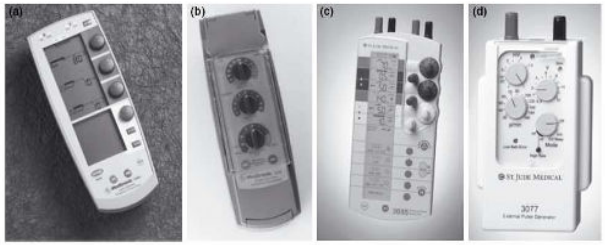

Figure 3 Commonly used temporary pulse generators. (a) Medtronic model 5388 (Medtronic, Minneapolis, MN, USA), (b) Medtronic model 5348 (Medtronic). St Jude models 3085 (c) and 3077 (d) (St Jude Medical, Sylmar, CA, USA). Photographs provided by St Jude Medical and Medtronic.

removal of wires

- Pacing wires should be removed only after therapeutic heparin has been discontinued and before warfarin is commenced.
- They are removed by constant gentle traction, allowing the motion of the heart to assist dislodgement from the epicardial surface. Excessive traction should not be applied: occasionally the wires are caught by a tight suture either in the epicardium or somewhere along their course through the chest. In this case they should be pulled as far as is felt safe, and cut as close to the skin as possible. This will allow the cut ends to retract. There is no evidence that wires left like this have any adverse effect.

- Complications of wire removal include:
(i) tamponade (ii) rhythm disturbance (iii) disruption of anastamoses

special circumstances

MRI:
- MRI involves the application of both magnetic fields and radiofrequency pulses. A temporary pulse generator contains too much ferrous material to be allowed into the magnetic field with the patient. MRI is therefore not possible in a patient dependent on temporary epicardial pacing. Whether a patient with epicardial wires in place, which are not being used, may have an MRI scan is more controversial.

IABP:
- If the IABP is timed according to a cardiac monitor with the high frequency filter disabled (to allow pacing spikes to become visible), the spikes may be misinterpreted by the IABP as QRS complexes. In the case of isolated ventricular pacing, the adverse effect of this small timing difference can be easily overcome by manual adjustment of the IABP timing parameters. However, if both atrial and ventricular spikes are misread as two QRS complexes, this will not be possible to correct. Either the IABP should be timed according to the arterial pulse, or the high frequency filter applied. This problem is lessened with bipolar leads, which have a smaller ECG representation than unipolar leads.

indications

Conduction abnormality
Prolonged AV delay (common after cardiac surgery; artificially shortening this using AV sequential pacing may improve mechanical coupling between the atria and ventricles)
AV block: third degree, or type II second degree
During the insertion of a pulmonary artery catheter in a patient with left bundle branch block (although this is noted to be controversial)
Bifasicular block with first degree block
New onset bifasicular block (indicative of active ischaemia)
Prolonged QT syndrome in the presence of significant bradycardia (to prevent torsades de pointes)
Tachycardia
AV junctional tachycardia (common after cardiopulmonary bypass): may be terminated by a brief period of pacing, which can then be discontinued
To terminate re entrant SVT or VT
Type I atrial flutter (rate < 320–340 beats.min^{-1})
Prophylactic
Bradycardia-dependent ventricular tachycardia
Prophylaxis of atrial fibrillation
Other
Sinus bradycardia (as an alternative to pharmacologic treatment)
To restore AV mechanical synchrony in underlying third degree block, AV junctional or ventricular rhythms
Hypertrophic obstructive cardiomyopathy (in particular if effective in reducing systolic anterior motion of the anterior mitral leaflet)
Following heart transplantation

epicardial pacing wires

Unipolar:
- A unipolar system consists of a single wire (the negative anode) attached to the epicardium, with the positive electrode attached at a distance in the subcutaneous tissues.

Bipolar:
- Bipolar system involves a single wire with two conductors insulated from one another, which both run to the epicardial surface.
- As the current must travel a much shorter distance between electrode tips, the electrical potential required to bring the myocardium to threshold is less than in the unipolar system.
- This makes bipolar electrodes more suitable for use in dual chamber applications, as the likelihood of between chamber interference is less when smaller potential differences are applied.
- Epicardial wires are also used by pacemakers to sense endogenous electrical activity. The smaller current path of bipolar electrodes makes them less susceptible to electrical interference when performing the sensing function.
- The larger current in a unipolar system creates much larger pacing spikes on the surface ECG.
- As bipolar electrodes require less energy to begin with, they may have a greater longevity in pacing compared to a unipolar system

- wire connected to the negative terminal of the pulse generator is epicardial for unipolar and distal epicardial for bipolar

typical settings

Atrial and ventricular output	10 mA or V (10–20 mA or 10–20 V)
PR interval/AV delay	150 ms (20–300 ms) or 'auto', determined by rate
Lower rate limit ('rate')	40 (backup); 80–100 (pacing)
Atrial overdrive stimulation	up to 800 ppm
Atrial sensitivity	5 mV (0.4–10 mV)
Ventricular sensitivity	5 mV (0.8–20 mV)
PVARP	250 ms or 'auto', determined by rate

complications

(i) infection,
(ii) myocardial damage,
(iii) perforation,
(iv) tamponade, and
(v) disruption of coronary anastomoses
(vi) undersensing, oversensing, failure to capture, unstable lead position

diagnostic use

- atrial pacemaker wires can be used to create an atrial electrogram
- the atrial electrogram may be the best method of differentiating atrial and junctional arrhythmias, and in defining the nature of an AV block.
- On many modern ECG recorders, there are three leads made specifically for this purpose: two for the bipolar atrial wires and a third for a skin electrode on the patient's flank. When the AEG channel is set to lead I, the potential between the tips of the two atrial electrodes is recorded (a 'bipolar' recording). This shows a large deflection with atrial depolarisation, but almost no signal with ventricular depolarisation.
- When set to lead II or III, the potential between one of the wires and the skin electrode is recorded (a 'unipolar' recording). In comparison to the bipolar recording, a larger ventricular signal is recorded.
- Alternatively, on an ECG machine without specific AEG leads, the connectors that usually go to the right and left arm leads can instead be attached to the bipolar atrial pacing wires. In this arrangement, a bipolar AEG will be similarly recorded in lead I, and a unipolar AEG in leads II or III.