Clinical Applications of Permanent Cardiac Pacemakers
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Review of the Conduction System:
Comprised of 3 main structures:
- SA node: situated in lateral wall of right atrium
  - responsible for the heart’s intrinsic rate, as well as rate response to
    various stimuli, this is the heart’s natural pacemaker
- AV node: near the crux of the heart, separating atria from ventricles
  - conduction is momentarily slowed here, to allow completion of atrial
    contraction, and to prevent non-physiologic rapid ventricular rates
- His bundle and Purkinje system (right and left bundles): disperses electrical signal rapidly to all segments to the ventricles to allow synchronized contractility

- Block or dysfunction may occur at any of these sites
- SA nodal dysfunction associated with both slow rates, ie. Sinus bradycardia, sinus arrest, etc or atrial tachydysrhythmias, ie. Intermittent atrial fibrillation in combination with sinus bradyarrhythmias (brady-tachy syndrome)
- AV nodal dysfunction is comprised of the following:
  - 1° Block: stable prolongation of the PR interval due to slowed conduction through the AV node
  - 2° Block: intermittent non-conduction through the AV node
    - Mobitz Type I (Wenkebach): progressive lengthening of the PR interval until one P wave stimulus is not conducted through the AV node, resulting in a pause. Graded as number of P waves: number of QRS complexes, ie 2:1, 4:3 etc.
    - Mobitz Type II: usually normal PR interval with irregularly dropped QRS complexes. Level of block is below the AV node, ie. His bundle or below, and more likely leads to unpredictable complete heart block.
  - 3° Block: complete heart block; no relationship between P waves and QRS complexes, may be congenital or acquired, permanent pacemaker usually required in adults, unless transient and related to inferior myocardial infarctions

Symptoms suggesting need for pacing:
Symptomatic bradycardia is the commonest indication for pacing, with the block occurring at any site in the conduction system. Symptoms include fatigue, from diminished cardiac output or chronotropic incompetence, syncope or presyncope, angina, or congestive heart failure. Pre-renal insufficiency can be seen with severely reduced cardiac output. When palpitations are also present, brady-tachy syndrome or ventricular arrhythmias are suspected. Certain indications exist for pacemaker implantation in relatively asymptomatic individuals, due
to a high risk of future, unpredictable high grade heart block. Electrolytes and thyroid function should be routinely assessed prior to permanent pacemaker implantation of bradycardia.

**Pacemaker Nomenclature:**

There currently exists a 5 position code system for pacing nomenclature:

**Position I:** The first position reflects the chamber(s) paced. ‘A’ refers to the atrium; ‘V’ refers to the ventricle; and ‘D’ means dual chamber, ie. both atrium and ventricle

**Position II:** The second position reflects the chamber(s) sensed. Similar codes as position I, and ‘O’ for absence of sensing

**Position III:** The third position refers to the mode of sensing, or how the pacemaker responds to a sensed event. Output may be either inhibited (I), triggered (T), or both /dual (D). In response to a sensed event, ‘I’ indicates that a sensed event inhibits the output pulse and causes the pacemaker to recycle for one or more timing cycles. An even sensed in the atrium inhibits the atrial output but triggers a ventricular output, after a predetermined AV delay. This delay in the dual chamber mode between the sensed atrial event and the triggered ventricular output mimics the normal PR interval. If a native ventricular signal or R wave is sensed, it will inhibit the ventricular output.

**Position IV:** The fourth position of the code reflects rate modulation. ‘R’ in the fourth position indicates that the pacemaker has rate modulation and incorporates a sensor to control the heart rate independently of intrinsic electrical activity of the heart.

**Position V:** The fifth position specifies only the location or absence of multisite pacing and is infrequently used.

ie. ‘VVI’ pacemaker therefore paces the ventricle only, senses the ventricle only and is inhibited in the ventricle when it senses in the ventricle. A ‘DDDR’ pacemaker paced both atrium and ventricle, senses both, and may be inhibited or triggered on sensing depending on the sensing chamber; rate response is present.

**Indications of Pacing:**

Recurrent or persistent symptomatic bradycardia is the commonest Class I pacing indication. Frequent indications include chronotropic support when rate slowing or antiarrhythmic drugs are deemed necessary. Biventricular pacemakers pace the right ventricle from the RV apex, and the left ventricle through the coronary sinus and result in resynchronization of contractility which can be disturbed in the presence of a wide QRS complex, (eg. LBBB) and produces symptomatic improvement in heart failure patients and mortality reduction. Indications in the peri-infarct period also include persistent 2° or 3° block below the AV node, whether symptomatic or not, and transient 2° or 3° AV infranodal block with bundle branch block. The ultimate prognosis in patients with MI related heart block is determined by the amount of left ventricular dysfunction remaining after recovery. Certain neuromuscular disorders including myotonic dystrophy qualify for pacing in the presence of any AV block, due to the unpredictable development of high grade AV block or asystole.
Complications of Pacemakers:
   Early: Infection, pneumothorax, brachial plexus injury, lead dislodgement, pocket hematoma
   Late: Infection, pocket erosion, lead or pulse generator failure, pacemaker syndrome (2° to loss of AV synchrony in VVI systems), central vein occlusion. Most systems currently last approximately 10 years, before requiring battery replacement, generally under local anesthesia.

Questions your patients may have:
1. Can I use a microwave? Yes, today’s devices are not interfered with by kitchen appliances.
2. Can I use a cell phone? Small amounts of electromagnetic interference from cell phones may affect pacemaker function. Hold the phone with the opposite hand from the pacemaker, and avoid carrying the phone in a pocket over the pacemaker.
3. What about security and anti-theft devices? Generally safe, do not linger in the device. Patients who are pacemaker dependent may ask for alternate checks when the pacemaker sets off the metal detector in airports.
4. Can I weld? Generally safe if patients stays more than 2 feet from an electric welder, and wears insulated gloves.
5. Can I have an MRI? Still controversial, with most centres reluctant to perform MRI on pacemaker patients, but overall little risk.

References: