Pacemaker Syndrome and Pacemaker Complications

Synonym: AV dyssynchrony syndrome

This article deals with the complications of pacemakers, including pacemaker syndrome. Pacemakers are discussed further in the separate Pacemakers and Pacing, Inserting Temporary Pacemakers, and Implantable Cardioverter Defibrillators articles.

- Pacemakers provide electrical stimuli to cause cardiac contraction during periods when intrinsic cardiac electrical activity is inappropriately slow or absent.
- Pacing systems consist of a pulse generator and pacing leads.
- Pacemaker output generally stimulates the cavity of the right atrium and/or right ventricle (endocardial pacing). Alternatively, epicardial leads can be implanted surgically on to the heart's surface.

Epidemiology[^1]

- The rate of acute complications of pacemaker insertion is 4-5% and mostly related to operator experience.
- The incidence of late complications of permanent pacemakers has been reported as 2.7%.

Pacemaker complications[^2, 3]

- **Failure to output**: no pacing spike is present despite an indication to pace. This may be due to battery failure, lead fracture, a break in lead insulation, oversensing (inhibiting pacer output), poor lead connection at the take off from the pacer, and 'cross-talk' (ie a phenomenon seen when atrial output is sensed by a ventricular lead in a dual-chamber pacer).
- **Failure to capture**: pacing spike is not followed by either an atrial or a ventricular complex. This may be due to lead fracture, lead dislodgement, a break in lead insulation, an elevated pacing threshold, myocardial infarction at the lead tip, certain drugs (eg, flecainide), metabolic abnormalities (eg, hyperkalaemia, acidosis, alkalosis), cardiac perforation, poor lead connection at the take off from the generator, and improper amplitude or pulse width settings.
- **Oversensing**: pacer incorrectly senses electrical activity and is inhibited from correctly pacing. This may be due to muscular activity, particularly oversensing of the diaphragm or pectoralis muscles, electromagnetic interference, or lead insulation breakage.
- **Undersensing**: pacer incorrectly misses intrinsic depolarisation and paces despite intrinsic activity. This may be due to poor lead positioning, lead dislodgement, magnet application, low battery states, or myocardial infarction.
- **Pacemaker tachycardia**.
- **Pacemaker syndrome**: some patients with VVI pacemakers, especially with sinoatrial (SA) rather than atrioventricular (AV) disease, will show retrograde ventriculoatrial (VA) conduction during ventricular pacing which can cause fatigue, dizziness and hypotension. Pacemaker syndrome is associated with atrial cannon waves caused by simultaneous atrial and ventricular contractions. Replacement with a dual chamber is required.
- **Operative failures[^4]**:
  - Pneumothorax (may require chest drain).
  - Pericarditis.
  - Infection.
  - Haemothorax.
  - Air embolism.
  - Erosion of the pacer through the skin (rare - requires pacer replacement and systemic antibiotics).
  - Haematoma (may require drainage).
  - Lead dislodgement - usually occurs within two days following implantation of a permanent pacer and may be seen on chest radiography (if the lead is floating freely in the ventricle, malignant arrhythmias may develop).
  - Venous thrombosis - rare and usually presents as unilateral arm oedema.

Complications of temporary pacing

- **Immediate complications include**:
  - Ventricular tachycardia or fibrillation.
  - Arterial puncture.
  - Pneumothorax.
  - Brachial plexus injury.

- **Late complications include**:
  - Ventricular arrhythmias.
  - Septicaemia (especially staphylococcal infection).
  - Wrong position requiring repositioning.
Investigations\textsuperscript{[1, 3]}

- Blood tests: electrolytes, coagulation screen, digoxin levels if appropriate, myocardial injury markers - eg, troponins (may indicate recent myocardial infarction but may also indicate perforation)\textsuperscript{[6]}
- 12-lead ECG - any sign of myocardial ischaemia, arrhythmias or abnormal sensing.
- CXR: evaluate lead position and look for lead fracture. A CXR can be used to identify the pacemaker model, as most pacemakers have an X-ray code which is visible on a standard CXR.
- Echocardiogram: to assess for lead position, pericardial effusion or tamponade, or lead fracture.
- Pacemaker assessment:
  - Review triggering thresholds, lead impedance, and battery function. Some brands may have stored electrocardiograms.
  - Magnet application:
    - This will result in asynchronous pacing mode and can reveal loss of capture and battery depletion.
  - Telemetry monitoring:
    - Usually useful in the early post-implant period; can reveal loss of capture.
  - Transtelephonic monitoring:
    - As devices become more reliable and battery life increases, monitoring by telephone is becoming increasingly rare\textsuperscript{[6]}.
  - Imaging:
    - To evaluate lead fracture - fluoroscopy is the gold standard, but ultrasound may be used if unavailable.

Pacemaker syndrome\textsuperscript{[7]}

Pacemaker syndrome refers to the occurrence of symptoms relating to the loss of AV synchrony in patients with a pacemaker, ie the atria contract at the same time as paced ventricular contractions. The result is decreased cardiac output in response to which the total peripheral resistance will increase. But not all patients exhibit a rise in blood pressure and indeed some will have a drop in their blood pressure.

In 1994 Furman redefined pacemaker syndrome as\textsuperscript{[8]}:

- Loss of AV synchrony.
- Retrograde VA conduction.
- Absence of rate response to physiological need.

The incidence of pacemaker syndrome has been estimated to range from 5% (symptoms severe enough to warrant pacemaker revision) to 80% (mild to moderately severe symptoms). Asymptomatic pacemaker syndrome is probably common and the true incidence of pacemaker syndrome much higher.

Risk factors

- Sick sinus syndrome as have preserved AV conduction\textsuperscript{[9]}.
- Single-chamber ventricular pacing\textsuperscript{[10]}.

Presentation of pacemaker syndrome

- Symptoms can vary considerably and also vary in severity.
- Symptoms include pulsation and fullness in the neck, dizziness, palpitations, fatigue, light-headedness and syncope.
- Symptoms and signs of heart failure may occur.
- Signs include hypotension, tachycardia, tachypnoea, raised JVP and cannon waves.
- There may be variations in pulses and fluctuating blood pressure - a drop of 20 mm Hg or more during ventricular pacing compared with that during atrial or AV synchronous pacing is suggestive.

Differential diagnosis

- Pseudopacemaker syndrome - AV dyssynchrony may also occur without a pacemaker - eg, severe first-degree AV block, and hypertrophic cardiomyopathy with complete AV block.
- Other causes to consider - pacemaker malfunction, worsening heart failure, iatrogenic, and autonomic dysfunction.

Management

- In patients with other pacing modes, symptoms usually resolve after upgrading the pacemaker to a dual-chamber pacing system or reprogramming the pacemaker parameters - eg, AV delay, post-ventricular atrial refractory period, sensing level, and pacing threshold voltage.
- Medical therapy has a limited role but electrolyte abnormalities may need to be corrected and the medication regime should be reviewed and adjusted as needed.

Prevention\textsuperscript{[11]}

- Use atrial pacing rather than ventricular.
Use of dual-chamber pacing with long AV interval (provided marked first-degree AV block is not present).

Control AV delay, to achieve physiological timing of atrial and ventricular contractions.

Prognosis
Once the pacemaker has been optimised as above the symptoms resolve fully.

Further reading & references

- ACC/AHA/NCMP Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices; American College of Cardiology/American Heart Association/North American Society for Pacing and Electrophysiology, 2002
- Iqbal A et al; Pacemaker Syndrome, 2019
- Lazar S et al; Pacemaker and ICD Troubleshooting, 2016

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