First transistorized, wearable, battery-powered pacemaker.
The Pacemaker System

- Patient
- Lead
- Pacemaker
- Programmer

Acute Complications of Pacemaker Implantation

- **Venous access**
  - Pneumothorax, hemothorax
  - Air embolism
  - Perforation of central vein
  - Inadvertent arterial entry

- **Lead placement**
  - Brady – tachyarrhythmia
  - Perforation of heart, vein
  - Damage to heart valve

- **Generator**
  - Pocket hematoma
  - Improper or inadequate connection of lead

Myocardial perforation.

Aguilera A L et al. Radiographics 2011;31:1669-1682

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Cardiac perforation:

- Less than 1% of insertions.
- Consider if:
  - New RBBB
  - Hiccups or intercostal movements
  - Pericardial friction rub
  - Prickarditis, effusion, tamponade.

Delayed Complications of Pacemaker Therapy

- Lead-related
  - Thrombosis/embolization
  - SVC obstruction
  - Lead dislodgement
  - Infection
  - Lead failure
  - Perforation, pericarditis

- Generator-related
  - Pain
  - Erosion, infection
  - Migration
  - Damage from radiation, electric shock

- Patient-related
  - Twiddler syndrome
Lead Connection

Twiddler syndrome
Pacemaker Follow-up

GOAL OF FOLLOW-UP
- Verify appropriate pacemaker operation
- Optimize pacemaker functions
- Document findings, changes and final settings in order to provide appropriate patient management

Dual Chamber Pacemaker
Pacemaker syndrome:

- Typically occurs in a patient with VVI pacing who develops symptoms as a result of loss of AV synchrony.

- Most common presenting complaints are vague symptoms of SOB, dizziness, fatigue, orthopnea and confusion. Also palpitations, pulsations or fullness in neck or abdomen.
Pacemaker syndrome

- Complaints related not only to loss of atrial kick, but also to complex alterations in autonomic function, effects of atrial loading on atrial receptors and bioreceptors that alter vagal tone.

- 20% of patients get a mild form in the 1st month and adapt. 1/3 of these have severe symptoms.

Pacemaker Syndrome

Management

- 1/3 of patients adapt and symptoms resolve
- 1/3 require placement of a dual chamber pacer
- **Caution**: Symptoms of pacemaker syndrome are non-specific and the same as patients presenting with pacemaker malfunction.
Categories of pacemaker failure:

1) Failure to sense properly.
   - Undersense
   - Oversense

2) Failure to pace properly.
   - Output failure
   - Capture failure

Under sensing

Failure to sense properly

- The pacer will ignore any intrinsic rhythm and pace at a fixed rate.

- Example: A pacer spike occurring between the end of the QRS complex and the T wave.
Undersensing

- Pacemaker does not “see” the intrinsic beat, and therefore does not respond appropriately.

Intrinsic beat not sensed

Scheduled pace delivered

Undersensing:

- Failure to sense properly

Caused by:

- Lead displacement.
- AMI.
- Myocardial perforation.
- Electrolyte abnormality severe enough to widen the QRS and delay its upstroke.
- Lead or pacer failure (fibrosis, fracture, etc.)

No magnet needed - call EPS.
**Oversensing:**

- Pacemaker detects electrical complexes incorrectly as QRS complexes.
- Results in inhibition of pacemaker function and therefore usually underlying bradycardia.
Oversensing:

- Caused by:
  - Far field and crosstalk.
  - Electromagnetic interference.
  - Lead fracture.

- Can result in a pacemaker-mediated tachycardia.

Myopotential Sensing

*Braunwald's Heart Disease, 2005*
Failure to pace:

- Failure of pacer output:
  - Lead failure.
  - Generator failure.
  - Other

- Failure of pacer capture:
  - Lead failure

Failure of pacer output:

- Suspect failure of output if HR is below the pacer rate and no pacer activity is noted on the EKG.
Causes of failure of output:

- Lead failure:
  - Lead fracture.
  - Loose lead to generator

- Generator failure
  - Very rare - lithium battery.

- Oversensing.

Failure to capture:

- Inability of an appropriately discharged pacing spike to depolarize tissue.

- Causes:
  - Lead displacement.
  - AMI.
  - Myocardial perforation.
  - Lead or pacer failure (fibrosis, fracture, fails.)
  - Inappropriate programming.
Intermittent Loss of Ventricular Capture

Braunwald's Heart Disease, 2005
What's your diagnosis?

- CAVB
- VVI-R 2 years ago
What's your diagnosis?

- PPM insertion 2 weeks ago
- SOB

Answer

 DIAGNOSIS? MANAGEMENT?

 RETROGRADE P WAVES
What's your diagnosis?

ECG after insertion

Case #12

Answer

RBBB MORPHOLOGY

LEAD INSERTED IN CS vs PERFORATION
Pseudo Malfunctions

Magnet Operation

- Magnet application causes asynchronous pacing at a designated “magnet” rate
Upper Rate Behavior

- Pseudo-Wenckebach operation will cause a fluctuation in rate

- 2:1 block operation will cause a drastic drop in rate
Rate Responsive Pacing

- An accelerating or decelerating rate may be perceived as anomalous pacemaker behavior

![ECG waveform with VVIR 60/120][1]

Hysteresis

- Allows a lower rate between sensed events to occur; paced rate is higher

![ECG waveform with Lower Rate 70 ppm and Hysteresis Rate 50 ppm][2]
Rate Drop Response

- Delivers pacing at high rate when episodic drop in rate occurs
  - Pacing therapy indicated for patients with neurocardiogenic syncope

THANK YOU