CARDIAC RHYTHM DEVICES: PACEMAKERS, ILR, ICD, CRT:
WHAT'S OUT THERE AND WHAT SHOULD I KNOW?

William F. McIntyre MD FRCPC
Clinical and Research Fellow
McMaster University
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Disclosures

Faculty: William F McIntyre MD, FRCPC
Clinical and Research Fellow in Hearth Rhythm, McMaster University

Relationships with commercial interests:
• Not applicable

Potential for conflict(s) of interest:
• My income is derived in part from implantation of these devices
Mitigating Potential Bias

• All the recommendations involving clinical medicine are based on evidence that is accepted within the profession.
• All scientific research referred to, reported, or used is in the support or justification of patient care.
• Potential bias will be mitigated by presenting a full range of products that can be used in this therapeutic area.
Cardiac Devices and Pacemakers

- 3-5 M Worldwide
- 1 M Implanted Annually
- Allows normal Lifestyle
- Misunderstood?
Learning Objectives

By the end of this session, participants will be equipped to:

• Know the devices that are now available
• Know the indications for these devices
• Know what to be aware of for patients who have devices
Cardiac Devices

A. Permanent Pacemaker (PPM)
B. Implantable Cardioverter Defibrillator (ICD)
C. Cardiac Resynchronization Therapy (CRT)
D. Implantable Loop Recorder
A. Pacemakers
75 Year old male
Feeling fatigued x 1 month
Routine ECG is done

Which of the following is/are indications for a pacemaker?

A. Sinus bradycardia
B. First-degree AV Block
C. Second Degree AV Block, Wenckebach
D. Second Degree AV Block, Mobitz
E. Third Degree AV Block

Answer: D and E
75 Year old female
Faint (Syncope)
Routine ECG is done

Which of the following is/are indications for a pacemaker?
A. Sinus bradycardia
B. First-degree AV Block
C. Second Degree AV Block, Wenckebach
D. Second Degree AV Block, Mobitz
E. Third Degree AV Block

Answer: D and E, Possibly C
What are these rhythms?

2\textsuperscript{nd} Degree AV Block, Wenckebach (Mobitz 1)

PR Interval Prolongs, then a single P wave is dropped

Normal Physiology, Reassure (unless symptoms)

2\textsuperscript{nd} Degree AV Block, Mobitz 2

PR Interval Constant, then one or more P waves are dropped

200 ms 210 ms 216 ms Dropped

180 ms 180 ms Dropped

Pathologic, Refer

2017 Clinical Update
Which rhythms require pacing?

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Pacemaker?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus Bradycardia (&lt; 40 bpm)</td>
<td>Only if clear symptoms</td>
</tr>
<tr>
<td>First Degree AV Block</td>
<td>Rarely</td>
</tr>
<tr>
<td>Second Degree AV Block, Wenckebach</td>
<td>Only if syncope or clear symptoms</td>
</tr>
<tr>
<td>Second Degree AV Block, Mobitz</td>
<td>Almost always</td>
</tr>
<tr>
<td>Third Degree AV Block</td>
<td>Almost always</td>
</tr>
</tbody>
</table>

- Pauses in sinus rhythm >3s (while awake/active)
- Pauses in atrial fibrillation > 5s (while awake/active)
When is a pacemaker an emergency?

1. Persistent symptoms
2. Recurrent Syncope
3. Very long pauses (>10 s?)
4. Complete heart block with wide QRS (>130 ms)

If you are uncertain about urgency, your friendly on-call cardiologist/EP can help!
What does “dual chamber” pacemaker mean?

A. A lead in each of the ventricles
B. A lead in the atrium and the ventricle
C. The device has a pacing chamber and a shock (ICD) chamber
D. The leads are constructed with multiple coils to increase longevity

Answer: B
Dual Chamber Pacemaker

- One lead in the A and One in the V
- Used to maintain A-V synchrony
- Used *primarily* with heart block \((2^0/3^0)\)

Not to be confused with Bi-V pacemaker!
(Coming later in the talk)
<table>
<thead>
<tr>
<th>Category: Chamber(s) Paced</th>
<th>Position:</th>
<th>The Revised NASPE/BPEG Generic Code for Antibradycardia Pacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Chamber(s) Sensed</td>
<td>Chamber(s) Sensed</td>
</tr>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>T = Triggered</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td>I = Inhibited</td>
</tr>
<tr>
<td>D = Dual (A + V)</td>
<td>D = Dual (A + V)</td>
<td>D = Dual (A + V)</td>
</tr>
</tbody>
</table>
Simplified Version

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber Paced</td>
<td>Chamber Sensed</td>
<td>Response to Sense</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>O = None</td>
<td>O = None</td>
</tr>
<tr>
<td>D = Atrium and Ventricle</td>
<td>V = Ventricle</td>
<td>I = Inhibited</td>
</tr>
<tr>
<td></td>
<td>D = Atrium and Ventricle</td>
<td>D = Synchronizing</td>
</tr>
</tbody>
</table>
Common pacing modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOO</td>
<td>Asynchronous</td>
</tr>
<tr>
<td>VVI</td>
<td>Single-chamber in Ventricle</td>
</tr>
<tr>
<td>DDD</td>
<td>Dual Chamber Atrium and Ventricle</td>
</tr>
</tbody>
</table>
Device Surgery
What to expect:

- Usually same day procedure
- Therapeutic warfarin and anti-platelets can be continued, NOACs generally held
- No driving for 1 week (private), 4 weeks (commercial)
- Implant side elbow stays below shoulder for 4-6 weeks

Follow-up in device clinic: 1 week pacemaker, 2 weeks ICD
Device Surgery Complications

Incidence ~ 1%

- Bleeding
- Infection (↑ if Replacement)
- Pneumothorax
- Pericardial Effusion
- Radiation
- Need for Re-operation

NEVER Stick a needle in the pocket

Call the centre who put it in!
Device: Follow-Up

- 1-2 weeks
- 3 months
- Then Q6-12 mo
- Remote in some cases
- More frequent if problems
Does this Patient Have a Pacemaker?

Leadless Pacemaker

Used for:
- Venous access issues
  - Dialysis
  - Endocarditis
- The very young

Show and Tell Item!
Contra-Indications to MRI

1. Epicardial leads
2. Abandoned or capped leads
3. Remnants of leads
4. Fractured leads
5. Pacemaker dependence with non-MRI conditional device

*Practice varies between centres
Call the device clinic. Don’t assume it’s impossible
HIS PACEMAKER_keeps opening and shutting THE GARAGE DOOR.
Implantable Cardioverter Defibrillator (ICD)
Implantable Cardioverter Defibrillator (ICD)

- A Pacemaker with *Extra Features*
  - The ability to sense and treat arrhythmia

Every* ICD is a pacemaker!

Show and Tell Item!
ICD: Continuous Monitoring for VT/VF
75 Year old male
ICD in Place
Faints
Neither patient nor bystanders appreciated a “shock”

True or False:
Since there was no shock, the faint was not due to an arrhythmia.

Answer: False
25 Year old female
New ICD for Familial Syndrome
Long distance runner
Asks if she can still exercise

True or False:
The device should be able to tell the difference between healthy sinus tachycardia and lethal ventricular arrhythmia

Answer: True
How does an ICD Recognize and Treat Arrhythmia?

1. Counts Heart Rates (R-R) Intervals

2. When the perceived HR surpasses a programmed threshold, it will assess that rhythm and try to “diagnose it” using:
   a. The absolute rate
   b. The onset/offset
   c. Morphology (similar to sinus QRS)
   d. The regularity

3. Depending on programming it may:
   A. Just watch (monitor)
   B. Deliver therapy
      A. Antitachycardia Pacing (ATP)
      B. Shock(s)
What kind of things might “fool” an ICD into erroneously diagnosing and treating VF/VT?

- **SVT**
  - AFib/Flutter*, ATach, Sinus Tach
- **Electrical Noise**
  - Internal to device (lead #, loose screw)
  - From the body (muscle potentials)
  - Outside the body (arc welder, MRI, TENS Unit)

*Most Common
Indications for an ICD

• Secondary Prevention
  – Survivors of Sudden Cardiac Death (SCD)
  – High-Risk VT

• Not Due to a reversible cause
  – Acute ischemia
  – Drugs (long QT)
Indications for an ICD

- Primary Prevention
  - Systolic Dysfunction
    - Ischemic/Non-ischemic w/ LVEF < 30-35%
  - High-risk syndromes
    - Brugada
    - Hypertrophic Cardiomyopathy
    - Arrhythmogenic Right Ventricular Cardiomyopathy
    - Long QT
75 Year old female
ICD In Place, No Prior Shocks
Shock While Watching TV
Felt normal before the shock
Felt normal after the shock
Calls your primary care office to ask what to do:

A. Call 911
B. Have someone drive patient to nearest ER
C. Have someone drive patient to ER of tertiary hospital
D. Come in to your primary care office
E. Call the pacemaker/device clinic

Answer: Doesn’t necessarily have to be A
D is not useful
E is going to be the most efficient option
When is a (perceived) ICD Shock an emergency?

1. Patient is unwell
2. > 1 shock in a 24-hour period

If neither of the above is true, the patient can call their device clinic on the next business day

*If you are uncertain about urgency, your friendly on-call cardiologist/EP can help!
Things that could be mistaken for a shock:

1. Device alarms (usually vibration or beeping):
   • low battery
   • lead noise
   • change in circuit parameters (impedance, threshold)

2. Phantom Shocks
   • PTSD
# ICD: Driving Restrictions

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Private Driving</th>
<th>Commercial Driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>New $1^0$ Prevention ICD</td>
<td>4 Weeks</td>
<td>Disqualified</td>
</tr>
<tr>
<td>New $2^0$ Prevention ICD</td>
<td>6 Months</td>
<td>Disqualified</td>
</tr>
<tr>
<td>Syncope with VT/VF</td>
<td>6 Months</td>
<td>Disqualified</td>
</tr>
<tr>
<td>Appropriate Shock</td>
<td>6 Months</td>
<td>Disqualified</td>
</tr>
</tbody>
</table>
The Shrinking ICD
A new category of implantable defibrillators

Transvenous (TV) ICDs

- Provides effective defibrillation
- Provides Brady pacing
- Provides ATP for patients with incessant monomorphic VT
- Provides atrial diagnostics
- Familiar implant technique

Subcutaneous (S-ICD)

- Provides effective defibrillation
- No risk of vascular injury
- Low risk of systemic infection
- Preserves venous access
- Avoids risks associated w/ lead extraction
- Fluoroscopy not required

Show and Tell Item!

Inside of:
- Ribs
- Veins
- Heart

Outside of:
- Ribs
- Veins
- Heart
"Good news — those tiny voices I've been hearing are from my pacemaker."
C. Cardiac Resynchronization Therapy (CRT)  
a.k.a. Biventricular (Bi-V) Pacer
CRT: Electro-mechanical dys-synchrony in CHF

Bundle Branch Block

Electrical Dys-synchrony

Mechanical Dys-synchrony

2017 Clinical Update
Cardiac Resynchronization Therapy (CRT) aka Biventricular (BiV) Pacemaker:
- For Patients with Heart Failure
- Pacing Both Ventrices Optimizes Function
- Improves Mortality and Symptoms
- Usually Equipped with ICD function (CRT-D)
- Can be pacemaker only without ICD (CRT-P)
Optimal Candidates for CRT

• Symptomatic HF with >1 year life expectancy
• LV Ejection Fraction <35%
• QRS Duration > 130 ms
• Guideline-Directed Medical Therapy
• Left Bundle Branch Block (LBBB)
• Sinus Rhythm (versus AFib)
60 Year old female
Congestive Heart Failure
EF 29%, LBBB

What would constitute
“guideline-directed medical
therapy” prior to CRT/ICD?
(4 items)

A. ACE Inhibitor/ARB (to target dose)
B. Beta-blocker (to HR 60 or target dose)
C. Re-vascularized (if applicable)
D. 3 Month Re-assessment of EF
66 Year old Female
ICD In Place, Feeling Well
Known to have a Fractured Lead
To Rural ER after 12 shocks
Continues to receive shocks in ER

How can you stop the ICD from shocking her?

Put a magnet on the ICD!
Magnet on an ICD:
Disables Therapies (ATP/Shock)
No effect on pacing

What about a magnet on a pacemaker?
Asynchronous Pacing (VOO Mode)
Devices at End-Of Life

• Pacemaker
  Rarely of consequence unless dependent
• ICD
  Therapies can be programmed off or apply magnet
“It’s a pacemaker for your heart. Plus, you can download apps for your liver, kidneys, lungs, and pancreas!”
D. Implantable Loop Recorder (ILR)

- 3 grams
- 3 year battery life
- Remote Transmission

Show and Tell Item!
Implantable Loop Recorder (ILR)

• Continuous Monitoring
• Atrial Fibrillation Detection Algorithms

Clinical Applications (2):

• Recurrent Syncope with failure to achieve symptom-rhythm correlation
• AF Detection After Cryptogenic Stroke
Advanced Device Features

• Complete Heart Bullet Block

Sheppard et al, HRS 2009
Devices:
Recognizing X-Rays
Pacemaker, ICD, or Loop?
Pacemaker, ICD, or Loop?
Pacemaker, ICD or CRT?
Pacemaker, ICD, or Loop?
Pacemaker, ICD, or Loop?

Subcutaneous
Questions & Discussion

William F. McIntyre MD FRCPC
Clinical and Research Fellow
McMaster University
William.McIntyre@phri.ca
Cases

William F. McIntyre MD FRCPC
Clinical and Research Fellow
McMaster University
William.McIntyre@phri.ca
Which device (if any) do you suggest?

- 70 F. Stent 3 years ago for angina
- 3 episodes of syncope without prodrome
- Occurred over 3 months
- Echo: normal
- Holter: no arrhythmia, no symptoms reported
Which device (if any) do you suggest?

- 65 F. Healthy. No meds.
- Visits GP with 6 months of fatigue
- Bloodwork normal. ECG shown:
Which device (if any) do you suggest?

- 75 M. Healthy. No Meds
- GP Visit. No symptoms
- Routine ECG:
Which device (if any) do you suggest?

- 65 M. All the Cardiac Risk Factors
- Chest pain -> collapses in mall -> EMS Defib
- Cath Lab: STEMI, Successful Stent, EF 40%
Which device (if any) do you suggest?

- 55 F. Healthy. No Meds.
- Visits ER with Nausea/Retching/Chest Pain
- Extensive workup confirms viral gastroenteritis
- “A little dizzy” with the following telemetry:
Which device (if any) do you suggest?

- 80 F. Hypertension on HCTZ
- 4 “faints” in 3 months, occurring first thing in the AM getting out of bed
Which device (if any) do you suggest?

- 75 M. Healthy. No Meds
- GP Visit. No symptoms
- Routine ECG:
Which device (if any) do you suggest?

- 25 M. Sudden Cardiac Death
- Autopsy:
  Gene-positive Hypertrophic Cardiomyopathy
- His parents are your patients
Which device (if any) do you suggest?

- 65 M. Heart Failure (ischemic cardiomyopathy)
- Guideline-directed med therapy x 3 months
- Optimally Revascularized
- EF 30%
Which device (if any) do you suggest?

- 45 F. Healthy, No Meds
- Severe Palpitations and Pre-syncope.
- Given adenosine -> no effect!
- Cardioverted!
Which device (if any) do you suggest?

- 65 F. New diagnosis of HF. Non-ischemic.
- Taking ACEi, BB, Lasix
- EF 25%
Which device (if any) do you suggest?

• 75 F. Healthy. Faints twice without prodrome

• Normal EKG, normal echo
Which device (if any) do you suggest?

- 55 F. Healthy.
- Seen for dizziness
- Normal EKG, Normal echo
- 1.8 s pause on Holter. No Symptoms diarized:

03:42 AM
Which device (if any) do you suggest?

• 65 F. ICD
• ICD Clinic called her last week to say she had a “lead fracture alarm”. Visit next week.
• Receives 12 shocks at home
• More shocks in your ER.