Analysis the Post Implant Programming

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CIED Follow Up

• CIED implants need
  • regular and life-long follow-up check
  • appropriate programming to improve patient outcomes

• Device interrogation and clinical follow up should be done at the time of discharge and then at 1, 3 and 6 months.
Pacemaker components

Battery (Lithium iodide or Vanadium silver)
Lead (pacing impedance)
Pulse generator
  1. Output circuit
  2. Sensing circuit
  3. Timing circuit
  4. Rate adaptive sensor
  5. Modes and mode switching
Lead impedance

• High impedance (>2000 ohm)
  • Loose lead connection
  • Lead fracture

• Low impedance (<200 ohm)
  • Insulation break

• Single impedance value may be of little useful without previous values for comparison.

• It may reflect body-fluid retention
Pulse generator output circuit

Capture threshold or Pacing threshold: Minimum amount of energy required to constantly cause depolarization

High Pacemaker Output can cause
- Reduce longevity
- Diaphragmatic stimulation
- Muscle Stimulation in Unipolar pacemakers
- Patient may “feel” heart beat
Pulse generator output circuit - Failure to capture:

1. Lead dislodgement or perforation
2. Lead maturation (inflammation/fibrosis) (exit block)
3. Battery depletion
4. Circuit failure (coil fracture, insulation defect)
5. Inappropriate programming (low output/pulse width)
6. Pseudo malfunction (pacing during refractory period)
7. Functional non capture (oversensing).
8. Metabolic, drugs, cardiomyopathies
Pulse generator output circuit - Failure to capture:

<table>
<thead>
<tr>
<th>Drugs that increase capture threshold</th>
<th>Drugs that decrease capture threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amiodarone</td>
<td>Atropine</td>
</tr>
<tr>
<td>Flecainide</td>
<td>Epinephrine</td>
</tr>
<tr>
<td>Propafenone</td>
<td>Isoproterenol</td>
</tr>
<tr>
<td>Sotalol</td>
<td>corticosteroids</td>
</tr>
<tr>
<td>Procainamide</td>
<td></td>
</tr>
<tr>
<td>lidocaine</td>
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</tbody>
</table>
Pulse generator output circuit

-Failure to output:

Absence of pacing stimuli and hence no capture.

Causes
1. Pseudo malfunction - hysteresis, PMT termination, sleep rate
2. Over sensing - EMI; T P R over sensing; Myopotential/diaphragmatic; Cross talk
3. Open circuit - lead fracture, loose screw, incompatible lead.
4. Battery depletion
5. Recording artifact.
Pulse generator sensing circuit
-Undersensing:

Causes

1. Defect in signal production – scar /fibrosis following MI, ectopic, cardioversion/defibrillation, metabolic.
3. Defect in pacemaker – battery depletion, sensing circuit abnormalities, committed DVI.
Pulse generator sensing circuit - Oversensing:

Inappropriate inhibition as failure to pace

Causes

1. EMI
2. T, P, R over sensing.
3. Far field R wave sensing (atrial).
4. Cross talk
5. Myopotential (unipolar)
6. Make break signals
Pulse generator timing circuit

- Lower rate limit (LRL)
- Hysteresis rate
- Refractory and blanking periods
- Ventricular safety pacing interval
- Upper rate response
Pulse generator timing circuit
- Lower rate limit

<table>
<thead>
<tr>
<th>Condition</th>
<th>LRL (beats/mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrequent pauses</td>
<td>40-50</td>
</tr>
<tr>
<td>Chronic persistent bradycardia</td>
<td>60-70</td>
</tr>
<tr>
<td>Relative bradycardia detrimental (long QT)</td>
<td>70-80</td>
</tr>
<tr>
<td>Detrimental fast heart rates (angina)</td>
<td>50-60</td>
</tr>
<tr>
<td>VVI</td>
<td>60-70</td>
</tr>
</tbody>
</table>
Pulse generator timing circuit

-Hysteresis

- Hysteresis allows the rate to drop below the programmed pacing LRL

- Advantages of hysteresis:
  1. Encourages native rhythm – maintain AV sync in VVI, prolong battery life
  2. Prevent retrograde conduction – avoids pacemaker syndrome
Pulse generator timing circuit
- AV interval

• AV interval (AVI) – pacemaker equivalent of PR interval

• Sensed vs paced AVI – paced AVI is programmed at 125-200ms, sensed AV interval is programmed at 20-50ms shorter than paced.

• Dynamic/adaptive AV delay: shorter AVI with increase in heart rate, allow pacemaker to respond to exercise and have better hemodynamics.
Pulse generator timing circuit - AV interval

• Longer AVI:
  Good AV conduction – maintains AV synchrony, long battery life
  Achieved by following methods: Programming longer AVI, AV hysteresis, ventricular pacing reducing algorithm (MVP, RhythmIQ, VP suppression...)

• Shorter AVI:
  HOCM – RV apical pacing decreases HOCM gradient
  CRT – usually 80-120ms, for 100% ventricular pacing and optimize CO
Pulse generator timing circuit  
- AV interval

- To avoid detrimental effect of ventricular pacing, longer AV interval setting or ventricular pacing reducing algorithm was adopted.

- For SSS pts. with prolonged PR interval. longer AV delay >240ms could be harm, especially for LV dysfunction
  - AV dyssynchrony
  - Mitral regurgitation
  - Limit the URL
  - Decrease the atrial arrhythmia detection
  - Pacemaker Mediated Tachycardia
## Pulse generator timing circuit
- Refractory and blanking periods

<table>
<thead>
<tr>
<th>Blanking period</th>
<th>Time</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrial blanking period</td>
<td>50-100ms</td>
<td>Non programmable, Avoid atrial sensing of its own paced beat</td>
</tr>
<tr>
<td>Post ventricular atrial blanking period</td>
<td>220ms</td>
<td>Avoid sensing of ventricular beat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long PVAB decreases detection of AF,AFL</td>
</tr>
<tr>
<td>Ventricular blanking period</td>
<td>50-100ms</td>
<td>Non programmable, Avoid ventricular sensing of its paced beat</td>
</tr>
<tr>
<td>Post atrial ventricular blanking period</td>
<td>28ms</td>
<td>if the PAvB period is too long, R on T - ventricular tachyarrhythmia.</td>
</tr>
</tbody>
</table>
Pulse generator timing circuit - Refractory and blanking periods

<table>
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<tr>
<th>Refractory period</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular refractory period (VRP)</td>
<td>Prevent sensing of T wave.</td>
</tr>
<tr>
<td>Atrial refractory period (ARP)</td>
<td>AVI (120-200ms).</td>
</tr>
<tr>
<td>Post ventricular atrial refractory period</td>
<td>Avoid sensing retrograde P waves (PMT), far field R waves.</td>
</tr>
</tbody>
</table>

![Diagram showing A-V Interval (Atrial Refractory), Ventricular Refractory Period (VRP), AP, VP, and Post Ventricular Atrial Refractory Period (PVARP).](image-url)
Pacemaker mediated tachycardia
IMPACT OF RETROGRADE CONDUCTION IN CARDIAC PACING

HEMODYNAMIC DISADVANTAGE

PACEMAKER SYNDROME

ENDLESS LOOP TACHYCARDIA (ELT)

REPETITIVE NONREENTRANT VA SYNCHRONY (RNRVAS)

THE EVIL GENIUS RETROGRADE P WAVES

VA CONDUCTION
100-400 ms rarely longer
INFLUENCED BY AUTONOMIC FACTORS, DRUGS, etc.
MAY PROLONG WITH INCREASE IN HEART RATE
RARELY OCCURS ONLY ON EXERCISE

OCCURS IN:
70-80% of SSS pts
35% of AV block pts

MANIFESTATIONS OF SUSTAINED VA CONDUCTION

- Regular 1:1 VA conduction
- Regular or irregular 2:1, 3:1 VA conduction
- Regular Wenckebach phenomenon of VA conduction

A. J. Pinnacee
Pulse generator timing circuit
-Refractory and blanking periods

• Retrograde VA conduction should be checked during implantation and follow up

• If VA conduction present, PVARP was set as adding 50msec to retrograde VA interval measure.
Pulse generator rate responsive pacing

• Rate responsive pacing refer to ability of pacemaker to increase its lower rate in response to physiological stimulus

• Upper rate limit (URL) : important to prevent tracking of rapid atrial activity like in AF

• If intrinsic atrial rate exceeds URL then wenckebach or 2:1 AVB

• Rate smoothing: allows variation of R-R interval <6%

• Choosing URL : young patients (150b/mt) , old angina (<110b/mt)
Pulse generator modes switching

**DDD / VDD**
- Atrial tachyarrhythmias
  - Sensed atrial events
    - Trigger fast ventricular rates
      - Palpitations. Dyspnoea. And Fatigue.

**DDIR / VVIR**
Arrhythmia monitoring at device

• Silent AF detection is important for anticoagulation therapy
• Consider to start anticoagulation therapy, if device detected AF duration > 24 hours, by CHA2DS2-VASc score
• Anti-tachycardia therapy for AFL/Af was effective in MINERVA study.
Check the patient during interrogation

• Symptom
• Pocket hematoma
• Pocket infection
• Venous thrombosis
• Pacemaker syndrome
• Pacemaker mediated tachycardia
Conclusion

• Appropriate programming of CIED is required for CIED patients life-long.

• Understanding of basic concept and new algorithm of CIED is essential

• In real world, the importance of retrograde VA conduction is frequently neglected

• Optimal AV interval setting is necessary as regard to underlying cause of bradycardia and patient condition

• ICD and CRT programming is not presented here, but more complex and difficult.
Thank You