ECG interpretation of patients with CIED (cardiac implantable electronic device)

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흉부 X선 검사 이상은?
심전도 판독 결과는?

답) Pacemaker rhythm
Introduction

1. 심전도가 보여 주는 CIED의 정보

2. Overpacing (= Undersensing), Underpacing (= Oversensing), and Capture failure

3. Railroad track pattern = T wave oversensing?

4. CIED interrogation: ICD shock, ATP (anti-tachycardia pacing), PMT (pacemaker mediated tachycardia)
1. 심전도가 보여 주는 CIED의 정보

- 심박동기의 모드 (AAI, VVI, DDD, VDD, …)

(AEI: atrial escape interval, VEI: ventricular escape interval)
- Pacing이 들어가는 리드의 위치

(RVA: right ventricular apex, RVOT: right ventricular outflow tract, CRT: cardiac resynchronization therapy)
RVA pacing
RVOT pacing
CRT pacing
어디에서 페이싱할까요? LVOT?
2. Overpacing (= Undersensing), Underpacing (= Oversensing), and Capture failure

- Undersensing

- Oversensing

- Capture failure
CASES AND TRACES

Crushing Heartbreak

ECG CHALLENGE

A 58-year-old woman with a dual-chamber pacemaker presented to the emergency department for sudden dizziness and fatigue after lying down on her left side. On arrival, her heart rate was 45 beats/min, and her other vital signs were normal. Cardiac examination revealed a regular, bradycardic rhythm with an S1 of variable intensity. Cannon A waves were present on neck examination. Her pulse generator site had no evidence of infection. The pulmonary, vascular, and neurological examinations were normal. Her 12-lead ECG is shown in Figure 1. What pacemaker malfunctions are present?

Please turn the page to read the diagnosis.
Admission ECG
Annotated admission ECG.

PP and RR intervals have regular cycle lengths of 520 ms and 1280 ms, respectively (arrows). Ventricular pacing stimuli (stars) occur 160 ms after each P wave, irrespective of the presence of a native QRS.
Chest radiography

- This ECG shows underlying sinus rhythm with complete AV block and a dual-chamber pacemaker in DDD mode with an appropriately sensing right atrial lead and an **undersensing, noncapturing RV lead**.
3. Railroad track pattern = T wave oversensing? (Male, 59 years)

- **CC:** recurrent shocks for 10 times (onset: visiting day on clinic, July.2.2012)

- **PHx:** Insetion of ICD (screw type) for primary SCD prevention (June.13.2012)
  
  Echo: LVEF 28%, LVIDd 5.8cm, LVIDs 5.0cm, global hypokinesia

<table>
<thead>
<tr>
<th></th>
<th>Inserted day</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>11.7mV</td>
<td>&gt;12.0mV</td>
</tr>
<tr>
<td>Threshold</td>
<td>0.5V/0.5ms</td>
<td>1.0V/0.5ms</td>
</tr>
<tr>
<td>Impedance</td>
<td>570 Ohms</td>
<td>360 Ohms</td>
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</tbody>
</table>
Episode #1
## Features to minimize T-wave oversensing

<table>
<thead>
<tr>
<th>Concept</th>
<th>Algorithmic/T-wave Derivative</th>
<th>Altered Sensing Vector</th>
<th>Signal Filtering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONCEPT</strong></td>
<td>Differentiation of sense EGM enlarges R-wave to T-wave amplitude ratio</td>
<td>Integrated bipolar electrograms often have a larger R-T wave ratio</td>
<td>A high pass filter will remove more T-wave than R-wave energy</td>
</tr>
<tr>
<td><strong>BEFORE</strong></td>
<td><img src="image1" alt="RV tip to RV ring EGM" /></td>
<td><img src="image2" alt="RVtip-RVring" /></td>
<td><img src="image3" alt="Signal Filtering" /></td>
</tr>
<tr>
<td><strong>AFTER</strong></td>
<td><img src="image4" alt="Filtered &amp; Rectified EGM" /></td>
<td><img src="image5" alt="Differential EGM" /></td>
<td><img src="image6" alt="Signal Filtering" /></td>
</tr>
</tbody>
</table>
Assessment

• Every episode showed the same pattern (short-long R-R interval), which provoked 10 times of inappropriate shock.

• However, sensing, threshold, impedance was within normal range.

• We assessed the problem might be related with T-wave oversensing, then controlled sensitivity, decay delay, detection zone and detection interval of VF.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>0.5mV</td>
<td>1.0mV</td>
</tr>
<tr>
<td>Decay delay</td>
<td>60ms</td>
<td>125ms</td>
</tr>
<tr>
<td>VF detection</td>
<td>200bpm(300ms)</td>
<td>222bpm(270ms)</td>
</tr>
<tr>
<td>Detection interval</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>
After 1 day

- There was no shock event for 24hrs, so discharge was planned.
- However, shock was delivered again on his way home.
Analysis, again

- The same pattern.

- However,
  - relatively too short R-R interval about 180 ms
  - Stable state during bed rest, but event during moving.

(episode)                                      (supine position)
Compared with surface ECG

- T wave oversensing (X) -> P and R wave sensing (O)
- Why P wave ? -> Where is Chest X ray?
Railroad track pattern

- T wave oversensing
- R wave double counting
- Sinus tachycardia with 3:2 AV Wenchebach
- Far-field R wave sensing

(Circ Arrhythm Electrophysiol. 2014;7:1237-1261)
4. CIED interrogation: ICD shock, ATP, PMT

1) ICD shock
1) ICD shock
1) ICD shock
2) ATP (anti-tachycardia pacing)
3) Inappropriate ICD shock
4) PMT (pacemaker mediated tachycardia)
위아래 보다는 좌에서 우로 ... 경청해 주셔서 감사합니다. ^^