INTERPRETING THE ECG IN PATIENTS WITH PACEMAKERS

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Disclosures: None

BEFORE INTERPRETING THE ECG:

QUESTIONS FOR THE PATIENT WITH A PACEMAKER

• When was the original implant?
• Why was it done?
• Who did it AND WHERE?
• How many leads (wires)?
• Was there a generator change? Why?
• What is the device?
• Is there a defibrillator in also?
• Do you have your ID card?

- Get the original records!
- Call the 800 manufacturers' numbers for patient ID from their data base
- Call the rep!

EXAMINATION OF THE PATIENT WITH A PACEMAKER

• Superior vena caval syndrome?
• Fever? (Pacing systems are a source of endocarditis)
• Pericardial rub?
• Evidence of pericardial effusion?
• Pneumothorax?
• Diaphragmatic stimulation with pacing?
• Pocket stimulation with pacing?
• Hematoma?
• Ecchymosis?
SUPERIOR VENA CAVAL SYNDROME

EXAMINATION OF THE PACEMAKER POCKET

- Clean?
- Intact?
- Red?
- Swollen?
- Large hematoma?
- Draining?
- Extruded device

HEMATOMA FORMATION AT PULSE GENERATOR/ DUE TO ANTICOAGULANTS
MAGNET FUNCTION

- Eliminates sensing of the electrical signal
- Non-programmable
- May have a constant and short AV interval
- May have changing rates and AV intervals (e.g., 3 AV outputs at 100 with short AVI, followed by outputs at 85 with programmed AVI)
- MRI conditional pacemakers have different AV rates and intervals

KNOW THE MAGNET RESPONSES

We perform all ECGs as simultaneously recorded 12-leads as rhythm strips, both without and with magnet, so as to see spontaneous morphology and paced morphology in all 12 leads. This method can also identify fusion and pseudofusion complexes, as well as functional noncapture.

DEFINITIONS

CAPTURE: Depolarization of myocardium by a pacing stimulus

PACEMAKER NONCAPTURE: Failure of a pacing stimulus to depolarize myocardial tissue, provided that temporal opportunity is present

FUNCTIONAL NONCAPTURE: Failure of a pacing stimulus to depolarize myocardial tissue due to lack of temporal opportunity, e.g., when the tissue is refractory from a prior depolarization

SENSING: Sensing of an electrical signal from the lead in that chamber
- Normal intracardiac signal
- Muscle potentials
- Far-field signals
- Electromagnetic interference (e.g., Bovie, MRI)

INHIBITION OF OUTPUT: Inhibition of pacing stimulus delivery on sensing an intracardiac signal

TRIGGERED OUTPUT: A sensed signal causes a pacing stimulus output to occur
DEFINITIONS

UNDERSENSING: Sensing of electrical intracardiac signals does not occur

OVERSENSING: Sensing of unwanted signals

ELECTROCARDIOGRAM - WHAT TO IDENTIFY AND RECOGNIZE

• Perform with and without magnet (to assess magnet rate and to verify capture)
• Identify:
  - Intrinsic atrial and ventricular rhythm, rate and QRS complex morphology
  - Paced P wave and QRS complex morphology
  - Fusion complexes
  - Pseudofusion complexes (superposition of pacing stimulus on intrinsic complex without contributing to depolarization)

ELECTROCARDIOGRAM - WHAT TO IDENTIFY AND RECOGNIZE

• Pauses in paced rhythm (oversensing in single-chamber systems)
• Inappropriately early ventricular paced events (undersensing in single-chamber ventricular systems, inappropriate triggering of ventricular-paced events in dual-chamber systems due to oversensing in atrial channel)
• Appropriate early paced ventricular event due to APCs
• Changing paced rates due to rate response feature
• Rapid paced ventricular paced rates (triggered by AT, AF/FL/PMT)

STATES OF DDD PACING

• Spontaneous sinus rhythm – atrial and ventricular sensing confirmed; capture not seen
• AV sequential pacing – sensing not seen
• ApVs - atrial pacing (confirmed) with intact AV conduction and spontaneous QRS complexes (ventricular sensing confirmed; atrial sensing not seen, ventricular capture not seen)
• AsVp – Atrial sensing confirmed, ventricular capture confirmed (atrial pacing not seen, ventricular sensing not seen)
CONSIDERATIONS IN ASSESSING CAPTURE

- Is the pacing stimulus clearly visible on the recording equipment?
- Are apparent noncapture episodes confirmed by multiple ECG leads?
- Are true fusion and pure paced complexes clearly identified and distinguished from pseudo- and pseudopseudofusion complexes? (True fusion implies capture, whereas pseudofusion does not.)

AV PACING, VENTRICULAR PSEUDOFUSIONS

Neither V sensing nor pacing is confirmed
NOT ALL PACING STIMULI ARE VISIBLE

ATRIAL PACING, VENTRICULAR FUSIONS
CONFIRMATION OF VENTRICULAR CAPTURE

AVI 200 ms  V Fusions

AVI 125 ms  Pure V Paced

NOT ALL WIDE QRS COMPLEXES CAN BE ASSUMED TO BE PACED

CONSIDERATIONS IN ASSESSMENT CAPTURE - 2

• In DDD mode, where the ECG reveals AV function, loss of atrial capture is confirmed by the occurrence of ventricular paced events. If AV pacing is occurring but the ventricular complexes are fusions, loss of atrial capture is confirmed at the time of occurrence of pure paced ventricular complexes.

• In DDD mode, where AV pacing is occurring, loss of atrial capture can be inferred by the onset of retrograde P-waves.
CONSIDERATIONS IN ASSESSMENT CAPTURE - 3

Is there temporal opportunity for capture?
(Functional noncapture will occur if myocardial tissue is refractory during the stimulus delivery)

“FUNCTIONAL” NONCAPTURE

EVALUATION OF SENSING FUNCTION

- Rate program to low rate to see spontaneous rhythm
- Sensing threshold
- Marker channel analysis and telemetered electrograms
- Trended information
EVALUATION OF ATRIAL UNDERSENSING IN DDD SYSTEMS

- Program low rate to achieve spontaneous atrial activity.
- Program short AVI to ascertain TRACKED ventricular response. If tracking is appropriate, then sensing function is confirmed.
- Delivery of atrial stimulus output on time (unless VA timing reset by a native or paced QRS)
- Event markers with surface ECG and intracardiac Egram
- Autothreshold
CAUSES OF PACEMAKER OVERSENSING

- Physiologic intracardiac signals
  R waves (atrial channel)
  T waves (ventricular channel)
- Physiologic extracardiac signals
  Muscle potentials (diaphragm, pectoral, seizure, tremor, shiver)
- Environmental signals
  Pacemaker related (crosstalk, lead fracture, insulation break)
  Pacemaker unrelated
  EMI
  Environmental
  Hospital

PACEMAKER – UNRELATED CAUSES OF OVERSENSING

- Electrocautery
- Catheter ablation
- Cardioversion and defibrillation
- Ionizing radiation
- MRI, other than “conditional”
- Cell phones
- Antitheft devices
- iPhones
- Tasers
- Transcutaneous or implanted nerve stimulators
- Implanted bladder stimulators

HOSPITAL SOURCES OF ELECTROMAGNETIC INTERFERENCE

- Medical equipment
  - Electrocautery
  - MRI
- Cardioversion, defibrillation
- Transcutaneous pacing
- Electrotherapy
- Transcutaneous nerve stimulation
- Implanted neuromuscular stimulators
- Ionizing radiation
CAUSES OF ABSENCE OF PACEMAKER STIMULUS OUTPUT

- Normal inhibition by native atrial and ventricular events, or by oversensed signals, including electromagnetic interference
- Loose lead-generator connections (stimulus is generated, but does not reach body tissue)
- Low-amplitude stimuli not registered by recording equipment (including telemetry and critical care unit monitors and ECG machines)
- Battery end-of-life
- Component failure

DIAGNOSIS OF CONDUCTOR WIRE FRACTURE

**ECG**
- Absence of stimulus artifacts
- Attenuation of stimulus artifacts
- Reversal of stimulus artifact polarity
- Intracardiac Electrogram Voltage transients sensed as “P” or “R” waves
- Interrogation
- High lead impedance

**Differential Dx**
- Low amplitude bipolar stimulus
- Low amplitude bipolar stimulus
- Artifact of recording equipment
- Actual far field signals
CAUSES OF RAPID VENTRICULAR PACED RATES* IN DDD PACEMAKERS

• Sinus tachycardia with normal tracking
• Atrial tachycardia
• Atrial flutter
• Atrial fibrillation
• Nonphysiologic rapid atrial sensed events (e.g., EMI)
• Runaway pacemaker (rare)

*AMS feature aborts these

INTERROGABLE PARAMETERS

• Mode of function
• Lead impedances
• Rate histograms
• Lower base rate
• Upper rate (atrial based, sensor based)
• AV, PV intervals
• Refractory periods
• Trends over time (impedance, capture thresholds, sensed signal voltages)
• Activity level
• High rate episodes
• Arrhythmia burden

THINGS YOU THOUGHT YOU KNEW BUT DON’T

• Lead configuration (unipolar, bipolar)
• Mode of function in pts with A and V leads
• Whether sensor is programmed on or off
• Response to rapid atrial rates, including mode switch operation
• Most intervals (e.g., URI, sensor-based LRI, URI)
• Response to “noise”
• Backup rate / mode / lead configuration
• ERI / EOL rates
CLINICAL PEARLS IN PACING

• The differential diagnosis of pseudofusion and true fusion cannot be made UNLESS the morphology of pure spontaneous and pure paced complexes is known
• The diagnosis of fusion IMPLIES intact capture
• If tracking of P-waves is appropriate, atrial sensing is confirmed; when tracking is lost and AV pacing ensues, atrial sensing is no longer occurring
• If there is a T-wave, there must have been a QRS complex
• In A-Vs conduction, occurrence of a paced QRS complex signifies loss of atrial capture
• If spontaneous QRS rhythm follows P waves at changing programmed rates, atrial capture is confirmed

THE NBG CODE FOR PACEMAKERS
UPDATED IN 2000

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Manufacturer
Designation only
(1 = Single, 3 = Dual (A-V), 5 = Dual (V-V))