Use of the pacemaker in the ICU

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Pacemaker in the ICU

Plan

1-) Indications for emergency cardiac pacing
2-) Types of temporary cardiac pacing
3-) Miscellaneous
4-) Conclusion

Indications

Emergency pacing

• Hemodynamically compromising bradycardia
• Bradycardia with escape rhythms
• Overdrive pacing of refractory tachycardia
• Bradyasystolic cardiac arrest (early, within 5 minutes)
• Bradycardia-dependent ventricular tachyarrhythmia (T-de-P)

“Standby” pacing

• Setting of acute MI with:
  - Symptomatic sinus node dysfunction
  - Mobitz type II second-degree heart block
  - Third degree heart block
  - Newly acquired left, right, or alternating BBB or bi-fascicular block
Indications

“Standby” pacing

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• Before electrical cardioversion of a patient with SSS or with high level of dependency to a permanent pacemaker

• Prior to permanent pacemaker implantation

• Prior to PA cath insertion if underlying LBBB

Types of temporary cardiac pacing

• Transcutaneous
• Transvenous
• Epicardial
• Transesophageal
• Transthoracic
• Mechanical

Transcutaneous cardiac pacing

• Dr. Paul Zoll, 1952
Transcutaneous cardiac pacing

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- Technique abandoned in the 1960's
- Reintroduced in clinical practice in the 1980's

Transcutaneous cardiac pacing

- To be used for short intervals as a bridge until transvenous pacing can be initiated or until the underlying cause of the bradyarrhythmia can be reversed

Surface patches

- Large, self-adhesive electrodes (area=8cm in diameter)
- Non-metallic
- Impregnated with conductive gel at the electrical surface with the skin

Surface patches placement

- Thoroughly clean skin with alcohol
- Remove any skin patches (nitro, nicotine,…)
- Do not shave

The cathodal (negative) electrode must always be positioned anteriorly.
Transcutaneous cardiac pacing
Surface patches placement

Pulse generator settings
- Rate (30-180 BPM)
- Current (0-200 mA)
- Demand / Asynch mode

** Know the different pacemaker units in the hospital

LIFEPAK 9
Transcutaneous cardiac pacing

Pulse generator settings:
- Rate (30-180 BPM)
- Current (0-200 mA)
- Demand / Asynch mode

LIFEPACK 9

Transcutaneous cardiac pacing

- Normally, capture is obtained at 40-80 mA
- No clear correlation between pacing threshold and:
  - Age
  - Body weight
  - Body surface area

Transcutaneous cardiac pacing

May see increased pacing threshold with:
- Suboptimal lead position (over bone; negative electrode placed posteriorly)
Transcutaneous cardiac pacing
May see increased pacing threshold with:
- Suboptimal lead position (over bone; negative electrode placed posteriorly)
- Poor skin-electrode contact
- Following intra-thoracic and cardiac surgery
- Emphysema
- Pericardial effusion
- Positive pressure ventilation
Transcutaneous cardiac pacing

May see increased pacing threshold with:
- Suboptimal lead position (over bone; negative electrode placed posteriorly)
- Poor skin-electrode contact
- Following intra-thoracic and cardiac surgery
- Emphysema
- Pericardial effusion
- Positive pressure ventilation
- Pharmacologic interventions (eg. A.A.)
- Hypoxia / ischemia / shock / acidosis / hyperkalemia

Transcutaneous cardiac pacing

Initiation of pacing
- Always use maximal current output and Asynch. mode initially in emergent bradyasystolic situations
- Adjust current output approx. 10 mA above threshold
- Sedation / analgesia as needed
Transcutaneous cardiac pacing

Initiation of pacing
- Always use maximal current output and Asynch. mode initially in emergent bradyasystolic situations
- Adjust current output approx. 10 mA above threshold
- Sedation / analgesia as needed
- Confirm capture by:
  > Pulse palpation
  > Doppler
  > Arterial line tracing

Pitfalls

- Failure to recognize the presence of underlying treatable VF
- Failure to recognize that the pacemaker is not capturing
Transcutaneous cardiac pacing

Potential complications

- Pain
- Induction of arrhythmia (very rare)
- Tissue damage (very rare)

Transvenous endocardial cardiac pacing

- Utilizes intravenous catheter electrodes to stimulate atrial and/or ventricular myocardial tissue directly with electrical current pulses provided by an external generator.

- Provides the most consistent and reliable means of temporary pacing

- Can permit atrial and/or ventricular pacing
- Stable system
- Well tolerated
- Takes more time and skills to insert
- Significant potential complications

- Offers different modes of pacing
  - 4-letter coding system
• Offers different modes of pacing
  • 4-letter coding system
    - 1st letter: chamber paced (V, A, D)
    - 2nd letter: chamber sensed (V, A, D)
    - 3rd letter: mode of response when an event is sensed
      I = inhibited
      T = triggered
      D = Inhibited or triggered
      O = neither inhibited, nor triggered
    - 4th letter: “R” = “rate-responsiveness” (only with permanent system)

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Different types of catheter electrodes
• 3-6 Fr in diameter
Transvenous endocardial cardiac pacing

Different types of catheter electrodes

- 3-6 Fr in diameter ** match adequate introducer size **
- Platinum-coated electrodes
- Made of relatively rigid woven polyester fabric or flexible plastic
- Tip may be straight or J-curved
- May be equipped with an inflatable balloon at tip
- Electrode may be unipolar or bipolar

Unipolar system characteristics
Transvenous endocardial cardiac pacing

Unipolar system characteristics
- Simple, less sophisticated electrode
- Dipole is between tip of electrode and generator
- Higher risk of oversensing
- Larger spike on EKG tracing

Bipolar system characteristics
- More complex electrode
- Somewhat larger than unipolar electrode
- Dipole is at tip of electrode
- Lower risk of oversensing
- Small spike on EKG tracing
- Higher risk of electrode failure

Conversion of a bipolar to a unipolar pacing system
Conversion of a bipolar to a unipolar pacing system

- Connect the distal or proximal electrode to the negative pole of the pacemaker
- Connect the positive pole to a wire suture, needle or metal plate in firm contact with the skin of the patient.
- Cover the tip of the unused electrode with a rubber glove (to avoid an accidental short-circuit in the pacing circuit)

Transvenous endocardial cardiac pacing

- Electrode should be inserted after transcutaneous pacing has been established
Transvenous endocardial cardiac pacing

- Electrode should be inserted after transcutaneous pacing has been established
- Blind insertion of rigid catheter should not be done
  - use fluoroscopy
- Blind insertion should be done with soft, flow-directed catheter with inflatable balloon
- Best venous access in emergency situations:
  - Right internal jugular vein
  - Left sub-clavian vein

Electrode placement may be guided by:

- Fluoroscopy / Echocardiography
- Endocardial EKG signal
- Surface EKG evidence of capture
- Pressure waves (PA cath. pacing system)
Transvenous endocardial cardiac pacing

Lead placement from IVC

Transvenous endocardial cardiac pacing

Lead position on CXR (PA view)

Transvenous endocardial cardiac pacing

Lead position on CXR (lat. view)

Transvenous endocardial cardiac pacing

Normal RV pacing (VVI)

Transvenous endocardial cardiac pacing

Pulse generator settings:
- Current (0.1-20 mA)
- Rate (30-180 BPM)
- Sensitivity (0.1mV- Asynch)
- Demand / Asynch. Mode
- Ventricular and/or atrial
Transvenous endocardial cardiac pacing
Pulse generators

Determination of the stimulation threshold (“capture”)

• Make sure pacemaker generator is “off” initially
• Set rate at 10 BPM above intrinsic rate
• Put on Demand mode and set sensitivity between 1.5 – 3 mV
• Set the Output current control at 5 mA and turn pacemaker generator “on”
Transvenous endocardial cardiac pacing

**Determination of the stimulation threshold ("capture")**

- Make sure pacemaker generator is "off" initially
- Set rate at 10 BPM above intrinsic rate
- Put on Demand mode and set sensitivity between 1.5 – 3 mV
- Set the Output current control at 5 mA and turn pacemaker generator "on"
- Verify surface EKG (or pulse by Doppler / art.line) for 1:1 capture

- Gradually decrease output current until 1:1 capture is lost

- Gradually increase the current Output to find the threshold at which capture is regained (= the stimulation threshold)

- Set final Output current at 2-3X the stimulation threshold

**Normal thresholds**

- atrium < 1.0 mA
- ventricle 0.5-1.0 mA
Transvenous endocardial cardiac pacing

Determination of the stimulation threshold (“capture”)

Ventrix: 0.5–1.0 mA
Atrium: < 1.0 mA

Normal thresholds

In emergent brady-asystolic situations, set pacemaker on “Asynch”, rate at 80-100 BPM and maximal Output current. Once capture is achieved, re-adjust the settings adequately.

Determination of the sensitivity threshold

- Set rate lower than the intrinsic rhythm
- Place in Demand mode
- Gradually reduce sensitivity (increasing the mV scale) until pacing output occurs.

Normal thresholds

Ventricle > 6 mV
Atrium > 1 mV

Adjust final sensitivity at 25-50% of the determined threshold.
Transvenous endocardial cardiac pacing

** Always have a functioning defibrillator unit close by when inserting and adjusting a transvenous pacemaker
** Perform daily threshold testing and paced 12-lead EKG

Contra-indications to transvenous pacing:

- Tricuspid valve mechanical prosthesis
- Existing endocarditis
- Infected endocardial pacemaker leads
- Sepsis / Bacteremia
- Ventricular arrhythmias due to dig. toxicity

Adequate myocardial capture will depend on:

- Stable catheter position
- Viability of the paced myocardial tissue
- Electrical integrity of the pacing system

Failure to capture (ventricle)
Transvenous endocardial cardiac pacing

Failure to capture (ventricle)

![ECG Image]

Failure to capture atrium (ventricular capture: ok)

![ECG Image]

Most common cause of loss of capture is...

Lead dislodgment

Loss of capture

• Catheter dislodgement / perforation
Transvenous endocardial cardiac pacing

Loss of capture
- Catheter dislodgement / perforation
- Poor endocardial contact
- Local myocardial necrosis / fibrosis
- Local myocardial inflammation / edema
- Hypoxia / Acidosis / electrolyte disturbance / drug effect (Ia and IC)
- Electrocautery / DC cardioversion damaging electrode or tissue interface
- Lead fracture
Transvenous endocardial cardiac pacing

**Loss of capture**
- Catheter dislodgement / perforation
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- Lead fracture
- Generator malfunction / battery depletion

**Undersensing**

**Undersensing (+ failure to capture)**
Transvenous endocardial cardiac pacing

Undersensing
- Lead dislodgment or perforation
- Local tissue necrosis / fibrosis
- Lead fracture
- Electrocautery / DC current damaging electrode or tissue interface
- Generator malfunction

Transvenous endocardial cardiac pacing

Undersensing
- Lead dislodgment or perforation
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Transvenous endocardial cardiac pacing

Oversensing (T waves)

Oversensing (myopotentials)

• P-wave sensing
• T-wave sensing
• Myopotential sensing
Transvenous endocardial cardiac pacing

**Oversensing**
- P-wave sensing
- T-wave sensing
- Myopotential sensing
- Electromagnetic interference

**Complications**
- Arrhythmias
- Thromboembolic events
  - ? necessity to anticoagulate
- Clinical infection / phlebitis
Transvenous endocardial cardiac pacing

Complications

• Arrhythmias
• Thromboembolic events
  - necessity to anticoagulate
• Clinical infection / phlebitis
• Bacteremia

Myocardial perforation by pacing electrode

Symptoms:

• Pericardial chest pain
• Shoulder pain
• Diaphragmatic pacing
• Skeletal muscle pacing
• Dyspnea, hypotension (if tamponade present)

Any problem with this paced EKG tracing?

DDD pacemaker with RBB paced rhythm...
Myocardial perforation by the ventricular lead

Signs:
Myocardial perforation by pacing electrode

**Signs:**
- Pericardial rub
- Intercostal muscle or diaphragmatic pacing
- Failure to pace or sense
- New pericardial effusion / tamponade

**CXR:**
- Change in lead position
- Extra-cardiac location of tip
- “Fat pad” sign

**Surface EKG:**
- Change in paced QRS morphology and/or axis
- Failure to pace or sense
- Pericarditis pattern
Transvenous endocardial cardiac pacing

**Failure to capture**
(myocardial perforation)

**Other potential complications**

- Knotting of catheter
- Tricuspid valve damage
- Induction of RBBB
- Phrenic nerve or diaphragmatic pacing *in the absence* of myocardial perforation

Epicardial pacing

- Temporary pacing wires passively fixed to the atrial and/or ventricular *epicardium* under direct visualisation at the time of cardiac surgery.

- Pacing wired usually *paired*
- Unipolar or bipolar leads
- Pacing and sensing thresholds tend to deteriorate progressively with time
Epicardial pacing

Transesophageal pacing

Transesophageal pacing electrodes

Transmyocardial transthoracic pacing

Mechanical pacing

“Percussion” pacing:

• Involves the administration of sharp blows with the ulnar aspect of the fist to the mid to lower 2/3 of the patient’s sternum.
Mechanical pacing

“Percussion” pacing:

• Involves the administration of sharp blows with the ulnar aspect of the fist to the mid to lower 2/3 of the patient’s sternum.

• Mech. of action: Involves mechanical-electrical transduction properties of the cardiac tissue

• May precipitate ventricular fibrillation

A few more points…

• Malfunctioning AICD with repeated inappropriate firing?

• Need to defibrillate / cardiovert a patient with an implanted permanent pacemaker?

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• Need to defibrillate / cardiovert a patient with an implanted permanent pacemaker?

• How to check the capture of a permanent pacemaker?
A few more points…

• Malfunctioning AICD with repeated inappropriate firing?

• Need to defibrillate / cardiovert a patient with an implanted permanent pacemaker?

• How to check the capture of a permanent pacemaker?

• What does it mean if a permanent pacemaker has a slower pacing rate than the one originally programmed?

Pacemaker tray in the CTICU

A few more points…

Conclusion

• Know your pacemaker system!
Conclusion

• Know your pacemaker system!

• Transcutaneous pacing should always be used first in an emergency (on Asynch mode)

• Use the appropriate introducer for transvenous leads

• Be comfortable with the basic troubleshooting (capture, oversensing, undersensing)

Questions ??

Merci !