Use of the pacemaker in the ICU

by

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MD, FRCPC

Pacemaker in the ICU

Plan

1-) Indications for emergency cardiac pacing

2-) Types of temporary cardiac pacing

3-) Miscellaneous

4-) Conclusion

Indications

Emergency pacing

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)

Indications

"Standby" pacing

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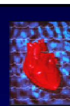
"Standby" pacing

•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



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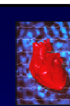

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•Prior to permanent pacemaker implantation

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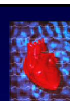

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•Before electrical cardioversion of a patient with SSS <u>or</u> with high level of dependency to a permanent pacemaker

•Prior to permanent pacemaker implantation

•Prior to PA cath insertion if underlying LBBB

Types of temporary cardiac pacing

- Transcutaneous
- Transvenous
- Epicardial
- Transesophageal
- Transthoracic
- Mechanical

Types of temporary cardiac pacing

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- Transvenous
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- Transesophageal
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- Mechanical

Transcutaneous cardiac pacing

- Dr.Paul Zoll, 1952

Transcutaneous cardiac pacing

- Dr.Paul Zoll, 1952

- 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

Transcutaneous cardiac pacing

Surface patches

Transcutaneous cardiac pacing

Surface patches

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

Transcutaneous cardiac pacing

Surface patches placement

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

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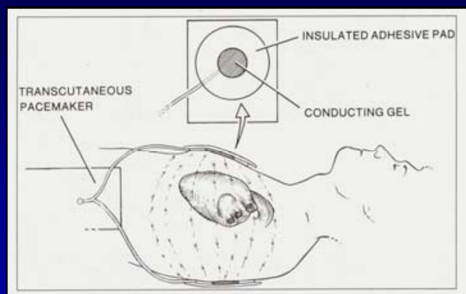
The cathodal (negative) electrode must always be positioned anteriorly

Transcutaneous cardiac pacing

Surface patches placement



Transcutaneous cardiac pacing

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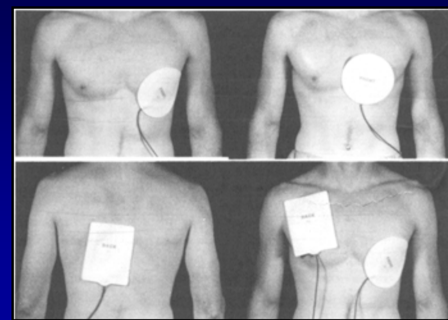

Transcutaneous cardiac pacing

Pulse generator settings

Transcutaneous cardiac pacing

Pulse generator settings

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

Transcutaneous cardiac pacing

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*** Know the different pacemaker units in the hospital*

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LIFEPAK 9

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LIFEPACK 9

Transcutaneous cardiac pacing

- Normally, capture is obtained at 40-80 mA

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:

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

Transcutaneous cardiac pacing

May see increased pacing threshold with:

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- Following intra-thoracic and cardiac surgery

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- Emphysema

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- Pericardial effusion

Transcutaneous cardiac pacing

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- Positive pressure ventilation

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- Pharmacologic interventions (eg. A.A.)

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- Hypoxia / ischemia / shock / acidosis / hyperkalemia
- After electrical cardioversion / defibrillation
- After prolonged resuscitation / arrest

Transcutaneous cardiac pacing

Initiation of pacing

- Always use maximal current ouput and Asynch. mode initially in emergent bradyasystolic situations

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- Confirm capture by:

Transcutaneous cardiac pacing

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- Adjust current ouput approx. 10 mA above threshold
- Sedation / analgesia as needed
- Confirm capture by:
  - *> Pulse palpation*
  - *> Doppler*
  - *> Arterial line tracing*

Transcutaneous cardiac pacing

Pittfalls

Transcutaneous cardiac pacing

Pittfalls

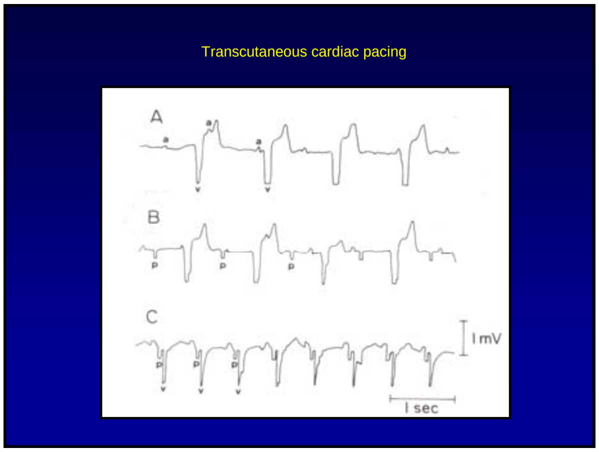
- Failure to recognize the presence of underlying treatable VF

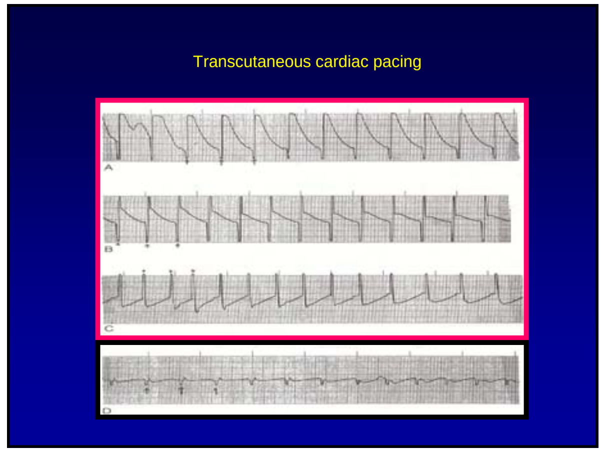
Transcutaneous cardiac pacing

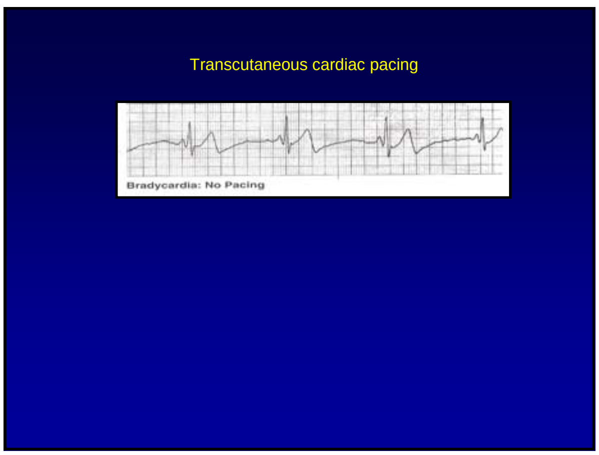
Pittfalls

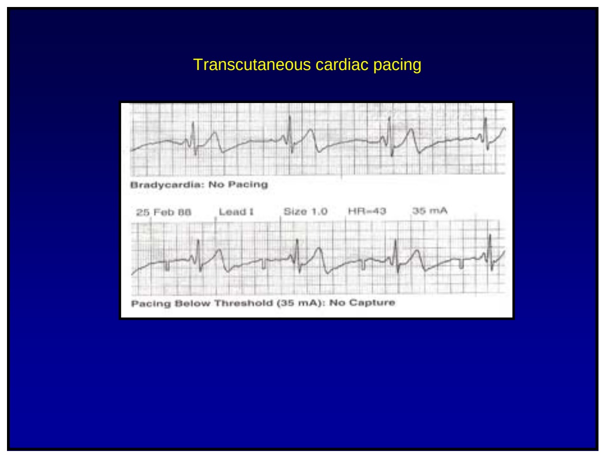
- Failure to recognize the presence of underlying treatable VF
- Failure to recognize that the pacemaker is not capturing

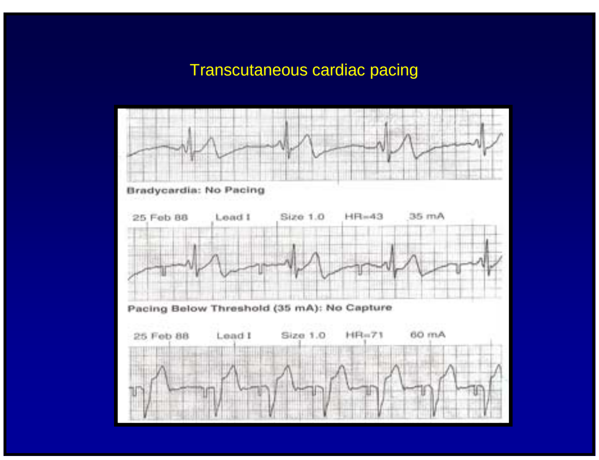
Transcutaneous cardiac pacing

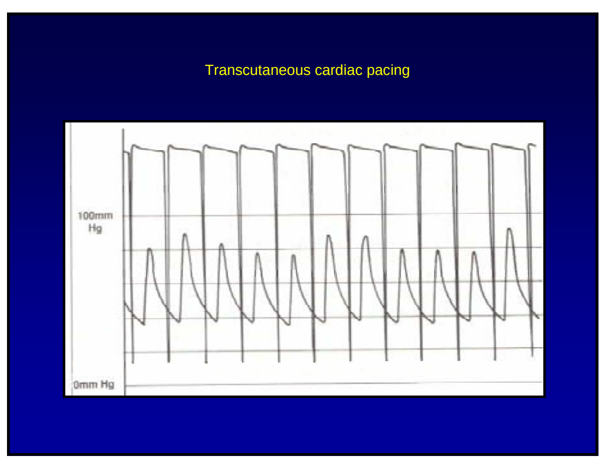

Transcutaneous cardiac pacing
A
B
C
I mV
I sec


Transcutaneous cardiac pacing


Transcutaneous cardiac pacing
Bradycardia: No Pacing


Transcutaneous cardiac pacing
Bradycardia: No Pacing
25 Feb 88 Lead I Size 1.0 HR=43 35 mA
Pacing Below Threshold (35 mA): No Capture


Transcutaneous cardiac pacing
Bradycardia: No Pacing
25 Feb 88 Lead I Size 1.0 HR=43 35 mA
Pacing Below Threshold (35 mA): No Capture
25 Feb 88 Lead I Size 1.0 HR=71 60 mA


Transcutaneous cardiac pacing
100mm Hg
0mm Hg

Transcutaneous cardiac pacing

Potential complications

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.

Transvenous endocardial cardiac pacing

- Provides the most consistent and reliable means of temporary pacing

Transvenous endocardial cardiac pacing

- 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

Transvenous endocardial cardiac pacing

- Offers different modes of pacing
- 4-letter coding system

Transvenous endocardial cardiac pacing

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- 1^{st} letter:
- 2nd letter:
- 3^{rd} letter:

Transvenous endocardial cardiac pacing

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- 1^{st} letter: chamber *paced* (V, A, D)
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  - I = inhibited
  - T= triggered
  - D= Inhibited or triggered
  - O= neither inhibited, nor triggered

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  - I = inhibited
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  - D= Inhibited or triggered
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- 4^{th} letter: “R” = “ rate-responsiveness” (only with permanent system)

Transvenous endocardial cardiac pacing

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 **

Transvenous endocardial cardiac pacing

Different types of catheter electrodes

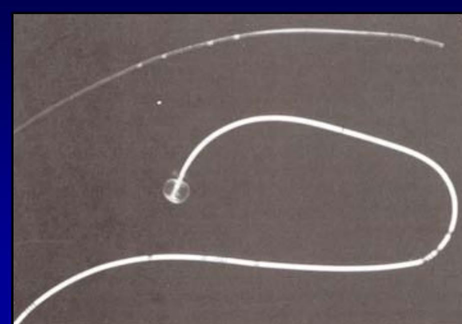
- 3-6 Fr in diameter ** match adequate introducer size **
- Platinum-coated electrodes
- Made of relatively rigid woven polyester fabric or flexible plastic
- Tip may be straight or J-curved
- May be equipped with an inflatable balloon at tip
- Electrode may be unipolar or bipolar

Transvenous endocardial cardiac pacing

Different types of catheter electrodes

Transvenous endocardial cardiac pacing

Different types of catheter electrodes



Transvenous endocardial cardiac pacing

Transvenous endocardial cardiac pacing

Unipolar system characteristics

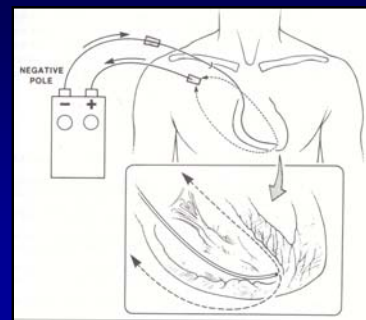
Transvenous endocardial cardiac pacing

Unipolar system characteristics

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

Transvenous endocardial cardiac pacing

Unipolar system



Transvenous endocardial cardiac pacing

Bipolar system characteristics

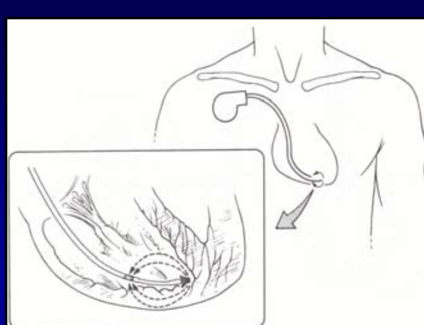
Transvenous endocardial cardiac pacing

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

Transvenous endocardial cardiac pacing

Bipolar system



Conversion of a bipolar to a unipolar pacing system

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- Connect the distal or proximal electrode to the negative pole of the pacemaker

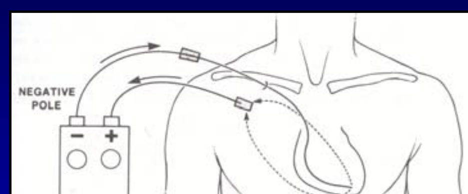
Conversion of a bipolar to a unipolar pacing system

- 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.

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)

Conversion of a bipolar to a unipolar pacing system



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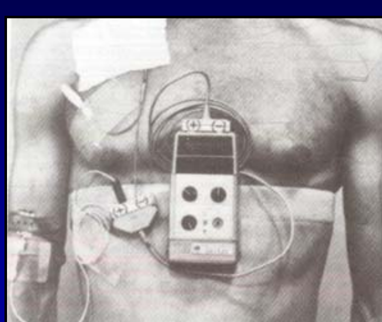

Transvenous endocardial cardiac pacing

- 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*

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- Blind insertion should be done with soft, flow-directed catheter with inflatable balloon

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

Transvenous endocardial cardiac pacing

Electrode placement my be guided by:

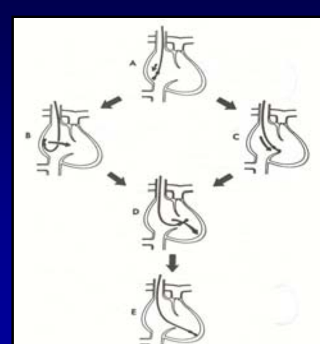
Transvenous endocardial cardiac pacing

Electrode placement my be guided by:

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

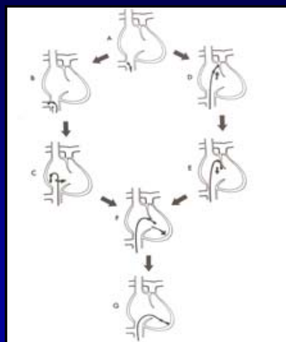
Transvenous endocardial cardiac pacing

Lead placement from SVC

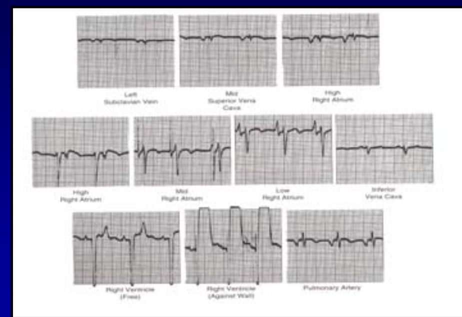


Transvenous endocardial cardiac pacing

Lead placement from IVC



Transvenous endocardial cardiac pacing

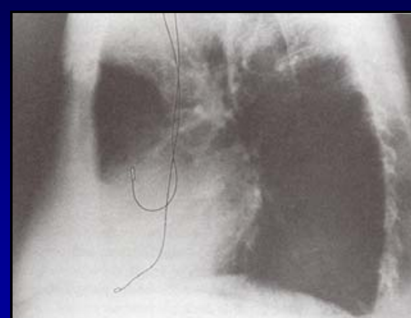


Transvenous endocardial cardiac pacing

Lead position on CXR (PA view)

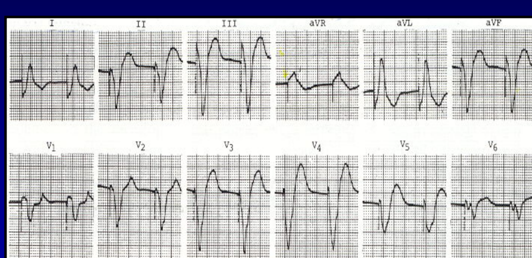
Transvenous endocardial cardiac pacing

Lead position on CXR (lat. view)



Transvenous endocardial cardiac pacing

Normal RV pacing (VVI)



Transvenous endocardial cardiac pacing

Pulse generator settings

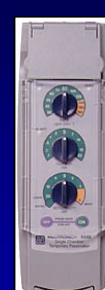
-Current (0.1-20 mA)

-Rate (30-180 BPM)

-Sensitivity (0.1mV- Asynch)

-Demand / Asynch. Mode

-Ventricular and/or atrial



Transvenous endocardial cardiac pacing

Pulse generators

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

- Make sure pacemaker generator is "off" initially

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

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

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"

Transvenous endocardial cardiac pacing

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- Verify surface EKG (or pulse by Doppler / art.line) for 1:1 capture

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

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

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

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

- 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

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

Normal thresholds
- *ventricle 0.5-1.0 mA*
- *atrium < 1.0 mA*

Transvenous endocardial cardiac pacing

Determination of the stimulation threshold ("capture")

Normal thresholds
- *ventricle 0.5-1.0 mA*
- *atrium < 1.0 mA*

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.

Transvenous endocardial cardiac pacing

Determination of the sensitivity threshold

- Set rate lower than the intrinsic rhythm

Transvenous endocardial cardiac pacing

Determination of the sensitivity threshold

- Set rate lower than the intrinsic rhythm
- Place in Demand mode

Transvenous endocardial cardiac pacing

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.

Transvenous endocardial cardiac pacing

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*

Transvenous endocardial cardiac pacing

Determination of the sensitivity threshold

- 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 <u>and</u> *paced* 12-lead EKG

Transvenous endocardial cardiac pacing

<u>Contra-indications to transvenous pacing</u> :

Transvenous endocardial cardiac pacing

<u>Contra-indications to transvenous pacing</u> :

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

Transvenous endocardial cardiac pacing

<u>Adequate myocardial capture will depend on</u>:

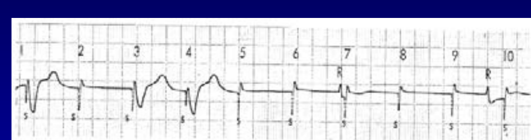
Transvenous endocardial cardiac pacing

<u>Adequate myocardial capture will depend on</u>:

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

Transvenous endocardial cardiac pacing

Failure to capture (ventricle)



Transvenous endocardial cardiac pacing

Failure to capture (ventricle)

Transvenous endocardial cardiac pacing

Failure to capture atrium
(ventricular capture= ok)

Transvenous endocardial cardiac pacing

Most common cause of loss of capture is…

Transvenous endocardial cardiac pacing

Most common cause of loss of capture is…

→ Lead dislodgment

Transvenous endocardial cardiac pacing

Loss of capture

Transvenous endocardial cardiac pacing

Loss of capture

- Catheter dislodgement / perforation

Transvenous endocardial cardiac pacing

Loss of capture

- Catheter dislodgement / perforation
- Poor endocardial contact

Transvenous endocardial cardiac pacing

Loss of capture

- Catheter dislodgement / perforation
- Poor endocardial contact
- Local myocardial necrosis / fibrosis

Transvenous endocardial cardiac pacing

Loss of capture

- Catheter dislodgement / perforation
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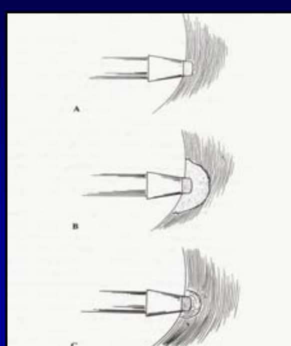
- Unstable electrical connections

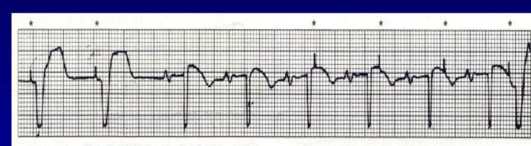
Transvenous endocardial cardiac pacing

Local myocardial inflammation / edema



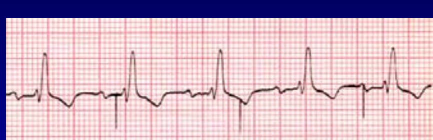
Transvenous endocardial cardiac pacing

Undersensing



Transvenous endocardial cardiac pacing

Undersensing (+ failure to capture)



Transvenous endocardial cardiac pacing

Undersensing

Transvenous endocardial cardiac pacing

Undersensing

- Lead dislodgment or perforation

Transvenous endocardial cardiac pacing

Undersensing

- Lead dislodgment or perforation
- Local tissue necrosis / fibrosis

Transvenous endocardial cardiac pacing

Undersensing

- Lead dislodgment or perforation
- Local tissue necrosis / fibrosis
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Transvenous endocardial cardiac pacing

Undersensing

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

Transvenous endocardial cardiac pacing

Undersensing

- Lead dislodgment or perforation
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Transvenous endocardial cardiac pacing

Undersensing

- Lead dislodgment or perforation
- Local tissue necrosis / fibrosis
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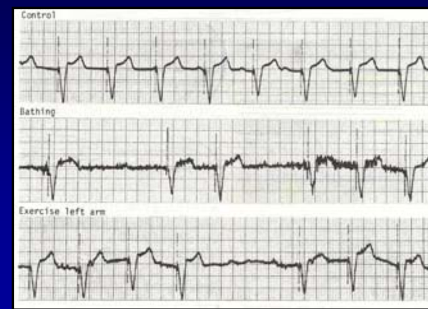
Transvenous endocardial cardiac pacing

Oversensing (T waves)

Transvenous endocardial cardiac pacing

Oversensing (myopotentials)



Transvenous endocardial cardiac pacing

Oversensing

Transvenous endocardial cardiac pacing

Oversensing

- P-wave sensing

Transvenous endocardial cardiac pacing

Oversensing

- P-wave sensing
- T-wave sensing

Transvenous endocardial cardiac pacing

Oversensing

- P-wave sensing
- T-wave sensing
- Myopotential sensing

Transvenous endocardial cardiac pacing

Oversensing

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

Transvenous endocardial cardiac pacing

Oversensing

- P-wave sensing
- T-wave sensing
- Myopotential sensing
- Electromagnetic interference
- Intermittent electrical contacts, unstable connections, or lead fracture

Transvenous endocardial cardiac pacing

Complications

Transvenous endocardial cardiac pacing

Complications

- Arrhythmias

Transvenous endocardial cardiac pacing

Complications

- Arrhythmias
- Thromboembolic events
  ? necessity to anticoagulate

Transvenous endocardial cardiac pacing

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Complications

- Arrhythmias
- Thromboembolic events
  ? necessity to anticoagulate
- Clinical infection / phlebitis
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- Myocardial perforation by pacing electrode

Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

Symptoms:

Transvenous endocardial cardiac pacing

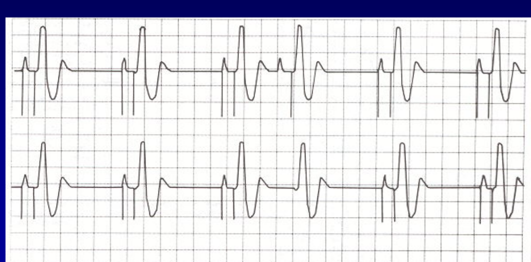
Myocardial perforation by pacing electrode

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



Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

Signs:

Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

Signs:

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

Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

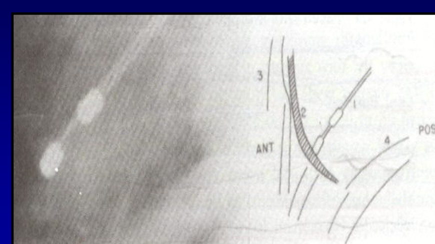
CXR:

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

Transvenous endocardial cardiac pacing

“Fat pad” sign on CXR

(Myocardial perforation)



Transvenous endocardial cardiac pacing

Myocardial perforation by pacing electrode

Surface EKG:

Transvenous endocardial cardiac pacing

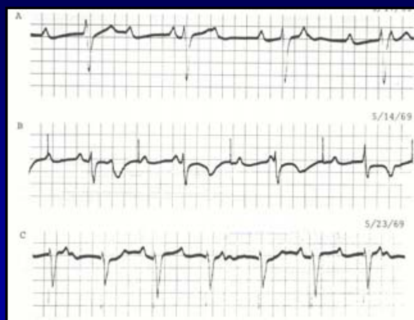
Myocardial perforation by pacing electrode

Surface EKG:

- Change in paced QRS morphology and/or axis
- Failure to pace or sense
- Pericarditis pattern

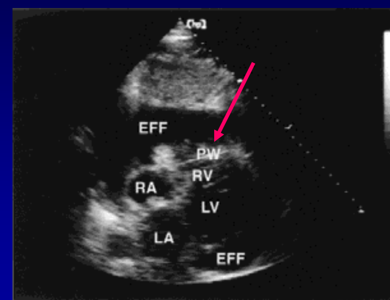
Transvenous endocardial cardiac pacing

Failure to capture
(myocardial perforation)



Transvenous endocardial cardiac pacing

Myocardial perforation + tamponade
(subcostal, 2-D echographic picture)



Transvenous endocardial cardiac pacing

Other potential complications

Transvenous endocardial cardiac pacing

Other potential complications

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

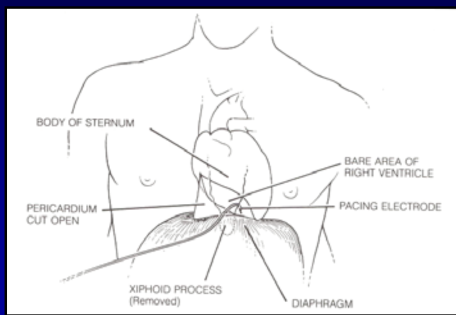
Epicardial pacing

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

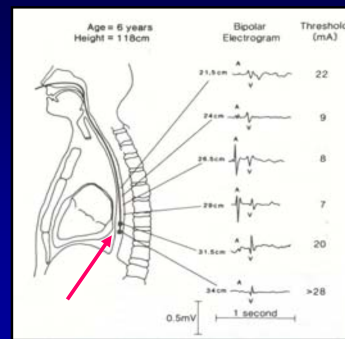
Epicardial pacing

- 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

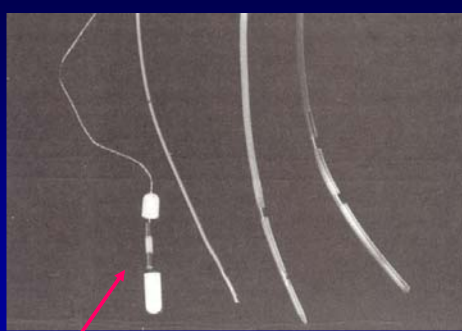
Epicardial pacing



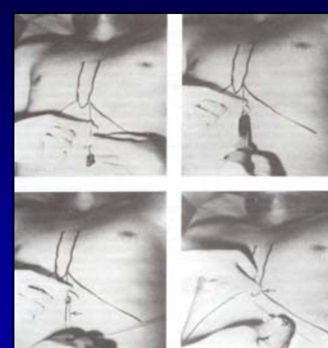
Transesophageal pacing



Transesophageal pacing electrodes



Transmyocardial transthoracic pacing



Mechanical pacing

"Percussion" pacing:

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- 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.

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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

Mechanical pacing

A few more points…

- Malfunctioning AICD with repeated inappropriate firing ?

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

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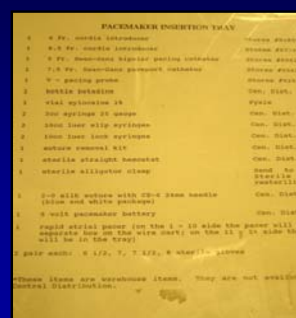
- Patient with a pacemaker going to the OR ?

A few more points…

Pacemaker tray in the CTICU

A few more points…

Pacemaker tray in the CTICU



PACEMAKER INSERTION TRAY

Conclusion

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Conclusion

- Know your pacemaker system !
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- Use the appropriate introducer for transvenous leads
- Be comfortable with the basic troubleshooting (capture, oversensing, undersensing)
- Know your pacemaker system !

Questions ??

Merci !