Post-Cardiotomy Hemorrhage

Learning Objectives:

- Recognize abnormal post-cardiotomy bleeding
- Understand techniques to reduce bleeding
- Know the indications for surgical re-exploration
- Identify when an emergent ICU thoracotomy is needed

Cause

- Classically divided into "medical" vs. "surgical"[1]
  - Medical: coagulopathy
    - Hemodilution of clotting factors and platelets
    - Contact of blood with circuit causing fibrinolysis
    - Systemic heparinization
    - Re-infusion of cell saver blood that lacks platelets or clotting factors
    - Too much protamine? Excess also causes coagulopathy
  - Surgical: something anatomic is bleeding and needs to be fixed

Risk factors

- Patient
  - elderly, female, pre-op anemia, pre-existing coagulopathy, comorbidities, lower BMI, chronic renal failure
- Pre-op
  - Antiplatelet or anticoagulant medications
- Operative
  - Complex operations, non-elective operations, reoperations, bilateral internal thoracic artery grafting

What to monitor

- Usual post-op labs and imaging
  - Repeat if clinical change
  - Classic parameters (INR, ptt, etc.) may not reflect *in-vivo* degree of coagulopathy due to poor function of clotting factors and platelets and increased fibrinolysis from circuit
  - ROTEM / TEG
- Output
  - Consider surgical re-exploration for:
    - >400cc/hr x 1 hr
    - >300cc/hr x 2-3 hrs
    - >200cc/hr x 4 hrs
- Color
  - Sudden change in color to bright red?
- High output followed by no output with hemodynamic instability… think about tamponade

Strategy

- Correct hypothermia, acidosis, anemia
- Correct coagulopathy if bleeding
    - Traditional coagulation markers
        - Keep plt > 50k, inr < 1.5, fibrinogen > 150 mg/dL
        - Prolonged ptt, consider need for additional protamine
    - ROTEM / TEG
- Decrease potential spaces to tamponade bleeding
    - Increase tidal volume and/or PEEP
        - This is why patients may dump when put on pressure support
- Recombinant Factor VII
    - Can consider use in severe bleeding not controlled by other means
    - Data not fantastic, but majority of studies found decreased bleeding
    - ~ 5% thrombosis risk for patients given rFVII for refractory bleeding [2]
        - 2.6% CVA
        - 1.5% MI
        - 0.8% DVT
        - 0.4% Intracardiac thrombus
- Surgical Re-exploration
    - Ongoing discussion with surgeon when concerned
    - Emergent ICU thoracotomy indicated when arrest or peri-arrest from bleeding or tamponade (in discussion with surgeon)

References:

1. Bojar RM. Manual of perioperative care in adult cardiac surgery: John Wiley & Sons; 2011.
2. Warren O, Mandal K, Hadjianastassiou V, Knowlton L, Panesar S, John K, et al. Recombinant activated factor VII in cardiac surgery: a systematic review. The Annals of thoracic surgery. 2007;83(2):707-14.
3. Dabbagh, Ali, Fardad Esmailian, and Sary Aranki, eds. *Postoperative Critical Care for Adult Cardiac Surgical Patients*. Springer, 2018.
4. Raphael, Jacob, et al. "Society of Cardiovascular Anesthesiologists clinical practice improvement advisory for management of perioperative bleeding and hemostasis in cardiac surgery patients." *Journal of cardiothoracic and vascular anesthesia* 33.11 (2019): 2887-2899.

Post Cardiotomy Pacing

Learning Objectives:

- Understand the basic pacemaker modes and terminology
- Understand the rationale for adjusting the capture threshold and pacer sensitivity
- Understand the difference between unipolar and bipolar epicardial leads
- Know conventions for epicardial lead placement in relation to sternotomy
- Have a basic algorithm for troubleshooting failed epicardial lead capture

Basic Pacer Modes

- Mode designated by 3 letter code: the *PSR* code determines the *Pacer* mode
  - 1st letter designates the chamber(s) being **P**aced
  - 2nd letter designates the chamber(s) being **S**ensed
  - 3rd letter designates the **R**esponse to when the pacer box senses something

P	S	R
A for atrium	A for atrium	0 = asynchronous
V for ventricle	V for ventricle	I = inhibit pacing if native electrical impulse sensed
D for dual	D for dual	D = same as I but for when both atrium and ventricle are being sensed

- Two most commonly used modes that are relevant to us as critical care providers
  - **VVI** = only delivers pacing spike to ventricle if native ventricle electrical activity is absent. Perfect for high grade AV block.
  - **DDD** = paces both chambers but will only deliver pacing spike to atrium when native atrium electrical activity is absent and only deliver to ventricle when native ventricle electrical activity is absent. It treats each independently in the sense and response.

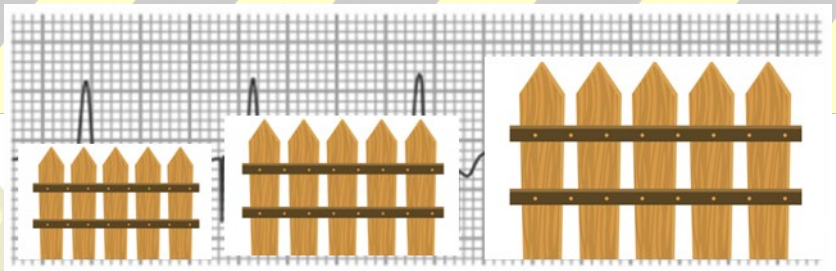
Capture threshold

- Current required to achieve electrical and mechanical capture designated in mAmps
  - May hear this referred to as “the mA” or simply “capture”

Sensitivity

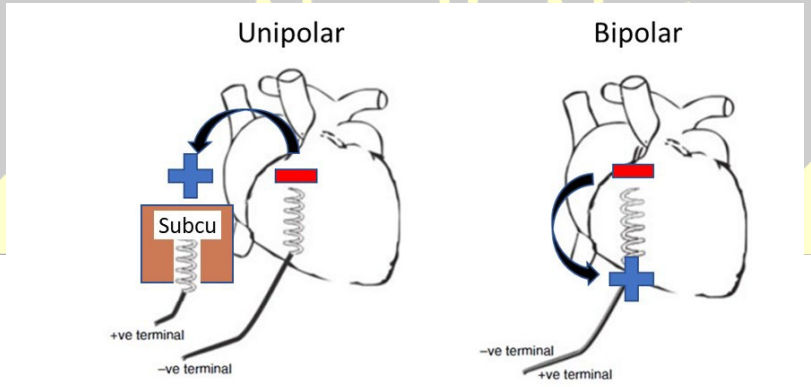
- Voltage required of a native electrical impulse for the pacer box to detect it.
  - setting this value very low means that the tiniest of electrical impulses will be picked up by the pacer box as the patient’s native electrical rhythm

        - the pacer box may over inhibit the delivery of pacer spikes if these tiny impulses are artifacts → patient is inappropriately *NOT paced*
    - setting this value high means that is takes a relatively strong native electrical impulse in order for the pacer box to detect it
        - the pacer box may not detect the patient's perfectly acceptable native rhythm → patient is inappropriately *paced*
- The term sensitivity makes sense but in my opinion is incredibly confusing because setting the number lower makes it more sensitive at detecting a native rhythm and vice versa. Instead, think of it as the "sensing threshold" or the fence/hurdle the native electrical activity has to clear for the pacer box to detect it → think "Fenceitivity" if that helps you remember it.

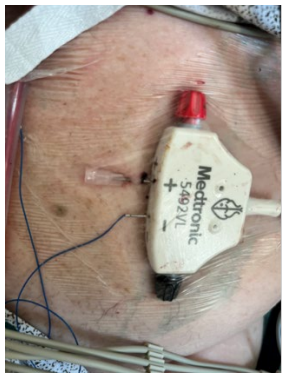


Epicardial Leads

- Implanted in epicardium at time of surgery when
    - Transient or permanent heart block is present or a risk
    - Improved cardiac output is needed (AV pace at higher rate than native)
    - Prophylactic atrial pacing is desired to lessen chance of developing afib in post-op period
- Typically last several days before leads become fibrosed → require more mAmps to achieve capture → higher current leads to faster fibrosis → leads fail
- Unipolar vs. bipolar leads



Modified from Reade et al. 2007



- By convention: leads exiting to Right of sternotomy go to atrium, Left of sternotomy to ventricle

Checking pacer function

1. Underlying rhythm
    a. Check for underlying rhythm by gradually turning down rate
    b. Do ***not*** disconnect wires, turn off box, or turn down mAmps as you risk not being able to regain capture
2. Sensing threshold
    a. Only do this if there is an underlying perfusing rhythm
    b. Turn mAmps to the lowest setting possible
    c. Increase the mV *number* on sensitivity until the sensing light no longer lights up: this is the sensing threshold
    d. Set the mV to ½ of the sensing threshold to give a margin of safety
3. Capture threshold
    a. Only do this if there is an underlying perfusing rhythm
    b. Turn rate up to 10 above patient's native rate
    c. Turn down mA until spikes no longer produce QRS
    d. Set mAmps to twice this value to give margin of safety

Basic algorithm for loss of capture

1. Check if box is on and connected
2. Hit the emergency button → switches to asynchronous pacing (DOO) with maximum mAmp output.
3. Reverse polarity of leads, plugging negative leads to positive terminal and positive leads to negative terminal
4. Create a ground with an 18-gauge needle in the skin
    - Creates a new ground for a unipolar system
    - Converts a bipolar system to a unipolar system
5. Pace externally and place temporary transvenous pacemaker

Resources:

- Reade, M. C. "Temporary epicardial pacing after cardiac surgery: a practical review: part 1: general considerations in the management of epicardial pacing." *Anaesthesia* 62.3 (2007): 264-271.

- Reade, M. C. "Temporary epicardial pacing after cardiac surgery: a practical review: Part 2: Selection of epicardial pacing modes and troubleshooting." *Anaesthesia* 62.4 (2007): 364-373.
- Derranged Physiology: Single and Dual Chamber Pacing Modes https://derangedphysiology.com/main/required-reading/cardiothoracic-intensive-care/Chapter%209.1.2.7/single-and-dual-chamber-pacing-modes
- Derranged Physiology: Sensitivity and output settings of the temporary pacemaker https://derangedphysiology.com/main/required-reading/cardiothoracic-intensive-care/Chapter%209125/sensitivity-and-output-settings-temporary-pacemaker
- Derranged Physiology: Anatomy of the Temporary Pacemaker Circuit https://derangedphysiology.com/main/required-reading/cardiothoracic-intensive-care/Chapter%209.0.1/anatomy-temporary-pacemaker-circuit