Cardiac Surgery
Advanced Life Support

- In the immediate postop recovery in a cardiac surgery patient is typically related to reversible causes
  - Tamponade
  - Bleeding
  - Ventricular arrhythmias
  - Blocks associated with conduction problems
- Survival to discharge can be up to 79%
  - If treated promptly

2010 AHA ACLS Guidelines

- Pros
  - EBP resuscitation guidelines
  - Standardized approach
  - Easy to teach and implement

- Cons:
  - Do not specifically address cardiac surgery arrests

Cardiac Arrests

- Hospitals developed own guidelines and protocols
- No standardization

2009

- Cardiac arrest
  - Access rhythm
  - Prepare for emergency revascularization
  - Consider revasc using PCI if not contraindicated
  - Treat with CPR

- Cardiac arrest in cardiac surgery
  - Consider a two person CPR
  - Use of vasopressors with ECMO
  - Early revascularization

- Acute coronary syndrome
  - Consider revasc if at significant risk
  - Early PCI if not contraindicated

- CTCAE
  - Acute coronary syndrome
  - Consider revasc if at significant risk
  - Early PCI if not contraindicated

- CEC
  - Acute coronary syndrome
  - Consider revasc if at significant risk
  - Early PCI if not contraindicated

- BRS
  - Acute coronary syndrome
  - Consider revasc if at significant risk
  - Early PCI if not contraindicated

- JAC
  - Acute coronary syndrome
  - Consider revasc if at significant risk
  - Early PCI if not contraindicated
But we are in the USA~

**CALS in the USA**
California Pacific Medical Center
San Francisco
Mayo Clinic
Florida
Duke University Medical Center
North Carolina
Temple University Hospital
Philadelphia
Beth Israel Deaconess Medical Center
Massachusetts
Society of Thoracic Surgeons (STS) soon!

www.csu-als.com

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**CALS**
Cardiac Advanced Life Support - Surgery

**CSU-ALS**

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**CALS-S**
Cardiac Advanced Life Support - Surgery

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**EACTS**

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**Key Concepts**
- Assess Rhythms
- Shock before Compressions
- Pacing/Atoptapine - not Epi
- Identify reversible causes
- Early re sternotomy

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**Assess Rhythm**
- Ventricular Tach or Fib
- Asystole or severe Bradycardia
- Pulseless Electrical Activity
- Ventricular Tach or Fib
- Asystole or severe Bradycardia
- Pulseless Electrical Activity

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**CARDIAC ARREST**
Assess rhythm

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**CARDIAC ARREST**
Assess rhythm
Delay Compressions if able to shock or pace within 60 seconds

- No evidence to support CPR prior to defibrillation for in-hospital arrests
- Best survival for in-hospital arrests is when defibrillation occurs within two minutes of VF/VT
- Successful restoration of rhythm may occur after the first defibrillation in 86-96% of patients
- Success declines with each sequential shock with unlikely success after the fourth shock
- Potential trauma or complications from the compressions.
  - The unstable sternum or sternal wires may cause disruption of vascular sutures or right ventricular tear.
  - Thus, defibrillation is recommended first, if it can be achieved within sixty seconds

References listed in EACTs Cardiac Surgery Guideline

Potential for Right Ventricular Tear After CPR

Rewired sternum

Sternum during CPR

RV tear after sternum recoils

Photos courtesy of AJ Ley

No Epinephrine
Unless ordered by cardiac provider or Cardiovascular Surgeon

- Restoration of sinus rhythm after early defibrillation or resternotomy is highly successful
- Administration of epinephrine may result in severe rebound hypertension leading to suture line disruption or aortic rupture

CARDIAC ARREST

Assess rhythm

Start basic life support

Prepare for emergency resternotomy

2nd person manages airway

Any shock or severe bradycardia

- Pace if wires available
- CPR
- Atropine 3 mg IV
- Consider external pacing
- Prepare for resternotomy
- CPR

Pace if wires available

DDD 90 bpm and max MA

Cardiac arrest

Airway

Assessment

Shock

Start basic life support

Prepare for emergency resternotomy

2nd person manages airway

X

Restoration of sinus rhythm after early defibrillation or resternotomy is highly successful

- Administration of epinephrine may result in severe rebound hypertension leading to suture line disruption or aortic rupture
Atropine 3 mg IV

- No evidence available in favor of atropine in cardiac surgery arrests
- Relatively benign drug with few side effects
- Thus recommended for asystole or extreme bradycardia

Pulseless Electrical Activity (PEA)

- Cardiac surgery patients who arrest with PEA are typically experiencing treatable causes
  - Hypovolemia
  - Hypoxia
  - Tamponade
  - Tension pneumothorax
- Prompt treatment results in good outcomes
- To assess for causes of PEA/nonschockable rhythm
  - Consider the 4 "Hs" and 4 "Ts"

Treatment of PEA causes

<table>
<thead>
<tr>
<th>Hypoxia</th>
<th>Hypoxia and Tamponade</th>
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<tbody>
<tr>
<td>Treat per airway management and assessment</td>
<td>Severe hypovolemia is typically due to bleeding</td>
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<tr>
<td></td>
<td>Severe hypovolemia and tamponade both require emergent resternotomy to correct</td>
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</table>

Assess for Reversible Causes

<table>
<thead>
<tr>
<th>Hypoxia</th>
<th>Tamponade</th>
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<tbody>
<tr>
<td>Hypovolemia</td>
<td>Tension</td>
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<tr>
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<td>Pneumothorax</td>
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<tr>
<td>Hypokalemia/ Hyperkalemia</td>
<td>Thromboembolism</td>
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<tr>
<td>Hypothermia</td>
<td>Toxin</td>
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</tbody>
</table>

- Most common causes of cardiac surgery arrests

Airway and Ventilation

- If ventilated, turn FIO₂ to 100% and turn off PEEP
- Assess for airway patency and lung sounds

2nd person manages airway
Steps to Ensure Adequate Airway and Ventilation

- Check endotracheal tube (ET) position and end tidal carbon dioxide (ETCO₂) waveform and reading
- Listen for an ET airleak and verify that is properly inflated
- Listen and look for bilateral breath sounds.
  - Consider removing the patient from the ventilator and give 100% oxygen via bag-mask-valve to more easily assess lung sounds and determine lung compliance
  - If bilateral lung sounds are present, reconnect the ET to ventilator.

- Feel the trachea to verify it is midline.
- If a tension pneumothorax is suspected, insert a large bore needle into the 2nd intercostal space, mid-clavicular line.
- If unable to ventilate the patient with a bag-mask-valve, attempt to suction the ET tube.
  - If unable to pass the suction catheter, ET occlusion or malposition should be suspected.
  - Remove the ET and ventilate with a bag-mask-valve.

Six Key Roles

1. External cardiac massage
2. Management of airway and breathing
3. Defibrillation
4. Team leader
5. Medication administration
6. ICU nursing Coordinator

Team leader
- Conducts the management of the arrest
- Ensures the protocol is followed
- Assigns roles

ICU nursing Coordinator
- Manages the arrest from the peripheral bedside
- Resternotomy preparation
- Managing additional personnel
- Calling for expert assistance as needed
- Reporting back to the team leader

Emergent Resternotomy

- In all three arms of the algorithm, prepare for emergent resternotomy if:
  - The initial treatment is unsuccessful
  - Resuscitation efforts are likely to last longer than 5 – 10 minutes
  - Internal cardiac massage is superior to external cardiac massage in cardiac surgery patients

Medication Administration

- CALS-S recommends as best practice to stop all medication infusions
- Continuing pre-arrest medication infusions is unlikely to assist resolution of the cardiac arrest
- An inadvertent flushing of a vasodilator or residual medication in a central line lumen causing the arrest
- May be restarted as needed for hemodynamic stability
- Sedative infusions may be continued if there is a concern about patient awareness.
Small Resternotomy Set

- Sterile all-in-one thoracic drape
- Scalpel
- Wire cutter
- Heavy needle holder
- Sternal retractor.

Upon calling of cardiac arrest, prepare for emergent resternotomy

- Emergent situation = Aseptic Technique -- hand washing is not necessary prior to sterile gloves
- Two staff members
  - Put on sterile gowns and gloves
  - Prepare the emergency sternotomy set
  - A third person should be the circulator to hand-in or open sterile equipment.
  - The surgeon and all assistants
    - Wear sterile gowns and gloves, but face-masks and surgical caps are not essential per EACTS guidelines.
    - However, CDC guidelines for invasive procedures recommend personnel wearing face-masks and surgical caps.

Who Does the Resternotomy?

- EACTS guidelines suggest if a surgeon is not immediately available resternotomy by another staff member maybe be lifesaving.
- State licensure regulations determine who is eligible to perform the resternotomy and internal massage.

Practice makes Perfect Training: Resternotomy Practice

Special Equipment

The sternotomy manikin
Sample Scenario Screen

Key Scenarios
- Bleeding
- Ischemia
- Tamponade
- Respiratory failure
- High output failure
- Acute mitral regurgitation
- Bradycardia
- Ventricular tachycardia
- Supraventricular tachycardia

Benefits of Team Training
- Review equipment
  - Internal paddles, cart trays
  - Pacemakers
- Resuscitation responses
  - Defibrillation/pacing
  - Code management
- Teamwork
- Pre-resuscitation management
  - Early recognition and management of hypotension
  - Avoidance of full blown arrest
  - Critical thinking skills

CALS-S vs ACLS
<table>
<thead>
<tr>
<th>ALS-S</th>
<th>ACLS</th>
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<tbody>
<tr>
<td>For VF/VT</td>
<td></td>
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<tr>
<td>Defibrillation takes priority, may defer massage for up to 1 minute</td>
<td>External massage should be performed on all patients</td>
</tr>
<tr>
<td>3 successive shocks before CPR</td>
<td>CPR → 1 shock → CPR</td>
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<tr>
<td>For Asystole</td>
<td></td>
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<tr>
<td>DDD pacing at maximal output</td>
<td>External massage &amp; vasopressor</td>
</tr>
<tr>
<td>For VF/VT, Asystole, Pulseless Electrical Activity</td>
<td></td>
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<tr>
<td>No vasopressor unless senior MD</td>
<td>Epi 1000 mcg every 3-5 minutes</td>
</tr>
<tr>
<td>Pre-arrest Epi dose &lt; 100 mcg</td>
<td>+/- vasopressin 40 units x 1</td>
</tr>
<tr>
<td>Utilize 6 key roles during arrest</td>
<td></td>
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<tr>
<td>Additional 2 people gown &amp; glove</td>
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</tr>
<tr>
<td>Rapid resternotomy in (&lt;5 min) if no response to defib/pacing</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Emergency Resternotomy Considerations
- Recommended up to POD #10
- Beyond POD #10, senior clinician should decide
- Internal cardiac massage should still be considered in preference to prolonged external compressions especially if a reversible cause is suspected
- EACTs recommends only use in the ICU
  - May consider use in progressive units in early post op days
  - Cardiovascular ICU nurses would respond and direct the emergent resternotomy

Why Implement?
- What happens when we get standardized, “bundle” approaches to patient care?
  - VAP
  - Sepsis
  - CAUTI
Resources For Evidence & Training

- Literature
  - Published guidelines
  - Pocket guide
  - Course book
  - Listserve
- Web
  - csu-als.com
  - Youtube
  - www.lulu.com
- Other

Herrmann, C. Cardiac Advanced Life Support-Surgical Guideline. AACN Advanced Critical Care 2014;26(2).

Implementation

- Thorough review of the guidelines to determine the applicability to your institution's cardiac surgery population
- Identify a change champion and key team members
- Get approval Medical Executive Committee
  - Not currently a course in the USA
  - Create written approved internal protocols for management of cardiac surgery arrest patients
- Attend CALS-S or create your own
- Practice

Key Concepts

- Assess Rhythm
- Shock before Compressions
- Pace/Atropine – not Epi
- Identify reversible causes
- Early re sternotomy

AN OUNCE OF PREVENTION IS WORTH A POUND OF CURE.

Conquering Complications:

Cheryl Herrmann, APN, CCNS-CSC-CMC
Trauma Triad of Death

- Coagulopathy
- Hypothermia
- Acidosis
- Decreased myocardial performance

Cardiac Surgery Triad of Disaster

- Coagulopathy
- Hypothermia
- Metabolic Acidosis
- Decreased myocardial performance

Hypoperfusion Starts the Triad of Disaster

- Coagulopathy
- Hypothermia
- Metabolic Acidosis
- Decreased myocardial performance
Hypothermia

Causes of Heat Loss
- Cooled during CPB
- Cold OR room
- Cool room and/or fan on
- Cold fluids
  - 1 unit of pRBC can lower body Temp 0.25°C
  - 1 liter of fluids unit can lower body Temp 0.5°C
- No blankets
- Head uncovered

Ugly consequences of hypothermia
1. Increased oxygen debt
   - Cold hemoglobin can not release oxygen to the cells
   - Left shift of the oxyhemoglobin dissociation curve
2. Increased lactic acid production
   - Change from aerobic to anaerobic metabolism
   - Leads to acidosis
3. Coagulopathy
   - Prolonged clotting cascade
   - Platelet dysfunction – platelets are extremely temperature dependant
4. Altered cardiovascular function
   - Decreased cardiac output
   - Risk of arrhythmias
   - Increased SVR due to vasoconstriction
5. Hyperglycemia
   - Decrease insulin production
6. Decreased cerebral blood flow
   - 6 – 7% decrease in CBF with body temp decrease of 1°C

Rewarming techniques
- Warm room – no fan
- Warm blankets – keep patient covered
- Bare Hugger
- Use blood warmer to give blood products
  - Have blood warmer and bare hugger in room

Cardiac Surgery Triad of Disaster
- Coagulopathy
- Hypothermia
- Metabolic Acidosis
- LOS Complications Death
- Decreased myocardial performance
Ugly consequences of acidosis

- Decreased cardiac contractility & cardiac output
- Impaired response to catecholamine (ie intropes are not effective)
- Increased PVR
- Vasodilation - decreased SVR
- Bradycardia
- Increased arrhythmia risk
- Coagulopathy
- Compensatory hyperventilation.

Identify cause of acidosis

- Type A Lactic Acidosis
- Type B Lactic Acidosis

Hypothermia causes peripheral vasoconstriction and impairs oxygen delivery to the tissues

Hypovolemia caused by bleeding reduces tissue perfusion

cellular metabolism changes from aerobic to anaerobic

serum lactate levels rise

metabolic acidosis develops

Metabolic Acidosis

- Type B Lactic Acidosis
  - Occurs in the absence of tissue hypoxia
  - May be catecholamine-induced metabolic effect (especially with epinephrine)
  - May be caused by hyperglycemia & alterations in fatty acid metabolism

Metabolic Acidosis

Ongoing Metabolic Acidosis means something is not being perfused

- Type A Lactic Acidosis
  - Reflects impaired tissue oxygenation & anaerobic metabolism resulting from circulatory failure
  - The lactate ion more than the acidemia contributes to potential cardiovascular dysfunction

CHECK BLOOD GLUCOSE
The Value of Lactate

- Serum lactate levels are used to assess the acid-base state and adequacy of tissue perfusion
- By product of anaerobic metabolism if tissue hypoxia (from hypoperfusion) exists
- A change from aerobic to anaerobic metabolism

The Value of Lactate

Serial lactate levels predictor of perfusion
- Normal <2.5mmol/L
- Mild acidosis 2.5-4.9mmol/L (mortality 25-35%)
- Moderate acidosis 5.0-9.9mmol/L (mortality 60-75%)
- Severe acidosis > 10mmol/L (mortality > 95%)


Serum Lactic Acid Levels

- May be the first indication that something is wrong
- Excess lactate demonstrates measurement of tissue oxygen debt
- Results in metabolic acidosis due to tissue hypoperfusion and “starvation”

Serum Lactic Acid Levels

- Increasing lactic acid levels
  - Tissues are hypoperfused
  - Patient is getting worse.
- Decreasing lactic acid levels
  - Tissues are getting perfused
  - Patient is getting better.

Cardiac Surgery Triad of Disaster

Coagulopathy

↑ LOS
Complications
Death

- Metabolic Acidosis
- Decreased myocardial performance
- Hypothermia
-LOS

Triad of Disaster

Coagulopathy

↑ LOS
Complications
Death

- Metabolic Acidosis
- Decreased myocardial performance
- Hypothermia
-LOS

Coagulopathy

↑ LOS
Complications
Death

- Metabolic Acidosis
- Decreased myocardial performance
- Hypothermia
-LOS
Causes of Coagulopathy

- Hypothermia
- Acidosis
- Underlying diseases
- Medications
- Dilation with fluids

Causes

- Mechanical Causes
  - Bleeding from suture lines
  - Clip comes off graft
  - Aortic or ventricular rupture
  - Chest wall bleeders
- Abnormal clotting factors due to
  - Preop anticoagulant meds
  - Systemic heparinization during CPB
  - Breakdown of factors during CPB

Signs & Symptoms

- CT bleeding > 100 – 200 cc/hr
- Low or labile B/P
- Low CVP or PAD
- Falling SvO₂ and CO/CI
- Abnormal clotting Factors
- Bleeding from line sites, incisions

Treatments

- Monitor CT output. May need to replace CT output cc for cc with packed cells
- Keep B/P < 140 to prevent stress on suture lines
- Keep CT patent by gently milking and stripping
- Use warming blanket to keep normal thermic.
  - Hypothermia interferes with clotting factors
- Keep sedated – possibly add PEEP
Treatment: Blood and Blood Products

- Give blood and blood products
- FFP for ↑ PT or PTT
- Platelet Phoresis for ↓ Platelet count
- Cryoprecipitate for ↓ Fibrinogen level
- Packed cells for ↓ H & H

Rule of thumb

- Replace CT output ml for ml
- After every 4th unit pRBCs
  - Calcium Chloride
  - FFP

Keep blood on HOLD --- communicate with blood bank that you have a bleeder

- May need to use type specific blood

Treatments

- Pharmacological Interventions
  - Protamine to reverse effects of systemic heparinization
  - Aminocaproic Acid (Amicar) to inhibit conversion of plasminogen to plasmin
  - Desmopressin to improve platelet function
- May need to return to surgery to repair mechanical cause of bleeding

Bleeding patient summary of vital signs

<table>
<thead>
<tr>
<th>Time</th>
<th>Chest tube output</th>
<th>Art B/P</th>
<th>HR</th>
<th>PAS/PAD</th>
<th>CVP</th>
<th>SVO2</th>
<th>CO</th>
<th>CI</th>
<th>SVR</th>
<th>Temp</th>
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<tr>
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Pt received 3 units of pRBCs
Compression of the heart due to collection of fluid or blood in the pericardial space

Cardiac Tamponade: Causes
- Blood accumulated in the chest from:
  - CTs clotted off and unable to drain excess blood
  - Epicardial wire removal
- May occur quickly within minutes of hours or may occur slowly over days or weeks

Cardiac Tamponade: Signs & Symptoms
- Hypotension
- Low urine output
- Rising & equalization of CVP & PAD
- Falling $SVO_2$, CO/CI
- Sudden decrease in CT output
- Widening mediastinum on CXR
- Neck Vein Distention
- Tachycardia
- Pulses Paradox $> 20$ mmHG
- Diminished heart sounds
- For tamponade that occurs slowly may also see these S/S:
  - Shortness of Breath
  - Chest Pain
  - Ischemic changes on EKG
  - Nausea

Cardiac Tamponade
- Beck’s Triad
  - Hypotension
  - Neck vein distention
  - Muffled heart sounds

Cardiac Tamponade: Treatment
- Urgent surgical exploration to evacuate excess blood & correct cause of the tamponade
- Bedside echo may be used to make differential diagnosis between tamponade & LV failure
- Administer fluids & inotropes or Calcium Chloride until patient can be returned to OR
- Prepare for possible exploration of chest at bedside
Don’t miss the obvious!

In Summary
Cardiac Arrest...
- In the immediate postop recovery in a cardiac surgery patient is typically related to reversible causes
  - Tamponade
  - Bleeding
  - Ventricular arrhythmias
  - Blocks associated with conduction problems
- Survival to discharge can be up to 79%
  - If treated promptly