Andrea Gabrielli, MD, FCCM

Cardiac Arrest: General Considerations

Cardiopulmonary resuscitation (CPR) is described as “a series of assessments and interventions performed during a variety of acute medical and surgical events where death is likely without immediate intervention.” Among these events, sudden cardiac arrest (SCA) is a leading cause of death in the USA in adults. Cardiac arrest (CA) is defined as “cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.” As its name implies, in the prehospital arena adults SCA is most commonly due to Ventricular Fibrillation (VF) due to ischemic heart disease; asystole and pulseless electrical activity (PEA) are less common initial rhythms with SCA, although these rhythms may represent the initial identified rhythm in adults who experienced an acute VF or ventricular tachycardia (VT) event. Although VF/VT are considered to be the most common out-of-hospital (OOH) arrest rhythms, only 20-38% of in hospital arrest patients have VF or VT as their initial rhythm. In contrast, children and young adults require CPR most commonly for respiratory arrest, airway obstruction or drug toxicity. VF/VT is identified as the initial rhythm in 5 to 15% of OOH arrests in children. Other conditions like trauma, external or internal hemorrhage, drowning, etc. may call for resuscitation at any age.

Regardless of the cause, immediate and effective CPR can save lives. In patients with witnessed VF CA, CPR doubles or triples the rate of survival. Unfortunately, only ~27% of OOH arrest victims receive bystander CPR. The primary goal of CPR is to generate sufficient oxygen delivery to the coronary and cerebral circulations to maintain cellular
viability while attempting to restore a perfusing cardiac rhythm by defibrillation, pharmacological intervention, or both.

In general, effective CPR can be performed by following a few basic rules.

➢ Immediately assess the environment for danger and move the patient if necessary.

➢ Minimize the time from cardiac arrest recognition to starting effective CPR. For every minute without CPR during witnessed VF CA, survival decreased by 7-10% in contrast to a decrease in survival by 3-4% per minute when bystander CPR preceded attempted defibrillation.

➢ Defibrillate immediately if a defibrillator is available (<3-5 minutes) in patients with shockable rhythm (VF or pulseless ventricular tachycardia). This should be the primary treatment focus within the first few minutes of SCA due to ventricular fibrillation. For each minute delay in defibrillation, chances of eventual hospital discharge decreased by 8-10%. Note that if the time from arrest to EMS arrival and initiation of CPR is more than five minutes, provision of two minutes of CPR before attempted defibrillation is associated with improved outcome.

➢ “Push hard and fast” during chest compressions and minimize the duration of interruptions to reassess the patient’s rhythm. It is recommended to interrupt chest compressions about every 2 minutes to assess the rhythm and switch rescuer if feasible.

➢ While CPR is being performed attempt to identify the cause of arrest. Although the steps of CPR are uniform, other resuscitation interventions may be indicated based on the cause of CA. If the patient fails to respond to standard CPR
interventions think about delayed recognition and, recall the H’s and T’s to help identify a potentially correctable cause for ongoing cardiac arrest.

- Good teamwork increases the effectiveness of resuscitation when more than one rescuer is available.

- Attention to post-resuscitation care is an important element of neurological outcome. Focus on restoring and supporting cardiac output and tissue perfusion, monitoring and maintaining normal blood glucose concentrations, treating the underlying cause of the arrest, avoiding hyperthermia and considering therapeutic hypothermia to maximize survival and cerebral recovery.

- If the patient fails to respond to effective CPR, appropriate judgment is needed as to when to stop resuscitative efforts.

Guidelines for CPR and advanced adult and pediatric advanced life support are published every five years by the American Heart Association (AHA). These guidelines are based on an extensive evidence-based review by national and international experts leading to the publication of a consensus on science and treatment recommendations prepared by the International Liaison Committee on Resuscitation (ILCOR).

**Cardiac Arrest During Anesthesia**

Cardiac arrest during anesthesia has become a rare event. The development of better monitoring, safer medications, adoption of clinical standards and advances in knowledge and training have all had a significant impact on patient safety. Despite this, cardiac arrest during anesthesia still occurs, and with prompt recognition, diagnosis and treatment can
be successfully managed.

Although general anesthesia represents one aspect of health care where the risk of death is relatively low, challenging surgical indications are now being extended frequently to higher-risk cardiovascular and elderly patients. Furthermore anesthetic procedures have extended outside the operating room (O.R.) into arenas such as the radiology and gastroenterology suites, and the role of the anesthesiologist has become prominent in the intensive care unit. The practice of anesthesiology and critical care medicine puts the anesthesiologist in a unique position to lead all in-hospital resuscitation in North America, with extension to prehospital care in many European emergency systems where they participate directly in ambulance rescue teams.

In the perioperative setting, patients typically deteriorate into a pulseless arrest over a period of minutes or hours, under circumstances wholly dissimilar to other in-hospital or out-of-hospital scenarios. Consequently, aggressive measures taken to support their physiology can avert, avoid, or forestall the need for ACLS. Additionally, patients in the perioperative period have a different milieu of pathophysiology. For example, hypovolemia is far more common than transmural infarction from plaque rupture and intraoperative myocardial ischemia from O2 delivery consumption imbalance rarely evolves to full pump failure or ventricular fibrillation in the operating room. The result is a different spectrum of dysrhythmias and desirable interventions in the operating room than in the Emergency Department. The most common cardiac dysrhythmia during general and neuraxial anesthesia is bradycardia followed by asystole (45%). The other
life threatening cardiac rhythms are severe tachydysrrhythmias including ventricular
tachycardia, ventricular fibrillation (14%), and pulseless electrical activity (7%).
Remarkably, in 33% of the cases the heart rhythm is not fully assessed or documented.
While the cause of circulatory arrest is usually unknown in patients found down in the
field, there is a relatively short list of probable causes in patients who have circulatory
collapse in the perioperative period. This certainty produces more focused and etiology
based resuscitation efforts, which frequently do not comply with the more generic
algorithms of the ACLS guidelines.

**Common Situations Associated with Peri-op Circulatory Crisis are listed below:**

**Anesthetic**
- Intravenous anesthetic overdose
- Inhalation anesthetic overdose
- Neuraxial block with high level sympathectomy
- Local anesthetic systemic toxicity
- Malignant hyperthermia
- Drug administration errors

**Respiratory**
- Hypoxemia
- Auto PEEP
- Acute Bronchospasm

**Cardiovascular**
- Vasovagal reflex
- Hypovolemic and/or hemorrhagic shock
- Tension Pneumothorax
- Anaphylactic Reaction
- Transfusion Reaction
- Acute Electrolyte Imbalance (high K)
- Severe Pulmonary Hypertension
- Increased intraabdominal pressure
- Pacemaker failure
- Prolonged Q-T syndrome
- Acute Coronary Syndrome
- Pulmonary Embolism
- Gas embolism
- Oculocardiac reflexes
- Electroconvulsive therapy

Sequence Rescue Approach for Cardiac Arrest in the OR
Based on the 2005 AHA guidelines (modified)
A Proposed Megacode for the OR Logistics

[Flowchart diagram]

1. Check EKG Leads
   - Check Pulse O2
   - Hold Surgery/Anesthetic Check
   - Anesthesia Machine Check
   - Check Airway
   - Effective CPR
   - Appropriate Ventilation
   - Call for Help

2. Think/Differential Diagnosis

   Shockable
   - Check rhythm
   - Shockable rhythm?
     - Give 1 shock
     - Manual biphasic device specific
     - (typically 100 to 200 J)
     - Monophasic 360 J
     - Resume CPR immediately

   Not Shockable
   - Asystole/PEA
   - Resume CPR immediately
     - 5 cycles
     - Epinephrine 1 mg IV/D
     - Repeat every 3 to 5 min or
     - May give 1 dose of vasopressin 40 U IV/D to replace first or second dose of epinephrine
     - Atropine 1 mg IV/D for asystole or slow FE rate
     - Repeat every 3 to 5 min (up to 3 doses)

3. Attempt transvenous/chronous pacer
   - Asynchronous, max MA output rate 100 cpm
   - Check pulse or arterial line present for capturing

4. Give 5 cycles of CPR
   - Check rhythm
   - Shockable rhythm?
     - Give 2 cycles of CPR
     - Continue CPR while defibrillator is charging
     - Manual biphasic device specific
     - (same as first shock or higher dose)
     - Note: unknown, use 200 J
     - Monophasic 360 J
     - Resume CPR immediately after shock
     - Consider anti-arrhythmia, give during CPR
       - Isoproterenol (80 mg/kg IV/D) or lidocaine (1 to 1.5 mg/kg IV/D)
     - First dose, then 0.6 to 0.7 mg/kg
       - IV/D, max/min 3 doses or 3 mg/kg
     - Consider magnesium, loading dose 2 g IV/D
       - for torsades de pointes

5. Check rhythm
   - Shockable rhythm?
     - Check CPR
       - Shockable
         - Go to Box 1
       - Not Shockable
         - Shockable
         - Go to Box 8H and 8T

6. During CPR
   - Rush hands and feel (100 cpm)
   - Ensure full circulatory
     - Minimize interruptions in chest compressions
     - One cycle of CPR: 30 compressions then 2 breaths
     - 5 cycles = 2 min
     - Avoid hyperventilation
     - Secure airway and confirm placement
     - After an advanced airway is placed, rescuers no longer deliver "cycles" of CPR.
     - Give continuous chest compressions without pause for 2 minutes delivered to 10 breaths/min. Check pulse and rhythm...
Cardiac Arrest in the OR: Special Considerations

- Wide open IV crystalloid without glucose unless hypoglycemia suspected.
- Ventilate by hand or anesthesia machine 10 min VT 5-7 ml/kg confirmed by spirometry or chest rise asynchronous with chest compressions
- Surgeon stand-by for possible open chest cardiac massage

Differential Diagnosis for perioperative PEA or Asystole: 8H & 8T

<table>
<thead>
<tr>
<th>Hypoxia</th>
<th>Trauma/hypovolemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Tension Pneumothorax</td>
</tr>
<tr>
<td>Hyper-vagal</td>
<td>Thrombosis of Coronary</td>
</tr>
<tr>
<td>Hydrogen Ion</td>
<td>Tamponade</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Thrombus in Pulmonary Artery</td>
</tr>
<tr>
<td>Malignant Hyperthermia</td>
<td>Long QT syndrome</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>Toxins (anaphylaxis)</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Pulmonary HTN</td>
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</tbody>
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Causes of PEA arrest and the EKG rhythm that most often precedes them

<table>
<thead>
<tr>
<th>Cause of PEA</th>
<th>Pre Arrest Rhythm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Narrow complex tachycardia or bradycardia</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>Bradycardia</td>
</tr>
<tr>
<td>Auto-PEEP</td>
<td>Narrow complex Tachycardia that devolves into bradycardia</td>
</tr>
<tr>
<td>Vaso-Vagal</td>
<td>Bradycardia, sometimes associated with peaked T waves</td>
</tr>
<tr>
<td>Anaphylaxis</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Tension Pneumothorax</td>
<td>Narrow complex tachycardia, then bradycardia</td>
</tr>
<tr>
<td>Tamponade</td>
<td>Narrow complex tachycardia</td>
</tr>
<tr>
<td>RV arrest</td>
<td>Narrow complex tachycardia which devolves into bradycardia</td>
</tr>
<tr>
<td>PA HTN</td>
<td>RBBB, RV strain</td>
</tr>
<tr>
<td>Coronary Syndrome/LV arrest</td>
<td>Q waves, ST depression followed by ST elevation, VT/F</td>
</tr>
<tr>
<td>Hyperkalemia complex PEA</td>
<td>peaked T waves, widened QRS, sine wave wide</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Narrow complex tachycardia</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>J or Osborne Waves</td>
</tr>
<tr>
<td>Long QT syndrome</td>
<td>Bradycardia</td>
</tr>
<tr>
<td>Hypokalemia</td>
<td>Flattened T waves, prominent U waves, widened QRS, prolonged QT, wide complex tachycardia</td>
</tr>
</tbody>
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Note: A more comprehensive review of this topic by the author is available on the ASA website, at http://www.asahq.org/clinical/Anesthesiology-CentricACLS.pdf