CARDIOPULMONARY RESUSCITATION - CPR
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• The #1 cause of cardiopulmonary arrest in adults is the acute coronary syndrome, usually via ventricular fibrillation...

Statistics:
• 300,000 cases/ year in the U.S.
• Out of hospital cardiac arrest survival (to hospital discharge): 5%

Note: This chapter discusses the evaluation & treatment of non-trauma patients. For patients w/ traumatic extremis or cardiopulmonary arrest (via blunt or penetrating trauma), an emergency thoracotomy (NOT basic life support – BLS or ACLS medications) is indicated... allowing for:
  • Evacuation of pericardial tamponade
  • Evacuation of tension pneumo &/or hemothorax
  • Direct control of intrathoracic vascular &/or cardiac hemorrhage
  • Control of air embolism
  • Cross–clamping/ occlusion of the descending aorta to redistribute blood flow & limit subdiaphragmatic hemorrhage
  • Direct cardiac massage/ defibrillation

‘CHAIN OF SURVIVAL’

1. CHECK FOR CONSCIOUSNESS
• Assessed by tapping on the patient, & shouting for the patient to wake up
  • If unresponsive, initiate an emergency medical response
    – Hospital: Have someone call a ‘code blue’ to activate the in-house code teams
    – Community: Have someone call 911, & obtain an automated external defibrillator – AED, becoming increasingly available in
public locations
• If no one is nearby, initiate the emergency medical response yourself & return to the patient to initiate CPR. However, if the arrest is due to hypoxemia, such as w/ suffocation or drowning, provide 2 minutes of CPR prior to initiating the emergency medical response

2. PERFORM A 5 SECOND SURVIVAL ASSESSMENT BREATHING (If the patient is breathing, a pulse must be present)
  • Assessed by looking, listening, & feeling for both:
    ◦ A rising & falling chest & abdominal wall
    ◦ Nasal or oral exhalation

CIRCULATION (may be skipped by the untrained rescuer)
• Assessed by palpating for a carotid pulse
  ◦ A palpable carotid artery pulse indicates a systolic blood pressure > 60mmHg
  ◦ A palpable femoral artery pulse indicates a systolic blood pressure > 70mmHg
  ◦ A palpable radial artery pulse indicates a systolic blood pressure > 80mmHg

3. PERFORM BASIC LIFE SUPPORT — BLS
   IF NO PULSE IS PALPATED
• Initiate chest compressions. Chest compressions delivered to patients subsequently found not to be in cardiac arrest rarely cause significant injury
  ◦ If not intubated: 30 chest compressions, interrupted by 2 ventilations, each over 1 second
    — Untrained rescuers should administer the easier ‘Hands Only’ (compression — only) CPR
  ◦ If intubated: ≥ 100 chest compressions/ minute without interruption, w/ ventilation @ 10–12/ minute

IF A PULSE IS PALPATED, BUT THE PATIENT IS NOT BREATH-
ING
• Assess the airways for patency by viewing the oral cavity
  ◦ Remove a possible obstruction via a finger sweep or suction device
• Tilt the head backwards (except if cervical spine injury is suspected†) & thrust the mandible forward w/ your 3rd–5th digits under the bilateral mandibular rami→
  ◦ **Open airway.** This position must be maintained for adequate ventilation until the patient is intubated
• **Give 1 positive pressure ventilation q5seconds,** each over 1 second‡ via:
  ◦ Mouth to mouth (while pinching the nose closed)
  ◦ Mouth to nose
  ◦ Bag–valve mask
  ... while looking & feeling for the corresponding rise & fall of the chest & abdominal wall

† Although the mandible thrust may itself cause spinal movement, if there is reason to suspect cervical spine injury, attempt the maneuver initially without tilting the head. However, if this fails to open the airway, tilt the head back regardless, as the priority is an open airway
‡ As overly abrupt ventilations→
  • Gastric distention→
  ◦ ↑Aspiration risk

4. PERFORM ADVANCED CARDIAC LIFE SUPPORT—ACLS
• Electrical cardioversion or defibrillation as indicated
• Intravenous, intrapulmonary, or intraosseous medications as indicated
• Search for, & attempt to treat the etiology

THE RESUSCITATION EFFORT

GOAL OF CARDIOPULMONARY RESUSCITATION—CPR
• Organized electrocardiographic—ECG activity→
  ◦ Tissue perfusion, as inferred from a palpable pulse, not con-
scioussness

• The predictors of successful resuscitation are:
  • Early initiation of CPR
  • Early defibrillation as indicated

...as neither the insertion of an advanced airway nor any medication has been shown to ↑ neurologically intact survival to hospital discharge.

Outcomes:
• ↑Delay in initiating defibrillation →
  • ↓Survival
    – A 5-minute delay → 40% ↓ survival, w/ a 10% ↓ q 5 minutes thereafter

TEAMWORK CPR
• One person should assume a leadership role (usually a senior physician knowledgeable about cardiac resuscitation if in a hospital) & immediately assign resuscitation tasks to the others involved = the team, as well as make clinical decisions (while inviting suggestions from team members) without directly performing procedures
• The decision to terminate resuscitative efforts should be agreed upon by all team members
• Regardless of the outcome, the code leader should debrief the team so that all may learn from the experience

PROPER TECHNIQUES
HOW TO PROPERLY PERFORM CHEST COMPRESSIONS
1. Place yourself at the patient’s side w/ knees to the floor, or to the bed, depending on where the patient is found
2. When possible, move the patient to a bed or gurney for easier patient access & management by the code team
   • If cervical spine injury is suspected, place on a flatboard & position a cervical spine collar prior to movement
3. Place the heel of 1 hand over the lower half of the sternum @ the nipple line, w/ the other hand atop the first
4. Maintain shoulder position directly above your hands & lock your
elbows
5. Use your entire upper body as a pendulum to intermittently compress directly downward \( \geq 2" \) @ \( \geq 100/ \text{minute} \), without ever lifting your hands off position
   • If this action does not produce a palpable carotid pulse, ↑chest compression force

Closed vs. open chest compression:
• Closed chest compressions→
  ◦ Near-equivalent rise in both arterial & right atrial pressures→
    →↓Arteriovenous pressure gradient→systemic blood flow < 25% normal levels
• Emergent thoracotomy, w/ direct ventricular massage→
  ◦ ↑Arterial pressure w/ ↓right atrial pressure→
    →↑Arteriovenous pressure gradient→ ≥ normal systemic blood flow

HOW TO PROPERLY VENTILATE A PATIENT
1. W/ the head tilted back & mandible thrust forward, insert a plastic oral airway (which serves to keep the tongue forward) & place a bag–valve mask on the patient
2. Use your 3rd–5th digits to maintain the head position while placing your thumbs & index fingers around the mask in a ‘C’ like shape, maintaining a strong skin–mask seal
   • You may use both hands while another person ventilates, or maintain position & seal w/ your dominant hand alone
3. During intubation attempts, CPR should not be held for > 20 seconds, after which time the laryngoscope should be withdrawn, & CPR continued until the next intubation attempt
4. Once the patient is intubated (as evidenced by carbon dioxide detection), detach the bag device from the mask, attach it to the endotracheal tube, & continue ventilations @ 10–12 breaths/minute without interruption

MEDICATION ADMINISTRATION
• It is preferable to administer intravenous medications via a central
venous line
  - ↓Systemic distribution time by ≥ 2 minutes
  - Intravenous access below the diaphragm (ex: femoral vein) should not be used, as there is minimal subdiaphragmatic venous blood flow during cardiac arrest
  - If a central venous line is unavailable, medication may be given via either of the following until a central venous line is placed
    - A peripheral intravenous line, followed by a 20mL saline flush, w/ limb elevation X 10–20 seconds
    - Intraosseous cannulation. Commercially available kits can facilitate intraosseous access
    - Endotracheal tube @ 2–3X the intravenous dosage (except Vasopressin, which is administered in the same 40 unit dosage), as pulmonary blood flow is significantly compromised →
      - Minimal transalveolar medication absorption

Medications which can be administered via endotracheal tube:
  - Lipid soluble medications, such as Naloxone, Atropine, Vasopressin, Epinephrine, Lidocaine = NA静脉

Proper administration of medication via an endotracheal tube:
  - Interrupt chest compressions, & inject a mixture of the medication in 10mL normal saline or distilled water into the endotracheal tube, w/ several subsequent bag–valve mask ventilations prior to resuming chest compressions →
    - Medication nebulization to the alveoli →
      - ↑Absorption

Contraindications:
  - Never give NON–LIPID SOLUBLE medications (SODIUM BI-CARBONATE, glucose, calcium) via endotracheal tube, as they will damage the airways mucosa, having a caustic effect

Rational for administering Epinephrine or Vasopressin:
  - Epinephrine & Vasopressin → systemic vasoconstriction →
• ↑Peripheral vascular resistance →
  – ↑Aortic diastolic blood pressure → ↑**coronary perfusion pressure**
• Relatively ↑external carotid artery vasoconstriction →
  – Internal carotid artery shunting of blood → ↑**cerebral perfusion pressure**
• Epinephrine is used in asystole due to its:
  • **Pro–dysrhythmic potential** →
    – ↑Chance of conversion to a shockable, & thereby more potentially treatable rhythm
  • Bronchial smooth muscle relaxation effects →
    – Improved ventilation

**MONITORING ORGAN PERFUSION STATUS DURING CPR END TIDAL PCO2**

• End tidal or end–expiratory CO₂ is usually <10mmHg in cardiac arrest patients (normal is 40–45mmHg, being nearly equivalent to the arterial PCO₂), being measured in real time, on a breath by breath basis via nasal cannula or endotracheal tube
  • A value ≤10mmHg after 20 minutes of CPR indicates unlikely successful resuscitation

**Pathophysicsology:**
  • ↑Systemic perfusion pressure →
  • ↑Pulmonary CO₂ delivery →
    – ↑End tidal CO₂, indicating ↑organ perfusion & better prognosis

**VENOUS BLOOD GAS ANALYSIS**

• Venous blood more accurately represents peripheral tissue oxygenation & acid/base status than arterial blood

**CPR LENGTH**

• Length of cardiac arrest prior to the initiation of CPR, the presence of asystole, & etiology are the determinative factors
  • If asystole, continue CPR for 10 minutes↑
  • For all other dysrhythmias:
- If < 6 minutes prior to CPR initiation, continue CPR for 30 minutes†
- If > 6 minutes prior to CPR initiation, continue CPR for 15 minutes†
  ...as prolonged CPR →
  • Ischemia & nutrient paucity mediated neuronal cell dysfunction ± death = anoxic encephalopathy →
    ◦ Neurologic impairment. Even within the parameters listed, neurologic impairment is common, & may be transient or permanent
• Normothermia (≥ 97°F) must be met prior to the termination of any cardiac resuscitation

† Satisfactory neurologic recovery has occurred several hours after beginning resuscitation, if due to, or accompanied by Barbiturate overdose, Childhood, Drowning, Electrocutation, or Hypothermia

ONCE RESUSCITATED
• The patient should be monitored in an intensive care unit
• Most successfully resuscitated patients do not immediately regain consciousness, due to anoxic encephalopathy. Comatose patients may need mechanical ventilation if they lack either:
  ◦ Spontaneous respiration
  ◦ Adequate ventilation, as per arterial blood gas values
  ...w/ ischemia & nutrient paucity mediated neuronal cell dysfunction ± death = anoxic encephalopathy →
  • †Time needed to heal to the point of regaining consciousness, the length of which is inversely proportional to the prognosis for a favorable neurologic recovery
  ◦ If > 24 hours, only 10% will successfully recover most of their neurologic function, w/ concomitant absence of the pupillary light reflex indicating a very low probability of any neurologic recovery
  ◦ If > 1 week, only 5% will successfully recover most of their neurologic function
If > 2 weeks, no neurologic recovery occurs

- Once conscious, the patient may manifest:
  - Behavioral disturbances
  - Post-arrest amnesia
  - Other neurologic impairment, which may be severe

**Neurologic assessment via brainstem reflexes**

- **Dolls eye maneuver**
  - Elicited by rotating the patients head from side to side. If the patient has suffered trauma, ensure that the cervical spine is stable via x ray prior to performing this test
  - An intact brainstem is indicated by an intact vestibulo-ocular reflex attempting to stabilize the eyes in space in order to maintain a steady retinal image, w/ both eyes deviating away from the direction of rotation, resembling the fixed forward gaze of a doll’s eye
  - A dysfunctional brainstem is indicated by no eye deviation

- **Ice water caloric**, being a stronger stimulus than the dolls eye maneuver
  - Elicited by injecting 50mL of ice cold water into the external auditory canal of a supine patient whose head is at a 30° angle, which orients the lateral semicircular canals in the most vertical plane. View the tympanic membrane to rule out perforation prior to performing this test
  - An intact brainstem is indicated by both eyes deviating towards the irrigated ear, as the cold inactivates the ipsilateral vestibular input to the eye movement center. This typically begins @ 20–30 seconds, lasting ~1 minute. If the patient is not in a coma, contralateral saccades also appear, being a corrective fast phase beat away from the cold stimulus. The eyes should be observed for one minute after irrigation is completed, repeating the test on the other side after 5 minutes
  - A dysfunctional brainstem is indicated by no eye deviation
• **Corneal reflex**
  - Elicited by using either a wisp of cotton to lightly touch the cornea, or a straw or syringe to squirt air at the cornea (not the scleral conjunctiva which is less sensitive)
  - An intact brainstem is indicated by a bilateral blink reflex
  - A dysfunctional brainstem is indicated by no blink reflex

**THERAPEUTIC MILD HYPOTHERMIA**
• **Normal average core body temperature is 98.6°F (37°C)**
• Induced mild hypothermia to a **core body temperature of 90–95°F (32–35°C) X 12–24 hours, IMPROVES NEUROLOGIC OUTCOME** in patients who remain comatose after successful resuscitation
• Obtain a baseline temperature via the rectum
• **Induction can be achieved quickest via peripheral bolus administration of refrigerated 40°F (4°C) intravenous fluids, w/ each liter decreasing body temperature by ~2°F (1°C)**
• Bolus administration prevents fluid rewarming. The safety of central vein infusion, however, is not known
• Subsequent rewarming is passive, avoiding rebound hyperthermia

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The following methods can be used for either induction or maintenance:
• Cooling blankets (under & over the patient, w/ separation via a sheet to ↓burn), mattresses, or vest systems
• Ice packs @ axilla, groin, & sides of neck
• Refrigerated saline lavage (gastric &/or urinary bladder)
• Femoral vein cooling catheter

Concurrent methods:
• Turn off room thermostat
• Acetaminophen in order to offset possible development of fever
• Avoid shivering mediated ↑temperature, usually beginning @ the neck & thorax, perhaps only noted via palpation (or as artifact on electrocardiograph–ECG). Subsequent involvement of the upper, followed by lower extremities occurs
  ◦ Magnesium sulfate–MgSO₄, Opioids (ex: Fentanyl, Meperidine, Morphine), Propofol, & Buspirone have antishivering properties
  ◦ Counter–warming of the extremities & head
  ◦ Further lowering the temperature, as there is a threshold temperature for shivering, below which it ceases
  ◦ Neuromuscular blockade, via bolus administration of Cisatracurium (Onset: 3minutes, Duration: 30minutes), which undergoes spontaneous degradation, termed Hofmann degradation – being organ independent, w/ no risk in patients w/ renal or hepatic failure
    –Prevents assessment of level of consciousness, requiring a sedative to be administered to ensure that patients do not awaken while they are cold & paralyzed
    –Prevents seizure recognition, requiring continuous electroencephalographic–EEG monitoring

Preferred temperature monitoring sites for induction:
• Central vein, being real time
• Esophagus, placing the tip in the distal third, being behind the heart, w/ the temperature lagging behind the core by only 5 minutes
...whereas **rectal & urinary bladder temperatures lag behind the core temperature by ~20 minutes during rapid temperature changes**, as w/ *induction of hypothermia*, which may lead to overcooling. Urinary bladder temperature is also contingent on urine output

**Monitoring:**

- **Mild hypothermia**→
  - **Cardiovascular**
    - ↓Myocardial metabolism→**sinus bradycardia**
    - **Dysrhythmia**
  - **Hematologic**
    - ↓Insulin secretion & sensitivity→**hyperglycemia**
      - Hypokalemia
      - Hypomagnesemia
      - Hypocalcemia
      - Hypophosphatemia
    - Coagulopathy
    - Leukopenia
    - Thrombocytopenia

*Via intracellular shift & diuresis (being reversed during rewarming)*

**Relative contraindications:**

- **Pregnancy**: May be performed in consultation w/ Obstetrics–Gynecology