Essential Learning

Hypothermia

- **Differential Diagnosis**
  - The differential for altered mental status is broad
  - In the context of hypothermia, both primary hypothermia and secondary hypothermia should be considered:
    - Infection (including meningitis and encephalitis)
    - Trauma (whether accidental or NAT)
    - Arrhythmias
    - Toxic ingestion, medication overdose or substance use
    - Neurologic causes (seizure, hemorrhage)
    - Metabolic/Endocrine (hyponatremia, hypothyroidism/myxedema, hypoglycemia, uremia, adrenal insufficiency)

- **Monitoring temperature in hypothermic patients**
  - Axillary and oral temperatures are often unreliable
  - Esophageal probe (in lower 1/3rd of esophagus) is preferred in intubated patients
  - 2nd line is rectal probe (inserted to 15 cm depth) or bladder probe
    - Will often lag behind true core temp
    - Can be falsely elevated during bladder/peritoneal lavage
  - Core temperature monitoring should be done for stages II-IV

- **Vital sign and ECG abnormalities typical in severe hypothermia**
  - Bradypnea
    - Typically appropriate for decreased metabolic demands
    - Avoid over ventilation in intubated patients
      - respiratory alkalosis may increase myocardial irritability
    - Pulse oximetry has limited accuracy
      - oxygen saturation should be determined by ABG
  - Bradycardia
    - Decreased cardiac output may be appropriate for decreased metabolic demands
    - Vasoconstriction can make detecting pulses difficult
    - Allow for 30-45 seconds to palpate carotid or femoral pulses and consider doppler or POCUS for cardiac function
    - Transcutaneous pacing is typically not required unless bradycardia persists despite rewarming
    - Relative tachycardia suggests secondary hypothermia and a comorbid condition
  - Hypotension

        - Hypotension is common in moderate to severe hypothermia due to dehydration and fluid shifts
        - this may worsen with rewarming
        - WARM IV fluids (40 to 42°C) are first line; norepinephrine may be considered in refractory hypotension
        - IO or a femoral central line may be needed
            - IJ and SC lines may irritate the right atrium and precipitate arrhythmias
    - What are the EKG findings seen with hypothermia?
        - Findings typically seen at < 32˚C and include:
            - Sinus bradycardia
            - Atrial fibrillation with slow ventricular rate
            - Prolongation of PR and/or QT intervals
            - Osborne wave (or J-wave)- extra deflection at terminal junction of QRS and beginning of the ST-segment takeoff (can also be seen with hypercalcemia and ICH)
                - Height of J-wave roughly correlates with degree of hypothermia
        - Ignore arrhythmias in a perfusing patient; rewarming is key

- **General stages, symptoms and treatment for hypothermia**
    - Mild Hypothermia
        - 35 - 32˚C, 90-95°F
        - Conscious, shivering, tachycardia, tachypnea
        - Warm, dry environment (remove wet clothes), heated blankets, consider forced air warming systems
        - Doesn't require core temp monitoring
    - Moderate Hypothermia
        - < 32 - 28˚C, 82-90°F
        - Altered, +/- shivering, bradycardia, atrial fibrillation, cold diuresis
        - **Active External Rewarming**
            - Warm, dry environment (remove wet clothes)
            - Forced air rewarming (e.g., Bair Hugger)
                - Rewarming rates are ~1-3˚C/hr
                - Electric blankets have similar efficacy to forced air
                - Consider external adaptive temperature control device using a circulating water bath (e.g. Arctic Sun)
                - Avoid radiant heating systems that may burn skin
                - Hot water baths are not recommended due to limitations placed on monitoring
            - Warm IV fluids (40 to 42°C) and warm humidified oxygen
                - Minimally effective at increasing core temp but prevent additional heat loss
        - Core temp monitoring
        - Minimize movements to avoid dysrhythmias (limited evidence to support this)

- Severe Hypothermia
  - < 28˚C, <82°F
  - Unconscious, no shivering, areflexia, muscle rigidity, fixed dilated pupils, loss of ocular reflex, pulmonary edema, hypotension - - > absent vital signs and ventricular fibrillation
  - These patients require a massive amount of departmental resources and time for resuscitation and are likely to include prolonged CPR, intubation, IO or central and arterial line placement, OG tube, foley, possible chest tubes (x4), etc; recruit help and mobilize supplies
  - **Active External + Internal Rewarming**
    - Stage II measures
    - ECMO is preferred, if available within 6 hours;
      - May reduce mortality 40-90%)
      - Hemodialysis may be considered as an alternative
    - If ECMO isn't available, consider warm bladder, gastric, thoracic and/or peritoneal lavage (see below)
  - For intubation, consider half dose RSI medications and expect a prolonged delay before onset
  - For cardiac arrest, guidelines for ACLS meds are controversial (may be ineffective and potentially harmful if ROSC is obtained)
    - Epinephrine and defibrillation may be considered, but repeated attempts should be avoided until the patient is warmed to 30°C or multiple degrees from initial core temp
    - Continue resuscitation until the core temp is at least 32°C
    - "They're not dead 'til they're warm and dead"

- **Techniques for active internal rewarming**
  - ECMO
    - Most effective rewarming technique
    - Allows for organ perfusion during cardiac arrest
    - Rewarming rates are ≥ 9˚C/hr
    - Consider transfer to ECMO center if available within 6 hours
    - Alternatives may include hemodialysis or cardiopulmonary bypass
  - Thoracic cavity lavage
    - Requires placement of two thoracostomy tubes (36F) on each side
      - Avoid left-sided chest tubes in a perfusing patient
      - Generally reserved for patients in cardiac arrest or with severe hypothermia; technically challenging in a patient undergoing CPR
      - Anterior (infusion) tube should be placed in the second or third intercostal space in the midclavicular line
        - Alternatively, may consider pigtail placement
      - Posterior (drainage) tube should be placed in the fifth or sixth intercostal space in the posterior axillary line

                - Drain fluid to wall suction or large cavity drainable bag
            - Warmed (40-42˚C) fluid is infused through the anterior tube and drained via the posterior tube
            - Tension hydrothorax can occur if adequate drainage is not ensured
            - Flow rates vary between 180-850 mL/minute requires a large volume of warmed fluid (10-30 liters/hour)
            - Rewarming rates are ~3-5˚C/hr
    - Peritoneal lavage
        - Warmed (40-42˚C) fluid is infused through a peritoneal catheter
        - Similar catheter placement as DPL
        - Fluid is removed after a dwell time of ~20-30 minutes
        - Rewarming rates are ~1-3˚C/hr
        - To speed rewarming, a second catheter can be placed for drainage
        - Prior to catheter insertion, the bladder and stomach should be emptied
        - Can be performed concurrently with CPR
    - Bladder lavage (less effective)
        - Traditional technique is infusion of 300 mL of 42˚C fluid into the bladder followed by removal of fluid after ~15 minutes; placement of a 3-way urinary catheter may allow for continuous irrigation
        - Foley temperature monitoring will no longer be reliable for core temp measurement
        - Less effective than other techniques above (low surface area for heat exchange) and may distract resources from superior options
    - Gastric lavage (avoid)
        - Traditional technique is infusion of 200-300 mL of 40-42˚C fluid into the stomach followed by removal of fluid after ~10-15 minutes
        - Serum electrolyte levels may fluctuate with large-volume irrigation
        - AVOID: less effective than other techniques, distracts resources from superior options, multiple potential complications

- **Continued core cooling (aka “afterdrop”)**
    - Core temp may continue to drop after patient is removed from cold environment
    - Caused by the 2nd law of thermodynamics- heat flows down gradient from warmer core to cooler periphery
    - Little evidence for “classic teaching” that cold blood returning from periphery leads to core temp drop
    - Has not been shown to have clinical significance

- **When can death be declared without rewarming?**
    - No universal guidelines, but in general:
    - Obvious signs of irreversible death
    - Potassium ≥ 12
    - History of normothermic arrest with subsequent cooling

- Patients who are frozen solid with an immobile chest wall (not rigor mortis)
  - Exception is the child with normothermic cardiac arrest and simultaneous rapid cooling (e.g., child falls through ice into very cold water)
- Consider termination of resuscitation when core temp ≥ 32˚C with asystole and without ROSC

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