Chapter 132 – Accidental Hypothermia

Episode Overview

- Passively rewarm patients with temperatures 32 - 35 degrees Celsius
- Indications for active rewarming:
    - Cardiovascular instability
    - Temperature < 32 degrees Celsius
    - Poor rates of passive rewarming
    - Endocrine insufficiency
- Hypothermia usually causes bradycardia - if you see tachycardia out of proportion, think about other things:
    - Hypoglycemia
    - Hypovolemia
    - Drug overdose
- Most medications don't work in cold bodies - so it often takes more drug for effectiveness in hypothermic patients - patients show drug toxicity when they warm up!
- Don't let normal coagulation tests fool you - they are run at 37 degrees Celsius
    - The patient is cold and coagulopathic!
- Hypothermia enhances cardiac toxicity to hyperkalemia while obscuring the typical ECG changes of hyperkalemia
- If you are having trouble rewarming a patient - think about other causes of ineffective heat production (e.g., endocrine insufficiency and infection) before calling off resuscitation efforts

Core Questions

1. List 5 mechanisms of heat loss and 5 physiological responses to cold
2. Describe 3 CV manifestations of hypothermia
3. What are the risk factors for hypothermia? List 6.
4. Define mild, moderate and severe hypothermia.
5. Describe the CNS, CVS, hematologic and GU presentations associated with hypothermia for each stage (mild, moderate, severe)
6. What are the changes made to BLS and ACLS in the setting of hypothermia?
7. What are the indications for CPR, defibrillation, and antidysrhythmics in the hypothermic patient?
8. Differentiate between active and passive rewarming. What are the two types of active rewarming?
9. What are five indications for active rewarming? Describe 6 techniques for active rewarming.
10. What are examples of:
    a. Active External Rewarming
    b. Active Core Rewarming
11. In what situations would you not initiate resuscitation of a hypothermic patient?

Wisecracks

1. What is core-temperature afterdrop?

2. List 5 DDx for an Osborne J-wave
3. List 5 laboratory abnormalities expected in hypothermia
4. What three mechanisms cause worsening bleeding in trauma in hypothermia?
5. Describe 5 management considerations other than rewarming in hypothermia
6. What are the prehospital management priorities for the hypothermic patient in each of these categories: mild, moderate and severe?

Rosen's in Perspective

- Accidental hypothermia has been something that has plagued the human race for time immemorial. It is something that will bring patients to your ED in any season.
    - Don't forget that today we are talking about accidental hypothermia (or primary hypothermia) - there are a myriad of other conditions causing secondary hypothermia (impaired heat production, impaired heat regulation)
        - Infections - sepsis, meningitis, encephalitis
        - Neurological - strokes, spinal cord injuries
        - Toxic - EtOH intoxication, hypoglycemia
        - Metabolic / endocrine - pancreatitis, hypothyroidism (myxedema coma), hypopituitarism, diabetes
    - Sometimes, it's these health conditions that get the person lost in the cold to begin with
- Hypothermia is defined as the following:
    - Having a CORE body temperature below 35 degrees Celsius
- Risk factors for the development of accidental hypothermia are:
    - Over exposure to an environment that's colder than your normal body temperature
    - Poor Health
    - Old Age
    - Drug Ingestion
    - Inadequate nutrition
- The primary means by which the body combats hypothermia (when your judgement or environment limits your ability to get out of the cold) is shivering - however, this can only last for several hours, as it is limited by fatigue and glycogen store depletion
- As core body temperature decreases, your compensatory mechanisms begin to fail, and at temperatures <24 degrees Celsius, autonomic and endocrinologic mechanisms cease completely
- Children cool at a faster rate than adults due to their increased body surface area to mass ratios
    - Always watch out for hypothermia in your pediatric populations

Core Questions

[1] List 5 mechanisms of heat loss and 5 physiological responses to cold

- Mechanisms by which heat is lost are:
    - **Radiation**
        - Most profound mechanism of heat loss at rest (>50%)
    - **Conduction**
        - At rest, not very much heat is lost

        - If wet, increases dramatically
    - **Convection**
        - Works with conduction to increase heat loss by up to 25x in the wet patient
    - **Respiration**
    - **Evaporation**

NOTE: Conduction, convection, and radiation are the biggest mechanisms by which heat is lost in the outdoors: it's key to develop behavioral defenses against these

- Physiologic responses to cold are:
    - **Shivering**
    - **Increased pre-shivering muscle tone**
    - **Vasoconstriction**
    - **Non-shivering basal thermogenesis**
    - **Endocrinologic thermogenesis**

[2] Describe 3 CV manifestations of hypothermia

- Cardiovascular responses to hypothermia are:
    - Tachycardia
        - Occurs initially, followed by progressive bradycardia
    - Bradycardia
        - The pulse diminishes with every drop in core body temperature
        - Occurs as the result of decreased spontaneous depolarization of the pacemaker cells in the heart
            - NOTE: This bradycardia will not respond to atropine
    - Osborn (J) Waves
        - Look at the junction of the QRS complex and ST segment
        - Typically appears with a core body temperature below 32 degrees Celsius
    - Prolongation of PR, QRS, and QTc (think - everything gets cold and slows down)
    - Atrial Fibrillation
        - Typically a rhythm that converts spontaneously after re-warming
    - Ventricular Fibrillation/Asystole
        - Occur for a multitude of reasons in the hypothermic patient
        - Can occur spontaneously after the core body temperature falls below 25 degrees Celsius

[3] What are the risk factors for hypothermia? List 6

SEE BOX 132.1 in Rosen's 9th Edition

NOTE: Think about it as a problem of heat production or heat loss. Heat is mostly produced by cellular metabolism in the heart, liver, muscles and lost through the SKIN and LUNGS.

The risk factors below relate to a body that isn't able to produce heat (elderly patient with liver disease, decreased cardiac output, thin skin on cardiac suppressing drugs) or something that puts someone at higher risk of exposure.

Risk factors for hypothermia include:

- Over exposure
- Poor Health
- Old Age
- Drug Ingestion
- Intoxicant Ingestion
- Inadequate nutrition

[4] Define mild, moderate and severe hypothermia

NOTE: Remember - you need to use a CORE temperature probe - so go rectal or bladder or preferably esophageal.

The stages of hypothermia are as follows:

- Mild Hypothermia
  - 35-32 degrees Celsius
- Moderate Hypothermia
  - 32-29 degrees Celsius
- Severe Hypothermia
  - 28-22 degrees Celsius
- Profound Hypothermia
  - 20-9 degrees Celsius
    - 9 degrees Celsius is defined as the lowest therapeutic hypothermia survival level

Note: There is a five level “Swiss staging” system that is used in some places (also supported by the International Commission for Mountain Emergency Medicine). This system is used by the International Commission of Alpine Rescue (ICAR). However, it’s not favored by all experts in the field of wilderness medicine because the clinical (especially the neurological) symptoms of hypothermia range widely from person to person. For example, a person could still be shivering and have a temperature below 32 deg.

HT I	Clear consciousness with shivering	35-32 degrees Celsius
HT II	Impaired consciousness without shivering	32-28 degrees Celsius
HT III	Unconsciousness	28-24 degrees Celsius
HT IV	Apparent death	24-15 degrees Celsius
HT VI	Death due to irreversible hypothermia	<15 degree Celsius

Check out: http://www.alpine-rescue.org for more.

[5] Describe the CNS, CVS, hematologic, and GU presentations associated with hypothermia for each stage (mild, moderate, severe)

NOTE: See table 132.1 in Rosen's 9th Edition for a complete table detailing the various manifestations of hypothermia

- Mild Hypothermia
  - 35-32 degrees Celsius
  - CNS
    - Amnesia
    - Dysarthria
    - Ataxia
    - Apathy
  - CVS
    - Normal blood pressure maintained
  - Heme
    - No effects
  - GU
    - Urine temperature drops
- Moderate Hypothermia
  - 32-29 degrees Celsius
  - CNS
    - Stupor
    - Decreased LOC
    - Pupils dilated
  - CVS
    - Atrial fibrillation
    - Pulse and cardiac output drop to 2/3 of normal
  - Heme
    - Insulin ineffective
- Severe Hypothermia
  - 28-22 degrees Celsius
  - CNS
    - Loss of reflexes and voluntary motion
    - No response to pain
  - CVS
    - Ventricular fibrillation susceptibility
    - Cerebral blood flow 1/3 normal
    - Cardiac output 45% of normal
    - Pulmonary edema susceptibility
    - Significant hypotension
  - Heme
    - Major acid-base disturbances

[6] What are the changes are made to BLS and ACLS in the setting of hypothermia?

NOTE: Don't forget the C-A-B's. Know that patients who are cold will have bradycardia - so have multiple people feel for a central pulse for at least one minute or use bedside echocardiography.
NOTE: If there are signs of life present (coordinated electrical activity on ECG; pulse palpable; cardiac contraction on echo) CPR should be withheld. Experts suggest that the changes to standard ACLS apply to patients < 30 degrees Celsius. Once the patient is re-warmed to > 30 degrees Celsius, normal protocols apply.

According to Dr. Doug Brown's paper: *The guidelines of the European Resuscitation Council recommend a modified approach to advanced life support, consisting of up to three defibrillations, with epinephrine withheld until the core temperature is higher than 30°C (86°F) and with the interval between doses doubled until the core temperature is higher than 35°C (95°F).These recommendations conflict with the American Heart Association guidelines, which state, "It may be reasonable to consider administration of a vasopressor during cardiac arrest according to the standard ALS [advanced life support] algorithm concurrently with rewarming strategies." Hence, the administration of up to three doses of medication and defibrillation is likely to be a reasonable approach, with further dosing guided by the clinical response.*

[7] What are the indications for CPR, defibrillation, and antidysrhythmics in the hypothermic patient?

CPR indications:

- Asystole
- If no ECG available
    - No palpable central pulse after a ONE minute pulse check (note this is different than the standard BLS ten second pulse check)

NOTE: Some experts recommended against providing CPR to patients with PEA arguing that the patients may have a small amount of cardiac output (without a palpable pulse) that would be disrupted with CPR. The goal in these cases is to WARM the patient up and thereby direct all human efforts to correcting the main underlying problem (i.e. not the pulselessness, but the hypothermia!).

Defibrillation:

- Not a lot of evidence to guide our management on this, so consensus seems to support:
    - Trial of epinephrine 1 mg if in arrest (knowing that below 30 degrees it will not be very effective and may be prodysrhythmic)
    - Trial single defibrillation attempt at 360 J
        - If unsuccessful don't re-attempt until the patient has been warmed 1-2 degrees Celsius; then attempts may resume again.
    - Key point: **don't make the patient with bradycardia go into VF!**
        - Avoid disturbing the moderate/severely hypothermic patient!
        - Avoid multiple attempts at defibrillation with 360 J for patients with temperatures < 28 degrees Celsuis and a wide complex tachyarrhythmia - there is no clear consensus on how many or how few shocks to give

Antidysrhythmics:

- Key goal is to rewarm the patient!
- Most hypothermia-induced dysrhythmias convert spontaneously during rewarming.
- Atrial dysrhythmias are common below 32°C (89.6°F), and are associated with a slow ventricular response. Atrial fibrillation is common but self-limited. It usually converts spontaneously during rewarming. Beta blockers and calcium channel blockers are contraindicated unless there is a rapid ventricular response.
- No clear consensus on administering antiarrhythmics - **probably safer not to.**
    - The ideal approach to ventricular dysrhythmias in the hypothermic patient has not been well studied. Lidocaine and propranolol have minimal hemodynamic effects during hypothermia. Their efficacy in the treatment of ventricular dysrhythmias appears limited.
    - The efficacy of amiodarone is not supported either
    - In hypothermia, at least one Group 1 antidysrhythmic agent, procainamide, increases the incidence of VF. Another drug in the same group, quinidine, can prevent VF during induced profound hypothermia and during cardiac manipulation at 25°C to 30°C (77°F–86°F).

Bradycardia management:

- Bradycardia is physiologic in hypothermia
    - Don't need to start pacing unless the temperature is >32 degrees Celsius and the patient is hypotensive
    - Avoid transvenous approaches to unstable bradycardia - transcutaneous approaches are less irritating to the cold heart
- Transvenous cardiac pacing is hazardous for bradydysrhythmias in hypothermia.
    - External pacing may be worth trying in the rare setting of profoundly disproportionate bradycardia. Transcutaneous pacing has been used to facilitate continuous arteriovenous rewarming in perfusing patients by raising the systolic blood pressure above 60 mm Hg. Other active rewarming techniques do not require specific pressure gradients.

Check out Dr. Doug Brown's video explaining a prehospital approach to accidental hypothermia: https://vimeo.com/57950513

[8] Differentiate between active and passive rewarming. What are the two types of active rewarming?

- Passive Rewarming
    - Non-invasive form of reheating; the patient should have the capacity to spontaneously rewarm themselves
    - Involves covering the patient with an insulator (blanket), and minimizing heat loss by evaporation and convection
    - Should have a warm room temperature, preferably >21 degrees Celsius
    - Remember, the primary means by which these individuals will reheat themselves is shivering; if they are able to do that (generally core temperature >32 degrees Celsius), passive rewarming is appropriate

    - Rates of passive rewarming are not set in stone, so look for a rise of 0.5-2.0 degrees Celsius per hour
    - You need to rewarm them fast enough to limit exposure to life-threatening arrhythmias
    - To recap, the key steps:
        - Remove the patient from the cold
        - Remove any wet clothes and dry the patient off
        - Cover them up with clothes
        - Turn up the temperature in the room
- Active Rewarming
    - Direct transfer of heat to the patient by invasive/non-invasive means
    - Used primarily for moderate to severe hypothermia
    - Required for moderate to severe hypothermia where cardiovascular instability is present
    - Defibrillation is not as successful when the patient is hypothermic
- Two types of active rewarming are:
    - Active External Rewarming
    - Active Core Rewarming

[9] What are five indications for active rewarming? Describe 6 techniques for active rewarming

See Box 132.3 in Rosen's 9th Edition for the list of indications for active rewarming in the hypothermic patient

Five Indications for Active Rewarming
1. Cardiovascular instability 2. Moderate to severe hypothermia (<32 degrees Celsius) 3. Inadequate rate of rewarming or failure to rewarm 4. Endocrine insufficiency 5. Traumatic or toxicological peripheral vasodilation 6. Secondary hypothermia impairing thermoregulation

Active External Rewarming

- Methods conduct heat with the skin
- Options include:
    - Plumbed garments
        - Warm fluids are pumped through malleable tubes that are in direct contact with the patient's skin
    - Hot water bottles
    - Heating pads
    - Forced-air warming systems (e.g., "bear hugger")
        - Air is pumped through a plastic blanket, transferring warmth directly to the patient
    - Radiant sources of heat

Active Core Rewarming

- As the name suggests, these methods of rewarming directly warm core body structures (e.g., airways, etc…)
- Includes:
  - Airway rewarming
    - Use of heated humidified air to warm the core and improve pulmonary functioning
  - Peritoneal dialysis
  - Heated irrigation (e.g., thoracic lavage)
    - Warmed fluids are pumped into each hemithorax via thoracostomy tubes
  - Endovascular Rewarming
    - Use femoral vein closed circuit system to comatose or cardiac arrest patients
  - Diathermy
    - Conversion of energy waves into heat
    - Use ultrasonic or microwave waves to deliver heat to the patient
  - Extracorporeal Rewarming (e.g., dialysis)
    - Directly warming the blood by removing and heating it, then returning it to the patient

NOTE: In general, the active INVASIVE core rewarming methods are reserved for cases where there is a patient with moderate to severe hypothermia who fails to respond to traditional means, is requiring CPR and isn't easily transferred to an ECMO / CPB centre.

NOTE: Very rapid rates of rewarming do not necessarily improve survival. Complications of rapid rewarming include DIC, pulmonary edema, hemolysis, and acute tubular necrosis. Extracorporeal circulation can provide cardiovascular support in perfusing but hemodynamically unstable patients. Extracorporeal rewarming should be considered in hypothermic cardiac arrest patients if there are no contraindications to CPR.

[10] List examples of active external rewarming and active core rewarming

For a complete list of active external and core rewarming modalities, please see question nine above.

[11] In what situations would you not initiate resuscitation of a hypothermic patient?

NOTE: Remember you can be cold and dead….starting a resuscitation that is NOT medically indicated puts many people at risk (not to mention uses resources ineffectively!)

Do not resuscitate (do CPR) the patient if:
1. DNR signed and present 2. Obvious lethal injuries are present 3. Major signs of blunt/penetrating trauma 4. Snow-packed airway 5. Chest wall compression is impossible

6. Abdomen is rigid (frozen)
7. No signs of life and asystole on the ECG (judgement call depending on the duration of burial (e.g. <35 min) and "down time"
8. Retrieval or resuscitation places the rescuers at too much risk
9. Too cold (? less than 9-15 degrees C) - controversial
10. Has signs of life (pulse, moving, respiratory effort)

Wisecracks

[1] What is core-temperature afterdrop?

Answer: A diminishment in the patient's core body temperature after removing them from the cold. This is caused by cool blood flowing to the core from the colder extremities as a result of vasodilation in the re-warmed patient. This results in greater drops in core temperatures and causes wide fluctuations in MAP and sudden change in peripheral vascular resistance

NOTE: Avoid this by warming the core of a hypothermic patient first!

[2] List 5 DDx's for Osborne J-Waves

Answer:

Differential Diagnosis for the J Wave
1. Local cardiac ischemia 2. Sepsis 3. CNS lesions 4. Hypercalcemia 5. Hypothermia

[3] List 5 laboratory abnormalities expected in hypothermia

Answer:

Laboratory Abnormalities Expected in Hypothermia
Blood Gases i. Increased PaO2 ii. Increased PaCO2 iii. Decreased pH **Basic Hematologic Evaluation** iv. High hematocrit v. Leukopenia vi. Thrombocytopenia vii. Increased Creatinine/BUN viii. Hyper/hypoglycemia ix. Elevated serum lipase

[4] What three mechanisms cause worsening bleeding in trauma in hypothermia?

Answer:

- A physiologic hypercoagulable state occurs in the hypothermic patient
    - This can lead to DIC, leading to catastrophic bleeding
- Diminished enzymatic activity and clotting factor activity is caused by diminished core body temperature
    - Remember, however, coagulation testing will be unreliable, as kinetic tests are performed at 37 degrees Celsius
    - Will be deceptively normal
- Thrombocytopenias due to splenic sequestration also increase the risk for bleeding
- Diminished activity of thromboxane A2 increases the risk for bleeding, particularly in trauma

[5] Describe 5 management considerations other than rewarming in hypothermia

Answer:

- Safety of you, the extrication team or other victims that may take precedence
- Identify and treat other potential life threats to the patient
    - ABC's
        - Intubate
        - Supplemental 0_2
        - Stop bleeding / volume resuscitate
- Treat other cold-induced injuries (frostbite)
    - Rewarm, analgesia, tetanus prophylaxis
- Treat other wounds
- Consider whether antibiotics are indicated:
    - Young children and the elderly should be given prophylactic antibiotics
    - Routine empirical antibiotics do not appear warranted in hypothermic, non–older adults. Antibiotics should be administered if the clinical picture is consistent with septic shock or if there is failure to rewarm.
        - Consider empiric IV hydrocortisone (in addition to antibiotics) in patients who fail to rewarm
- Contact patient's family / friends and get collateral information

[6] What are the prehospital management priorities for the hypothermic patient in each of these categories: mild, moderate and severe hypothermia?

Answer:

Specific goals of prehospital care include prevention of further heat loss with insulation, avoidance of afterdrop, gentle handling, and transporting in a horizontal position.

Patients should be actively rewarmed in the field, if possible.

Mild:

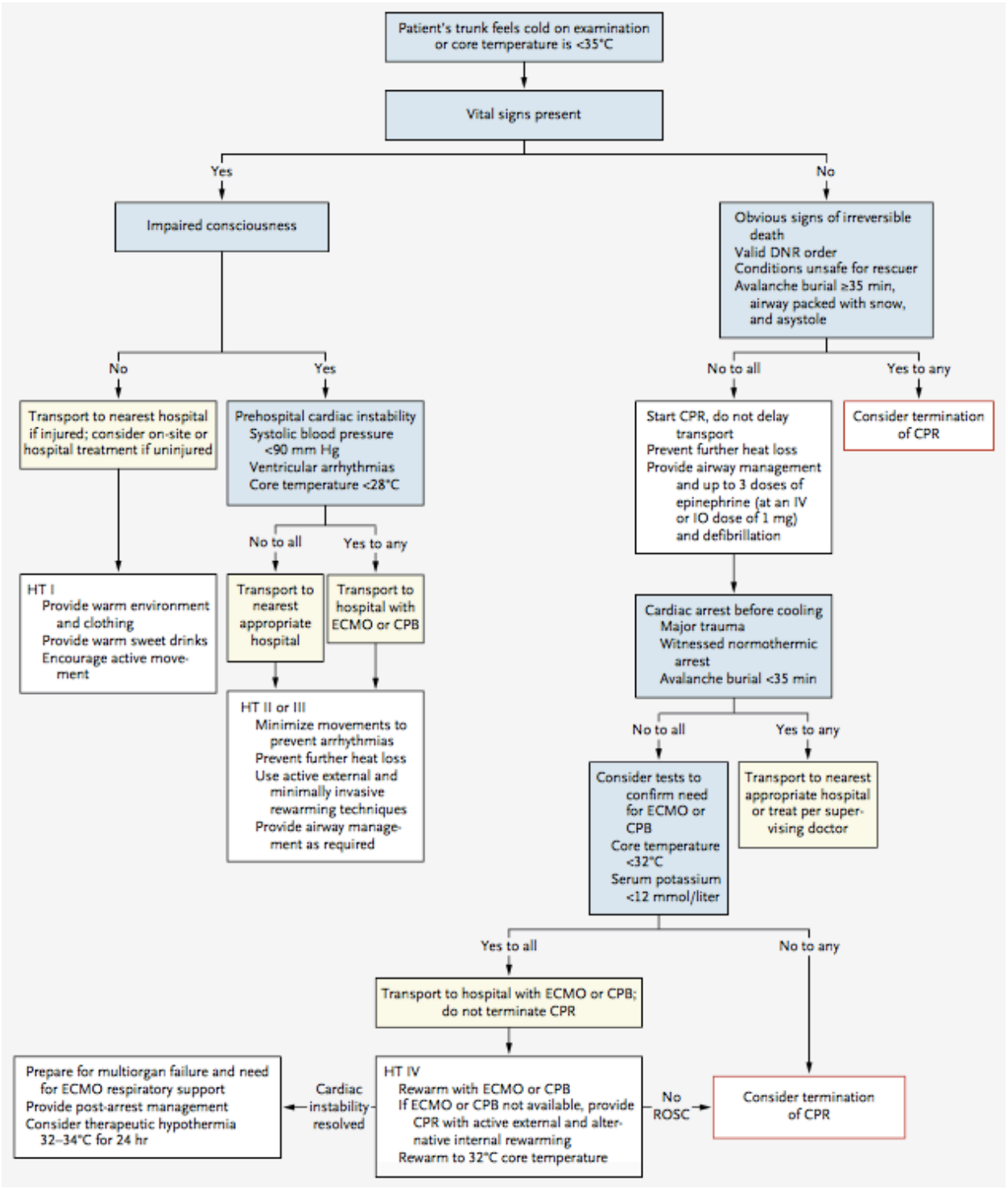
- Remove wet clothing, insulate with warm, dry clothes
- Drink warm, sweet liquids
- Encourage active movement
- Hike out / transport to warm environment
- Treat any other injuries (including cold-induced ones!)

Moderate & Severe:

- Text and figure below copied from: “Accidental Hypothermia” Douglas J.A. Brown, M.D., Hermann Brugger, M.D., Jeff Boyd, M.B., B.S., and Peter Paal, M.D. NEJM 2012.
    - Careful handling of the patient,
    - Provision of basic or advanced life support,
    - Passive and active external rewarming,
    - Transport to an appropriate facility.
- Detecting a pulse in a patient with hypothermia may be difficult, so signs of life and pulse should be checked carefully for 60 seconds. Persistent breathing or movement by the patient should prompt a strategy of watchful waiting, but if no signs of life are detected, then cardiopulmonary resuscitation (CPR) should be started. Full-body insulation and rewarming should be provided for all patients as long as it does not impede CPR or delay transport. For rewarming in the prehospital setting, only chemical, electrical, or forced-air heating packs or blankets provide a substantial amount of heat transfer (Table 3). Advanced airway management should be performed if indicated, since the risk of triggering a malignant arrhythmia is low.
- Highly recommend checking out this figure as it covers all priorities:

If you want some excellent summaries of Dr. Doug Brown’s work regarding accidental hypothermia in the prehospital setting check out: http://drdougbrown.ca/

NOTE: For the full table from the paper aforementioned, please see the next page


Patient's trunk feels cold on examination or core temperature is <35°C
Vital signs present
Yes
No
Impaired consciousness
Obvious signs of irreversible death
Valid DNR order
Conditions unsafe for rescuer
Avalanche burial ≥35 min, airway packed with snow, and asystole
No
Yes
No to all
Yes to any
Transport to nearest hospital if injured; consider on-site or hospital treatment if uninjured
Prehospital cardiac instability
Systolic blood pressure <90 mm Hg
Ventricular arrhythmias
Core temperature <28°C
Start CPR, do not delay transport
Prevent further heat loss
Provide airway management and up to 3 doses of epinephrine (at an IV or IO dose of 1 mg) and defibrillation
Consider termination of CPR
No to all
Yes to any
HT I
Provide warm environment and clothing
Provide warm sweet drinks
Encourage active movement
Transport to nearest appropriate hospital
Transport to hospital with ECMO or CPB
Cardiac arrest before cooling
Major trauma
Witnessed normothermic arrest
Avalanche burial <35 min
HT II or III
Minimize movements to prevent arrhythmias
Prevent further heat loss
Use active external and minimally invasive rewarming techniques
Provide airway management as required
No to all
Yes to any
Consider tests to confirm need for ECMO or CPB
Core temperature <32°C
Serum potassium <12 mmol/liter
Transport to nearest appropriate hospital or treat per supervising doctor
Yes to all
No to any
Transport to hospital with ECMO or CPB; do not terminate CPR
Prepare for multiorgan failure and need for ECMO respiratory support
Provide post-arrest management
Consider therapeutic hypothermia 32–34°C for 24 hr
Cardiac instability resolved
HT IV
Rewarm with ECMO or CPB
If ECMO or CPB not available, provide CPR with active external and alternative internal rewarming
Rewarm to 32°C core temperature
No ROSC
Consider termination of CPR