# Vascular Interventions for Hypothermia

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## Injury/Disease Demographics

- Accidental hypothermia occurs in people with normal heat production who are exposed to environments such as cold water immersion, where heat loss cannot be controlled.
- Ambient temperatures need not be below freezing to induce hypothermia.
- Hypothermia is most common during winter months, but can occur during any season.
- Hypothermia following trauma is an independent predictor of mortality.
- Hypothermia occurs when the rate of external heat loss exceeds that of endogenous thermogenesis.
- A 50% decrease in the metabolic rate is observed for every 10°C decrease in core body temperature.

## Clinical Presentation

- Initial physiologic changes include agitation, cutaneous vasoconstriction, thermogenic shivering, diuresis and confusion.
- Late changes include loss of shivering, hypovolemia, lethargy, bradycardia, and hypotension.
- Laboratory findings include metabolic acidosis
- Ventricular arrhythmia can occur below 33°C and asystolic arrest can occur below 28°C.

## Evaluation/Diagnostics/Imaging

- The initial evaluation should employ the standard ATLS protocols.
- Evidence of hypothermia will be found on physical exam.
- Core temperature measurement is performed using rectal, bladder, or esophageal temperature probes.
- Core temperature can be accurately measured with an Alsius catheter or a pulmonary artery catheter.
- Adjuncts should include ECG and FAST.

## Role of Conservative Management and Associated Considerations

- Passive rewarming prevents further heat loss and enables core temperature to rise through endogenous thermogenesis which occurs at approximately 1.2°C per hour.
- Passive rewarming measures include:
    - warming blankets.

    - convective warm air blankets to insulate against further heat loss and transfer heat to the skin (Bair Hugger, 3M, St. Paul, MN).
    - infusion of saline through rewarming circuits.
    - heat lamps.
    - warming ambient room temperature.
- Active surface rewarming using torso immersion in 40°C water:
    - the most effective external measure.
    - requires sufficient systemic perfusion.
    - cautioned in the presence of open fractures.
    - contraindicated in patient requiring CPR or emergency surgery.
- A large peripheral IV catheter is the most widely used and useful vascular intervention for treating hypothermia. Infusion of warm isotonic fluids is paramount to both restore intravascular volume and transfer thermal energy.
- Commercially available kits enable intraosseus (IO) catheter placement in patients where peripheral IV access is difficult. Humeral placement enables rapid delivery of fluids and medications into the subclavian vein.
- Large bore (21Fr) central venous catheter placement via Seldinger technique allows rapid infusion of warm fluids and medications to the central system and can serve as a platform to place central rewarming catheters. Femoral placement is preferred to avoid arrhythmia due to guide wire irritation of the right atrium. Ultrasound guidance facilitates intravascular placement when pulses are difficult to palpate.

## Indications for Invasive Active Rewarming

- Active rewarming should be pursued in patients with a core temp < 35°C, mental status changes, thermogenic shivering, and cold diuresis.
- The transition from passive rewarming to invasive active core rewarming (active intravascular methods) is guided by the degree of hypothermia, the hemodynamic status, and the response to simpler rewarming maneuvers.
- External rewarming should continue as invasive measures are initiated.
- All active core rewarming measures with the exception of ECMO/femoral-femoral bypass/formal cardiopulmonary bypass require spontaneous cardiac output.
- Patients undergoing CPR require femoral-femoral bypass/formal cardiopulmonary bypass.

## Pre-operative Preparation

- The most important principals in treating hypothermia are to prevent ongoing heat loss and correct the associated hypovolemic shock to restore oxygen consumption and endogenous thermogenesis.
- Patients who are obtunded or have airway compromise should be intubated and airway rewarming performed using warm (41°C) fully saturated humidified air.

- Blood pressure should be supported with vasopressors in patients with hypotension once euvolemic.
- CPR should be initiated in patients with hypothermic asystolic arrest -- this provides cardiac output and allows active core rewarming.

## Impact of Associated Injuries

- Hypothermic patients who have concomitant injuries are at risk for hemorrhagic exacerbation of shock. Likewise, injured patients who are hypothermic have a higher mortality risk.
- Hypothermia has profound effects on coagulation with observed decreases in clotting factor activity occurring with mild (35-32°C) hypothermia. Clotting factor activity can be as low as 20% of baseline in severe (<30°C) hypothermia.

## Operative Techniques/Intraoperative Considerations

- Three basic options for invasive active rewarming exist:
    - Multiport central venous rewarming catheters are placed in the IVC via femoral access sites (Alsius catheter, Delta Surgical, Staffordshire, UK).
    - Extracorporeal rewarming by venovenous bypass or arteriovenous bypass through a heat exchanger can be performed using large bore femoral catheters placed either by percutaneous Seldinger technique or femoral vessel cut down. Ultrasound guidance can be a useful adjunct to percutaneous artery or venous access.
    - ECMO can be initiated in patients without spontaneous circulation using femoral arterial and venous catheters placed either via Seldinger technique or via femoral cut down to both oxygenate and rewarm blood.
- Accidental hypothermia patients with any of the following criteria MAY BE pronounced dead:
    - Those having been rewarmed to a core temperature greater than 35°C without a return of spontaneous circulation
    - Serum potassium > 10mmol/L
    - Arterial pH < 6.5
    - Core temperature < 13°C

## Postoperative Management

- Torso surface rewarming should continue until the core temperature rises to 35°C. Cold and frozen extremities should be sequentially rewarmed once the core temperature reaches 33°C.
- Urine output should not be used to gage intravascular volume status because hypothermia impairs normal renal sodium reabsorption and the ability to concentrate urine.

## Complications

- Afterdrop is defined as a drop in core temperature during rewarming as cold surface blood is returned to the core.
- Hypothermia complicates the diagnosis of death. The patient is not dead until warm and dead (>32°C). The exceptions are patients in arrest that suffered anoxic insults and arrest while normothermic and later became hypothermic.
- CPR should be avoided in patients with an organized rhythm on ECG due to risk of inducing refractory ventricular fibrillation.
- Complications associated with the use of intravascular rewarming catheters and devises are usually limited to complications at the access site such as bleeding, pseudoaneurysm, dissection or thrombosis; bleeding complications may be exacerbated by cold associated coagulopathy.
- Burns from passive warming devices (heat lamps).

## Considerations for Special Populations

- The elderly are at increased risk for hypothermia due to impaired ability to decrease heat loss by vasoconstriction and impaired ability to increase thermogenesis.
- Children are at increased risk of hypothermia due to a relative increased surface area to volume ratio and limited energy reserves.

## Suggested Readings:


- Injuries due to burns and cold. In 'Advanced Trauma Life Support for Doctors Student Course Manual 9th ED. American College of Surgeons, Committee on Trauma 2012.
- Hypothermia and Trauma in Current Therapy of Trauma and Critical Care 2nd Ed. Asensio and Trunkey Eds. Elsevier Inc. Philadelphia PA, 2016
- ECC Guidelines Part 8: Advanced Challenges in Resuscitation, Section 3: Special Challenges in ECC. Circulation 102:I-229 (2000).