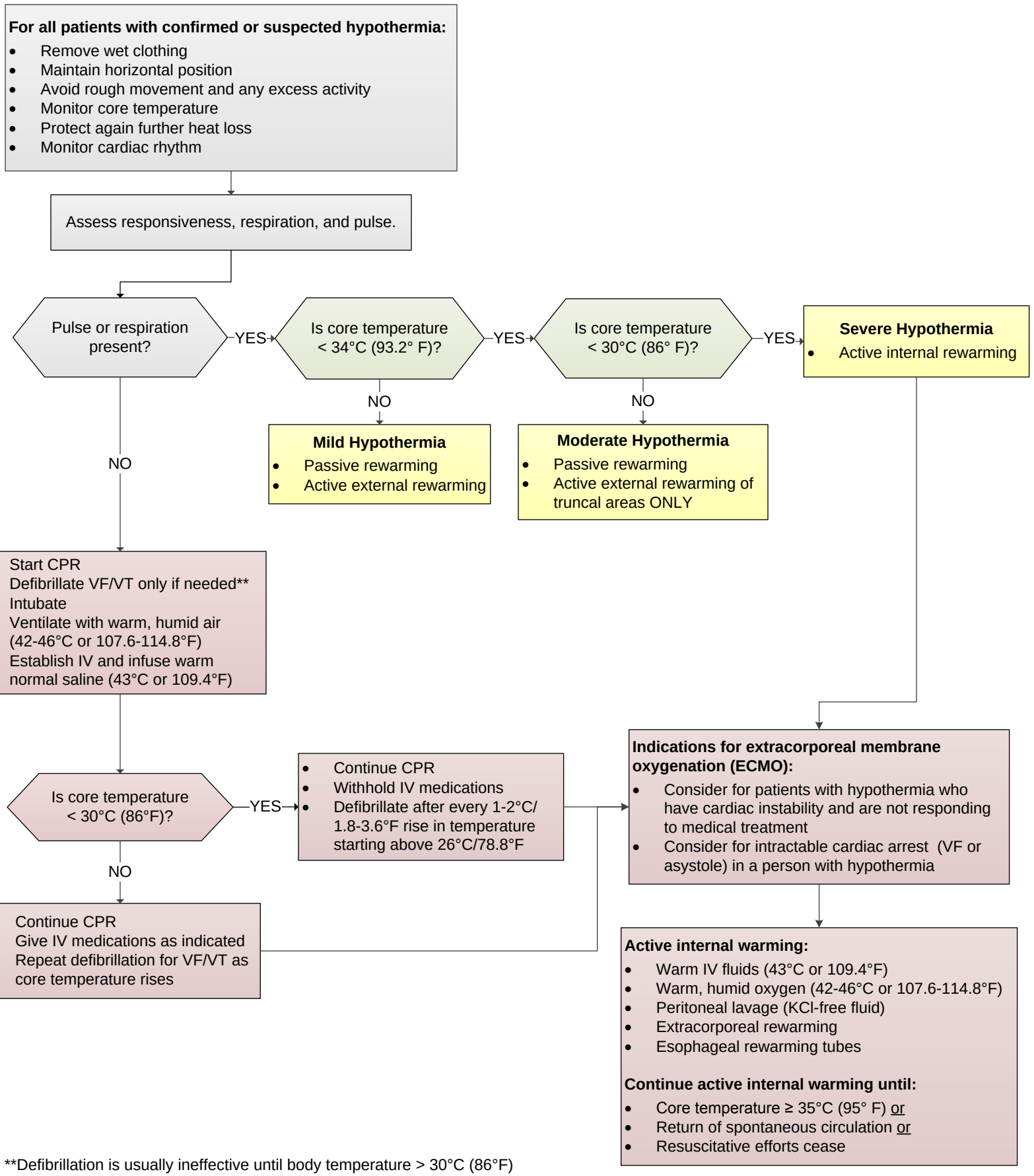
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

Management of Accidental Hypothermia



**Defibrillation is usually ineffective until body temperature > 30°C (86°F)

Source: Emergency Cardiac Care Committee and Subcommittees, American Heart Association. JAMA. 1992;268(16):2171.

Key Points

- Hypothermia occurs when the core body temperature falls to ≤ 35°C (95.0°F)
- If hypothermia is expected, use a low-reading core thermometer as standard oral thermometers do not read < 34°C (93.2°F)
- Hypothermia can be classified into three levels of severity based on the core temperature:
    - Mild Hypothermia: 35°C - 32°C (95.0°F - 89.6°F)
    - Moderate hypothermia: 32°C - 28°C (89.6°F - 82.4°F)
    - Severe hypothermia: < 28°C (82.4°F)
- See **Appendix A** for predisposing factors.

Clinical Presentation

At patient presentation, be vigilant for vital signs inconsistent with the patient's presumed degree of hypothermia. Such inconsistencies may suggest an alternative diagnosis.

Degree of Hypothermia	Clinical Assessment
Mild	• Clear cognitive function • Shivering
Moderate	• Impaired cognitive function • No shivering
Severe	• Unconscious • No shivering

NOTE: See **Appendix B** for table detailing clinical manifestations of hypothermia.

Physical Evaluation

- Total body survey
    - Evaluate patient for local cold-induced injuries and signs of trauma.
    - **Use caution** when performing the physical evaluation.
        - The hypothermic heart is sensitive to movement and rough handling of the patient may precipitate adverse health outcomes such as arrhythmias and ventricular fibrillation.
        - Slow atrial fibrillation is a common arrhythmia among patients with mild hypothermia and will spontaneously resolve with rewarming.
- Core temperature
    - Use low-reading thermometers **only**.
    - Esophageal probe inserted into the lower one-third of the esophagus is appropriate for intubated patients.
    - Bladder, rectal, and temporal thermometers should **not** be used.

Lab Evaluation

Patients who are previously healthy and are diagnosed with mild, accidental hypothermia may not require laboratory evaluation.

- The laboratory evaluations below should be considered for patients with moderate to severe hypothermia:
    - Arterial blood gas (See **Appendix C**)
    - BUN and creatinine
    - Chest X-ray
    - ECG
    - Glucose
    - Lactate
    - Lipase
    - Partial thromboplastin and prothrombin times
    - Serum electrolytes*
    - Serum hemoglobin, white blood cell, and platelet counts

**Rewarming can lead to rapid changes in electrolyte concentrations. Reassess electrolyte levels every four hours during rewarming.*

NOTE: See **Appendix D** for table detailing laboratory findings.

Treatment

The initial management of hypothermia focuses on resuscitation, assessment of the extent of injuries, and rewarming. See **Appendix E** for table detailing the recommended rates for various rewarming modalities.

Type of Rewarming	Methodology*
Passive External Rewarming (PER)	• Cover patient in blankets or other types of insulation • Maintain room temperature of 28°C
Active External Rewarming (AER)	• Use combination of blankets, heating pads, radiant heat, warm baths, or forced warm air applied directly to patient's skin*
Active Internal Rewarming (AIR)	• IV administration of warmed crystalloid*** • Warm humidified oxygen • Peritoneal and pleural irrigation with warmed isotonic crystalloid • Extracorporeal blood rewarming**

* Rewarm the trunk **PRIOR** to the extremities to minimize risk of adverse outcomes.

It is best to use a stepwise approach starting with less invasive rewarming techniques. Extracorporeal blood rewarming is performed in only extreme cases or when rewarming is inadequate despite all other therapies. See OSUWMC **Extracorporeal Life S upport (ECLS) guideline.

***Warmed IVF are useful only in trying to prevent further heat loss. They are NOT effective to significantly raise body temperature. (only 0.33°C/0.66°C/hr for IVF heated to 42°C/108°F.

Absolute Contraindications for ECMO

- Prolonged ventilation for > 10 days or with high airway pressure and/or high FiO_2 > 7 days
- Established multi-system organ failure
- Contraindication to anticoagulation
- Refusal to receive blood products
- Ungrafted severe burns
- Quadriplegia
- Bone marrow transplant recipients
- Severe immunosuppressed state (ANC < 400/mm^3)

Risk of Rewarming

- Rewarming of the trunk should be undertaken **PRIOR** to the extremities in order to minimize the risk of core temperature afterdrop, hypotension, and academia due to arterial vasodilatation.
    - Atropine does **not** work on hypothermic bradycardia.
    - Epinephrine may induce potentially lethal cardiac arrhythmias.
    - No evidence exists to support the use of antiarrhythmic medications.
- When using forced air warming systems, leave the extremities uncovered initially to minimize risk of afterdrop and to allow for proper heat transfer.
- Due to decreased sensation and reduced blood blow, body surface burns may result when using heading pads to rewarm a hypothermic patient.

Reference

- Brown, Douglas J.A., et al. "Accidental Hypothermia." *The New England Journal of Medicine* 367.20 (2012): 1930-1938.
- Herbert, Mel and Doug Brown. "Accidental Hypothermia - Part 1." 15 January 2014. *Emergency Medicine: Reviews and Perspectives.*
- Kerber, Richard E., et al. "Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care." *Journal of the American Medical Association* 368.16 (1992): 2171-2183.
- Lanken, Paul N., et al. *The Intensive Care Unit Manual*. Orlando: Elsevier, 2000.
- Mechem, C Crawford and Ken Zafren. "Accidental Hypothermia in Adults." October 2014. *UpToDate.*

Quality Measures

- ECLS outcome measures
    - Survival to decannulation
    - Survival to discharge
    - CPC score at discharge
- ECLS process measures
    - ED arrival to ECLS consult
    - ED arrival to cannulation
    - Total number of consults for this indication
        - Rate of approval
        - Rate of denial by reason
- LOS for inpatients with accidental hypothermia
- Mortality rate for inpatients with accidental hypothermia

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Guideline Approved

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Appendix A

Predisposing Factors for Hypothermia

Predisposing Factors	Clinical Examples

Increased Heat Loss	• **Environmental**
	  o Immersion
	  o Non-immersion
	• **Induced vasodilatation**
	  o Pharmacologic
	  o Toxicologic
	• **Erythrodermas**
	  o Burns
	  o Psoriasis
	  o Ichthyosis
	  o Exfoliative dermatitis
	• **Iatrogenic**
	  o Emergency childbirth
	  o Cold infusion
	  o Heatstroke treatment

Decreased Heat Production	• **Endocrine failure**
	  o Hypopituitarism
	  o Hypoadrenalism
	  o Lactic acidosis
	  o DKA/EtOH KA
	• **Insufficient Fuel**
	  o Hypoglycemia
	  o Malnutrition
	  o Extreme exertion
	• **Neuromuscular Physical Exertion**
	  o Age extremes
	  o Impaired shivering
	  o Inactivity
	  o Lack of adaptation

Impaired Thermoregulation	• **Peripheral Failure**
	  o Neuropathies
	  o Acute cord transection
	  o Diabetes
	• **Central Failure/Neurologic**
	  o SAH or CVA
	  o CNS trauma
	  o Metabolic
	  o Pharm/Tox
	  o Hypothalamic dysfunction
	  o Parkinson's disease
	  o Anorexia nervosa
	  o Cerebellar lesion
	  o Neoplasm
	  o Congenital intracranial path
	  o Multiple Sclerosis

Miscellaneous	• Sepsis • Multisystem Trauma Bacterial, viral, parasitic Pancreatitis Cardiopulmonary disease Vasculopathy • Uremia • Paget's disease Giant cell arteritis Sarcoidosis • SLE • Wernicke-Korsakoff Hodgkin's disease Shock • Sickle cell anemia • SIDS

Appendix B

Pathological Changes in Hypothermia

Level of Hypothermia	°C	°F	Characteristics
MILD	37.6	99.6	Normal rectal temperature
	37.0	98.6	Normal oral temperature
	36.0	96.8	Increase in metabolic rate and blood pressure and pre-shivering muscle tone
	35.0	95.0	Urine temperature 34.8°C; maximum shivering thermogenesis
	34.0	93.2	Amnesia, dysarthria, and poor judgment develop; maladaptive behavior; normal blood pressure; maximum respiratory stimulation; tachycardia, then progressive bradycardia
	33.0	91.4	Ataxia and apathy develop; linear depression of cerebral metabolism; tachypnea, then progressive decrease in respiratory minute volume; cold diuresis
MODERATE	32.0	89.6	Stupor; 25% decrease in oxygen consumption
	31.0	87.8	Extinguished shivering thermogenesis
	30.0	86.0	Atrial fibrillation and other arrhythmias develop; poikilothermia; cardiac output two-thirds of normal: insulin ineffective
	29.0	85.2	Progressive decrease in level of consciousness, pulse, and respiration; pupils dilated; paradoxical undressing
	28.0	82.4	Decreased ventricular fibrillation threshold; 50% decrease in oxygen consumption and pulse; hypoventilation
	27.0	80.6	Loss of reflexes and voluntary motion
SEVERE	26.0	78.8	Major acid-base disturbances; no reflexes or response to pain
	25.0	77.0	Cerebral blood now one third of normal; loss of cerebrovascular autoregulation; cardiac output 45% of normal; pulmonary edema may develop
	24.0	75.2	Significant hypotension and bradycardia
	23.0	73.4	No corneal or oculocephalic reflexes; areflexia
	22.0	71.6	Maximum risk of ventricular fibrillation; 75% decrease in oxygen consumption
	20.0	68.0	Lowest resumption of cardiac electromechanical activity; pulse 20% of normal
	19.0	66.2	Electroencephalographic silencing
	18.0	64.4	Asystole
	16.0	60.8	Lowest adult accidental hypothermia survival
	15.2	59.2	Lowest infant accidental hypothermia survival
	10.0	50.0	92% decrease in oxygen consumption
	9.0	48.2	Lowest therapeutic hypothermia survival

Appendix C

Management of Acid-Base Status in the Hypothermic Patient

- Resuscitation in a hypothermic patient should be titrated to pH. The person who is hypothermic has a slower metabolism and produces fewer waste products during normal function. It may be very normal for somebody who's core temperature is in the mid to low eighties to have a blood pressure that is low and a heart rate that is bradycardic (slow A-Fib) along with a respiratory rate < 6.

- If the blood gas shows a normal pH in a hypothermic patient, and they have a respiratory rate that is slow, they likely do not need to have their respiratory rate augmented by intubation. They are physiologically at the place that they need to be as long as their pH is normal. Acidosis or alkalosis promotes arrhythmia in these patients.

- Likewise, an 80°F patient with a heart rate of 18 who has a normal pH does not need CPR. This is more likely to generate an arrhythmia than it is to be useful. The heart rate and respiratory rate will come up as the temperature rises.

Appendix D

Laboratory Findings Indicative of Accidental Hypothermia

Laboratory Test	Clinical Findings
Arterial blood gas	Metabolic acidosis, respiratory alkalosis, or both
Electrolytes	No consistent abnormality
Glucose	Increased, decreased, or no change
White blood cell and platelet counts	Decreased due to splenic sequestration
Hemoglobin, hematocrit	Increased due to hemoconcentration
Lipase	May be increased due to hypothermia-induced pancreatitis
Prothrombin and partial thromboplastin times	Increased in vivo due to inhibition of coagulation cascade despite normal reported values
ECG	Prolongation of PR, QRS, or QT intervals. ST segment elevation, T wave inversions, atrial fibrillation or sinus bradycardia.
Chest X-ray	Aspiration pneumonia, vascular congestion, pulmonary edema.

Source: *Lanken, PN, et al. (2000). The Intensive Care Unit Manual. Orlando: Elsevier.*

Appendix E

Recommended Rewarming Rate by Modality

Modality	Indications	Rate of Rewarming	Additional Comments

Passive External Rewarming (PER)	• The stable patient with a core temperature > 32°C (89.6°F) is the ideal candidate for this treatment.
	• It is appropriate in mild hypothermia or as adjunctive to active rewarming
		• 0.5-1°C (0.9-1.8°F) per hour	• In order for this technique to cause an increase in body temperature, the patient must be able to generate heat.
			  ○ The patient will lose this ability at a core temperature < 32° C (89.6°F).
			• This method is focused on preventing any further loss of heat from a body by providing insulation and removing the patient from the offending environment.
			  ○ No outside heat is added to the patient and peripheral vasoconstriction is maintained.
			  ○ PER may be used in any patient as initial treatment in the field, or to prevent further heat loss in the ED.

Active External Rewarming (AER)	• Cardiovascular instability
	• Moderate to severe hypothermia T° < 32° C (89.6°F)
	• Failure to rewarm externally
	• Endocrinologic insufficiency
	• Traumatic or toxicologic peripheral vasodilatation
	• Secondary hypothermia impairing thermoregulation
	• Additional modalities should be added if T° fails to rise by at least 1-2°C (1.8 -3.6°F) per hour
		• Variable based on modality used:
		  ○ Radiant heat
		  ○ Hot water bottles
		  ○ Plumbed garments
		  ○ Electric heating pads and blankets
		  ○ Forced circulated hot air
		  ○ Immersion in warm water
			• The application of AER alone must be done cautiously with close monitoring for adverse thermic and BP changes.
			• Application should be limited to the trunk only.
			• Truncal AER may be used safely in conjunction with active core rewarming.

Heated Humidified Oxygen	• All patients with moderate to severe hypothermia.	• 1-2.5°C (1.8-4.3°F) per hour • ETT > mask	• The ideal temperature of the air to be delivered is 45°C (113°F). ○ Minor modification of respiratory equipment may be required to achieve this temperature. • Although shivering may be reduced with this method of core rewarming, the core temperature is elevated nonetheless.

Heated Infusions	• Any moderate to severe hypothermic patient	• 0.33°C (0.66°F) per liter of fluid warmed to 42°C (107.6°F)	• IV fluids should be heated to 40-42°C (104-107.6°F).
			  ○ A 1 L bag of crystalloid should be heated on high for ≈ 2 minutes in the microwave.
			  ○ Blood can be warmed in the Level One Infusor® to 35-38°C (95-100.4°F). **Never microwave blood**.

Modality	Indications	Rate of Rewarming	Additional Comments
Heated Irrigation of Hollow Viscous	• Moderate to severely hypothermic patients as an adjunct to other methods of rewarming.	• 1-1.5°C (1.8-2.7°F) per hour	• **DO NOT USE** heated irrigation in patients with GI tract injuries. • Warmed fluids used for direct irrigation should have a dwell time of ≤15 minutes. ○ The patient should be intubated before gastric lavage is performed as airway protection.
Heated Irrigation of the Peritoneum*	• Moderate to severely hypothermic patients	• 1-3°C (1.8-5.4°F) per hour	• Through a DPL catheter, normal saline, LR or 1.5% dextrose dialysate heated to 40-45°C (104-113°F), may be instilled into the peritoneum 2 liters at a time. ○ The fluid is left to dwell for 20-30 minutes and then exchanged. • Using dialysate, effective detoxification of certain substances and manipulation of certain electrolytes can be attained.

Heated Irrigation of the Thoracic Cavity*	• This technique is best reserved for patients who are not perfusing, unless extracorporeal warming is immediately available.	• 20°C (36°F) per hour	• The thoracic cavity can be irrigated with saline heated to 40-42°C (104-107.5°F) via anterior and posterior chest tubes (ant-MCL at 2 or 3 ICS; post-posterior axillary line at 5 or 6 ICS).
			  ○ Irrigation with this inflow/outflow system can be done using a Level One Infuser® (180-550 ml min) or by hanging heated IV bags.
			  ○ Care must be taken so as to not cause a tension hydrothorax by not allowing for enough time for adequate drainage of the posterior chest tube.
			• Single chest tube lavage can be done infusing 200-300 cc of saline at a time and removing the fluid by suction after each aliquot.
			  ○ The technique of thoracic irrigation has the advantage of allowing for preferential heating of the mediastinal structures.
			• The “thoracic pump model” of CPR is preserved so as to facilitate blood movement in what may be a very hard, non-compliant heart.
			• Placing chest tubes may precipitate a malignant rhythm.
			  ○ Right-sided tubes may help to avoid this complication.

Modality	Indications	Rate of Rewarming	Additional Comments
Heated Irrigation of the Mediastinum*	• Patients in cardiac arrest • Non-perfusing rhythms or severe hypothermia in patients for who bypass is available.		• Irrigation of the mediastinum can be done via a left sided thoracotomy (or median sternotomy), and the heart can be directly irrigated with saline warmed to 40-42°C (104-107.5°F). • Unless a perfusing rhythm is obtained, irrigation can be performed until the heart reaches a temperature of 32°C (89.6°F). • Defibrillation can be attempted at 1-2°C (1.8-3.6°F) intervals once the temperature has reached 26°C (78.8°F).

Extracorporeal Blood Rewarming	• Severe hypothermia with either cardiac arrest or failure of less invasive methods to increase temperature at an acceptable rate.	• Varies depending on the system used and the maximum attainable flow rate
		• Generally, temperature increases of up to 1-2°C (1.8-3.6°F) every 3-5 min is attainable.
			• **Extracorporeal Blood Rewarming (ECR**): ECR is a process in which blood is removed from the circulatory system, heated, and subsequently returned to the body.
			  ○ All of the systems offer the advantage of rapid rewarming at a controllable rate up to 2°C/3.6°F every 5 minutes.
			  ○ May be used with or without an oxygenator (by Fem-Fem, AV (without pump) or venovenous (without pump) or by hemodialysis with heat exchanger).
			• **Extracorporeal Membrane Oxygenation (ECMO):** ECMO is a technique for providing both cardiac and respiratory support.
			  ○ It can be very effective in providing circulation, oxygenation and warming for a severely hypothermic patient.
			  ○ Consider for patients with hypothermia who have cardiac instability and are not responding to medical treatment.
			  ○ It should be considered for intractable cardiac arrest (VF or asystole) in a person with hypothermia.
			• **Hemodialysis:** Using a 2 site cannulation or the simple, single site, 2 way flow catheter, 200-250 ml of blood per minute can be dialyzed and rewarmed.
			  ○ This method, while effective, is slower and provides less heat exchange than 2 vessel cardiopulmonary bypass.

* The peritoneal, thoracic and mediastinal cavities, via DPL, tube thoracostomy, and thoracotomy respectively, can all be irrigated with warmed solutions. In ascending order, these methods have progressively greater ability to raise core temperature rapidly. They are, however, more invasive than previously described methods.

Appendix F

Emergencies in the Hypothermic Patient

Table 1. Interventions for Cardiac Emergencies

Cardiac Emergency	Treatment Recommendations	Additional Comments
Atrial arrhythmias	• Atrial arrhythmias resolve spontaneously as temperature rises to normal. • They are common in moderate and severe hypothermia and do not require treatment.	• Atrial arrhythmias do not produce a rapid ventricular response.
Bradycardia	• Bradycardia *is not* responsive to atropine. • If the clinical condition requires, symptomatic bradycardia may be treated with external pacing. ○ Internal pacing may trigger a malignant ventricular arrhythmia.	• Slow heart rate is a normal response in hypothermia.

Ventricular arrhythmias	• Electrical defibrillation at up to 200J should be tried one time at the onset of VF at any temperature.
	  ○ Subsequent shocks will not likely restore a perfusing rhythm until the core T° > 30°C (86°F).
	  ○ In the thoracic lavage and extracorporeal rewarming protocols, defibrillation can be attempted at 1-2°C (1.8-3.6°F) intervals starting at a temperature of 26°C (78.8°F).
		• These include ectopy and fibrillation.
		  ○ Most cases of preexisting ectopy (frequent PVCs) will disappear with hypothermia.
		• Ventricular fibrillation can be induced by cardiac stimulation, ranging from jolts and bumps to CPR, to Swan-Ganz (or introducer wire) placement. Likewise, it can be spontaneous.
		• Prophylaxis with drugs has not, as of yet been adequately studied in humans.

Asystole	• Treat asystole per ACLS protocols	• Asystole, especially in the field, may be difficult to differentiate from fine VF. • Asystole may actually be the presenting rhythm of a hypothermic patient, completely bypassing VF. • Many patients have been successfully resuscitated from hypothermic asystole.

Cardiac Arrest	• Perform CPR is no sign of life is present	• CPR in contraindicated when:
		  ○ DNR status is established.
		  ○ The chest wall is immobile due to decreased compliance.
		  ○ Any pulse is present by palpation or Doppler.

Hypotension	• If the patient is hypotensive despite fluid therapy and rewarming, and blood loss is not considered a possible cause, dopamine infusion may be started and titrated to SBP of ~100 mmHg.	• Hypothermia will decrease mean arterial pressure and cardiac index. ○ Cardiac output drops to ~45% of normal at 25°C (77°F). • Peripheral vasoconstriction will occur increasing the SVR. • Evaluation of what should be a normal BP will be difficult.

Table 2. Additional Interventions for Medical Emergencies

Intervention	Indications	Comments
Intubation	• Airway protection is needed for lavage or altered mental status. • Respiratory rate or depth is inadequate to keep the uncorrected pH at 7.4. • The patient is unable to adequately oxygenate. • Airway bronchorrhea interferes with lung function.	• CO_2 production decreases by 50% for each 8°C (14.4°F) drop in temperature. • Patients may have RR of 4-10 and still adequately oxygenate and ventilate**.**
Ventilation and oxygenation	• 100% oxygen should be used during resuscitations and it should be heated to 45°C (113°F), if possible. • Ventilation rate of the hypothermic patient by BVM is usually slower than in normothermic patients but rate should be adequate to keep the uncorrected pH at 7.4.	
Termination or resuscitation efforts	• DNR status is documented and verified, or obvious signs of death exist. • All efforts at resuscitation have failed and the patient's T° >32°C (89.6°F). • Studies show that a potassium > 10 is an extremely poor prognostic factor. ○ If confirmed, a potassium at this level can be used as a criteria to terminate resuscitation.	