Emergency Health Services

6235.02 Environmental Emergencies

INTRODUCTION

Environmental emergencies encompass a wide range of etiologies, from the effects of heat and cold to near drowning, dysbarisms, electrocution, or lightning strike. Depending on local climate and geography, some environmental emergencies may be more common than others.

Hypothermia (defined as having a core body temperature less than 35°C) is one of the more common environmental emergencies. The body normally maintains a relatively stable temperature whereby heat production is balanced with heat loss. Most heat loss occurs at the skins surface by convection, conduction, radiation, and evaporation. The body may generate more heat by shivering, thereby increasing muscle activity, and promoting heat formation. As the temperature falls, the body shunts blood away from the skin to maintain the temperature of vital organs. If the body temperature continues to decrease, these organs begin to fail, and eventually death will occur. Accidental hypothermia can occur outdoors in any weather, but may also be seen indoors if the room temperature is low or the patient is lying on a cold surface.

Peripheral cold injuries may occur with or without systemic hypothermia. Frost nip represents a superficial cold insult with no tissue freezing, whereas the tissues actually freeze and become damaged in frostbite. Trench foot (wet cold) and chilblains (dry cold) are other non-freezing peripheral cold injuries.

Hyperthermia reflects an “overheating” of the body. The dominant mode of cooling in hot conditions is evaporation of sweat from the skin. During periods of higher ambient temperature or during significant exertion, the body’s modes of cooling can become overwhelmed. Those at greatest risk of heat-related illness include small children, the elderly, and individuals who overexert during work or exercise.

Heat illness typically occurs as a result of volume and/or salt depletion. Minor heat illness includes presentations such as heat cramps, heat edema, or heat syncope. Heat exhaustion and heat stroke represent more serious forms of heat illness. Heat stroke is a life threatening emergency that occurs when physiologic attempts to regulate body temperature fail. Patients with heat stroke often have a body temperature over 40°C.

Given our proximity to water, drowning and near drownings are unfortunately more commonly encountered. Drowning is death from asphyxia due to submersion in a liquid. Near drowning is the survival, at least in the short term, of a submersion event. When submersion occurs, a period of voluntary apnea is followed by an involuntary gasp causing aspiration and laryngospasm. Active aspiration causes hypoxia in most patients, while a minority will develop hypoxia due to persistent laryngospasm (“dry drowning”). Death occurs as a result of hypoxemia induced cardiac and central nervous system (CNS) dysfunction.

Scuba divers are at risk of experiencing hypothermia, drowning and dysbarisms. Dysbarisms are illnesses that result from exposure to increased ambient pressure. These illnesses occur as a result of volume-pressure changes within air-filled cavities of the body, or from the dissolution of gases in body tissues. There are a number of possible dysbarism-related conditions unique to the sport of scuba diving.

Finally, this guideline will also review the approach to electrical and lightning injuries. Factors that determine the extent of an electrical injury include the type of circuit (AC being worse than DC), duration of contact with current, resistance of tissues, voltage (high voltage is greater than 500V), amperage, and pathway of current through the body. Lightning is considered a massive current impulse.

SAFETY

Scene safety is paramount when dealing with environmental emergencies. Many environmental emergencies can involve multiple patients, so it is important to examine the scene closely. If there are multiple patients, triage (START) should be conducted in order to prioritize management.

Prehospital clinicians should be adequately prepared to work during extremes in temperature (appropriate clothing, hydration, etc.) Retrieving patients from water or from scenes where electrocution or a lightning strike has taken place requires particular attention to scene safety, and may require specialized training. The appropriate agencies (e.g. Nova Scotia Power, fire department) must be consulted prior to entering scenes that are questionably safe. Dangerous ground current may exist in the setting of downed power lines, and lightning can strike twice in the same place. Clinicians should refer to their relevant Occupational Health and Safety Program Manual for specifics on responding to scenes with safety hazards.

ASSESSMENT

Initial assessment includes level of consciousness and the presence of vital signs, regardless of the environmental emergency. If vital signs are absent, follow cardiac arrest guidelines.

Provided vital signs are present, the clinician should begin by assessing the adequacy of airway protection, respiratory effort and breath sounds, and whether the blood pressure is providing adequate perfusion (e.g. mentation, peripheral temperature and colour). A complete set of vital signs should be obtained, and a “low reading” thermometer should be used if you are assessing for hypothermia. Patients should be monitored for dysrhythmias that may complicate any environmental emergency.

Consider the presence of coexisting trauma or C-spine injury, and assess for this on history and physical exam.

Examine the skin for tissue injury that may occur in the setting of temperature related emergencies, dysbarisms, electrocution, or lightning strike. Patients with peripheral cold injuries may have mottled, pale, white or red skin. Often there is tinging and numbness. Patients with hyperthermia or electrocution may have significant burns. Patients struck by lightning may have a “feathering” pattern across their skin due to flashover.

Some specific findings observed with hypo- and hyperthermia are outlined in Tables 1 and 2. Assessment findings commonly associated with near-drowning incidents include respiratory distress and altered level of consciousness, as well as hypothermia.

Table 1: Zones & Symptoms of Hypothermia

Zones of Hypothermia	Symptoms
Mild (32-35°C)	• Shivering • Feeling cold • Low energy • Cold, pale skin
Moderate (28-32°C)	• Cessation of shivering • Being unable to think or pay attention • Confusion • Loss of judgement and reasoning • Difficulty moving around or stumbling (weakness) • Feeling afraid • Memory loss • Loss of coordination • Drowsiness • Slurred speech • Listlessness and indifference • Slow, shallow breathing • Weak pulse
Severe (less than 28°C)	• Loss of control of hands/feet/limbs • Unconsciousness • Shallow or no breathing • Weak, irregular or no pulse • Stiff muscles • Dilated pupils

Table 2: Presentation of Heat Exhaustion and Heat Stroke

Heat Exhaustion	Heat Stroke
Temp often normal **NO CNS dysfunction** Malaise Fatigue Headache Dizzy Tachycardia Dehydration Orthostatic hypotension Red, hot, diaphoretic Muscle cramps Nausea or vomiting *If heat exhaustion is untreated, it may quickly progress to heat stroke.	Temp often >40°C **CNS dysfunction** (coma, seizures, delirium) Dry hot skin *Heat stroke patients may also have the same findings as heat exhaustion in addition to the above findings.

Some possible presentations of patients with scuba diving related illnesses are summarized in Table 3. It is important to obtain data regarding the "dive profile" if available (depth, duration, gas mixture used), and whether the patient became symptomatic on descent, at depth, or on ascent. If a documented dive profile is available at the dive site, the prehospital clinician should collect it and bring it with the patient to the hospital.

Table 3: Examples of Dysbarisms

Dysbarism	Onset	Clinical presentation
Ear barotrauma	Descent	• Ear pain • Ruptured ear drum • Tinnitus • Vertigo • Vomiting
Nitrogen narcosis	At depth	• Confusion • Euphoria • Poor judgment
Oxygen toxicity	At depth	• Confusion • Incoordination • Agitation • Visual symptoms
Pulmonary barotrauma	Rapid ascent	• SOB • Decreased breath sounds Cough • Chest pain • Subcutaneous emphysema
Arterial gas embolus (AGE)	Rapid ascent	• Loss of consciousness <10min from ascent • Confusion • Disorientation
Decompression sickness (DCS I)	After long deep dive	• Pain in extremities or skin rash
Decompression sickness (DCS II)	After long deep dive	• Focal neurological deficits • Cyanosis Hypotension • Vertigo

Patients who have experienced electrocution or a lightning strike may suffer significant thermal burns, muscle damage, blunt trauma, nervous system dysfunction, vasospasm, and dysrhythmias.

Bystanders may be able to provide a clearer picture of what actually happened, how long ago, and when the patient was last seen asymptomatic. Information collected should also include the patient's past medical history, medications, and allergies.

MANAGEMENT

General Management

Environmental emergencies may require airway management as per the Airway Management Clinical Practice Guideline. If the patient presents with signs of hypoxia, supplemental oxygen should be administered. In the case of any environmental emergency where the patient appears unwell or is showing signs of shock, IV access should be obtained, and a 20 mL/kg bolus of normal saline administered. Some environmental emergencies may lead to a dysrhythmia, which should be managed as per the Cardiac Arrhythmia Clinical Practice Guideline. If trauma is suspected the patient should also be managed in keeping with the appropriate trauma/burns Clinical Practice Guidelines. If the patient is presenting with pain, management can be guided by the Pain Management Clinical Practice Guideline.

Specific Management

Environmental emergencies are varied, and therefore some specific interventions may be required in addition to those outlined above.

Hypothermia

The focus of therapy for all hypothermic patients is rewarming. Goals of therapy include moving the patient from the cold environment, removing any wet clothing, drying the patient, and wrapping them with warm, dry blankets including around the head, as this is a major source of heat loss. Passive external rewarming with blankets in a warm environment is adequate treatment for mild hypothermia. This minimizes further heat loss from evaporation, convection, and radiation.

Active external rewarming is required for moderate to severely hypothermic patients (**PEP 2 supportive**). This involves the direct transfer of heat to the patient. In the prehospital setting this is accomplished by administering warm humidified oxygen, warm IV fluids (ideally 42°C), and with the use of warming blankets if available. Warm IV bags or hot packs may also be applied to the neck, chest, axilla, and groin. Subsequent ED management will include more aggressive active core rewarming, and in extreme circumstances extracorporeal blood rewarming.

If the patient is initially unconscious and not shivering, the hypothermia is likely severe and care must be taken to avoid rough handling or jostling movements as the conduction system of the heart is irritable at very low temperatures. If the patient is thought to be in cardiac arrest, the cardiac arrest guideline may be followed with a few exceptions. Peripheral pulses will be difficult to detect in cold, bradycardic, vasoconstricted patients. Spend at least one minute assessing for a pulse. Initiate CPR if no pulse is obtained after one minute. When defibrillation is indicated, make only one attempt until the patient is significantly rewarmed (**PEP white**), as defibrillation is usually unsuccessful in severely hypothermic patients. Limit epinephrine administration to a single dose (**PEP white**). Until the patient is rewarmed the administration of IV mediations is futile. Even patients who are cold, stiff, and cyanotic with fixed pupils have been successfully resuscitated. Resuscitation efforts in cardiac arrest are continued until the patient is rewarmed, ideally to 35°C (**PEP 2 neutral**). Clinical support should be used (e.g. CSD/OLMC) when making the decision that resuscitation efforts may be futile. Patient age, health condition, length of time in the hypothermic state, and extrication and transport time should all be taken into consideration.

Peripheral cold injuries

Wet or constrictive clothing should be removed. Dry dressings should be applied to injured skin. The injured extremity should be insulated and immobilized. Rubbing the skin in an attempt to provide heat with fiction actually worsens tissue damage. If there is a risk of refreezing, active rewarming (i.e. applying heat to the area) should be avoided, as partial thawing then tissue refreezing greatly worsens outcomes. The extent of the cellular damage is directly related to the duration of tissue freezing, therefore transport to definitive care for complete rewarming should be expedited. Reperfusion is extremely painful and likely to require aggressive pain control.

Hyperthermia
The patient should be moved to a cool environment, and all excess clothing removed. Mild forms of heat illness may resolve in a cool environment with orally administered electrolyte solution (**PEP white**). Moderately unwell patients may also require IV fluid beginning with a 20 mL/kg bolus (**PEP white**). Heat stroke is diagnosed when a patient demonstrates CNS changes (altered LOC, seizures, confusion), and/or an elevated temperature. Heat stroke is a life threatening emergency, and mortality increases when cooling is delayed. Transport of heat stroke patients to definitive care should be expedited. These patients are likely to require repeat boluses of IV fluid. Ice packs can be applied to the axilla and groin (**PEP white**), or a cooling blanket may be used if available. Evaporation of water from the skin is also highly effective. If possible, the patient may be spritzed with water and the air conditioner and/or fans fully employed during transport (**PEP white**). Finally, the use of antipyretics such as aspirin, acetaminophen, or ibuprofen is not indicated and may actually be harmful. The pathophysiology of environmental hyperthermia is entirely different from fever.

Drowning
There are few specific recommendations for care of drowning or near drowning. It is important to consider the possibility of hypothermia, trauma, substance use, suicide, or homicide. A patient who has drowned and is also hypothermic may undergo a more prolonged attempt at resuscitation (**PEP 2 neutral**), until they are sufficiently rewarmed (ideally to 35°C). Attempts to drain or expel fluid from the lungs should be avoided as this increases the risk of vomiting and aspiration. Consider using 5–10 cmH_2O of PEEP or CPAP to augment airway management if required (**PEP 2 supportive**). In the setting where a scuba diver has drowned, the clinician should also consider the presence of dysbarisms.

Dysbarisms
Any air filled cavities in and around the body can sustain injury if they are not equalized with the surrounding water pressure during decent and ascent.
Barotrauma on descent can cause ear pain, tinnitus, vertigo, sinus and facial pain. Pulmonary barotrauma typically occurs during fast ascent, and includes pneumothorax, pneumomediastinum, subcutaneous emphysema, alveolar hemorrhage, and arterial gas embolus (AGE). Prehospital management is supportive, with the exception of needle decompression of a tension pneumothorax (**PEP white**). AGE is the second leading cause of death during scuba diving after drowning. AGE presents with CNS dysfunction, pulmonary symptoms, or cardiac collapse typically within minutes of ascent. Prehospital management is supportive and subsequent management includes hyperbaric oxygen.

Patients who become unwell "at depth" may be suffering from nitrogen narcosis or oxygen toxicity. Management is supportive.

At depth, nitrogen gas is dissolved into liquid and is present in the blood stream. During a controlled ascent, the nitrogen comes out of the solution, is carried to the lungs, and exhaled as a gas. Decompression sickness (DCS) occurs when nitrogen gas in the bloodstream is not afforded ample enough time to be exhaled, and instead accumulates in tissues causing discomfort. DCS type I ("the bends") presents with limb pain or skin changes/rash/pruritis. DCS type II involves the CNS system, lungs, and inner ear. Prehospital management of DCS is supportive, and transport to hospital is required for subsequent transfer to a facility with hyperbaric oxygen therapy. Even a minor complaint in the setting of a possible dysbarism (e.g. a sore joint) usually results in a patient receiving hyperbaric oxygen therapy.

In addition to the above pathologies, also consider hypothermia, drowning, and the possibility of trauma in all patients presenting with symptoms following scuba diving.

Lightning/electrocution
There are very few specific management strategies for these patients beyond the general principles outlined above. Cardiac monitoring is essential. Coexisting trauma must be considered and managed. In the event of a mass casualty incident involving lightning/electricity, traditional triage rules do not apply. Patients in cardiac arrest should be managed first. Patients who have survived the initial lightning strike/electrocution and are spontaneously breathing are likely to survive.

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TRANSFER OF CARE

Upon transferring care to the receiving facility, provide details regarding the mechanism of injury/illness as well as time of onset (if known), treatments provided and patient's response to the treatment. If a documented dive profile was brought with the clinician to the receiving facility, it should also be provided to the receiving staff. If a documented profile was not located, any information regarding the depth and duration of the dive, as well as the gas mixture used, should be reported.

If suicide or homicide is suspected, ensure this information is relayed to receiving staff.

CHARTING

In addition to the mandatory fields it is important to document the following in the ePCR text fields:

- ✓ Mechanism of illness/injury
- ✓ Time of onset (if known)
- ✓ Initial presentation
- ✓ Treatment provided
- ✓ Reassessment findings
- ✓ Dive details (if pertinent)
- ✓ Temperature
- ✓ Any signs or reasons for suspicion of suicide or homicide

Key Points – Environmental Emergencies

Supportive care is the focus

Consider coexisting trauma

Cardiac arrest care is modified in the setting of hypothermia

Heat stroke is a life-threatening emergency

Non-descript pain in the setting of a diving emergency may be a sign of a dysbarism

KNOWLEDGE GAPS

Historically, sodium bicarbonate was administered for electrical burns to prevent rhabdomyolysis however the evidence is inconclusive as to its benefit in these patients. Sodium bicarbonate or normal saline infusion may be subsequently administered during in-hospital care if the patient develops rhabdomyolysis.

EDUCATION

Many environmental emergencies are rarely encountered by the prehospital clinician therefore it is important to understand the more subtle signs and symptoms associated with each so time sensitive emergencies can be identified.

QUALITY IMPROVEMENT

It is important for the clinician to document all interventions as well as the response to interventions during the time the patient is under your care. This is especially important as EHS works with the hospital system of care to determine the clinical quality, safety and satisfaction of the patient.

REFERENCES

Ma, O.J., Cline, D.M., Tintinalli, J.E., Kelen, G.D., & Stapczynski, J.S. (2004). *Emergency Medicine Manual*. New York, NY: McGraw-Hill.

Marx, J. A., Hockberger, R. S., Walls, R. M., & Adams, J. (2002). *Rosen's emergency medicine: Concepts and clinical practice*. St. Louis: Mosby.

PEP 3x3 TABLES for ENVIRONMENTAL EMEREGENCIES

Throughout the EHS Guidelines, you will see notations after clinical interventions (e.g.: **PEP 2 neutral**). PEP stands for: the Canadian **P**rehospital **E**vidence-based **P**rotocols Project.

The number indicates the Strength of cumulative evidence for the intervention:
1 = strong evidence exists, usually from randomized controlled trials;
2 = fair evidence exists, usually from non-randomized studies with a comparison group; and
3 = weak evidence exists, usually from studies without a comparison group, or from simulation or animal studies.

The coloured word indicates the direction of the evidence for the intervention:
Green = the evidence is supportive for the use of the intervention;
Yellow = the evidence is neutral;
Red = the evidence opposes use of the intervention;
White = there is no evidence available for the intervention, or located evidence is currently under review.

PEP Recommendations for Environmental Emergency Interventions, as of 2015/06/11. PEP is continuously updated. See: http://emergency.medicine.dal.ca/ehsprotocols/protocols/toc.cfm for latest recommendations, and for individual appraised articles.

Diving Injury (Decompression Sickness or Bends)

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)		• Direct Transport To Hyperbaric Facility • NSAIDs		• Decompress Tension Pneumothorax • IV access • Trendelenburg on Lt side
	2 (fair evidence exists)				
	3 (weak evidence exists)		• Oxygen		

Hyperthermia

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)				• Evaporative cooling • Ice • IV Fluid as a cooling agent • Oral rehydration
	2 (fair evidence exists)				
	3 (weak evidence exists)				

Hypothermia

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)				• Crystalloid Fluid • Inhalation Rewarming
	2 (fair evidence exists)	• AER (Active External Rewarming)			
	3 (weak evidence exists)				

Hypothermic Cardiac Arrest

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)				• Delayed Defibrillation • Delayed Drug Administration
	2 (fair evidence exists)		• AER (Active External Rewarming) • Prolonged Resuscitation		
	3 (weak evidence exists)				

Lightning

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)				• Analgesia (iv narcotic) • Oxygen
	2 (fair evidence exists)				
	3 (weak evidence exists)		• Crystalloid Fluid • C-Spine immobilization		

Near Drowning

Recommendation		RECOMMENDATION FOR INTERVENTION			
		SUPPORTIVE (Green)	NEUTRAL (Yellow)	AGAINST (Red)	NOT YET GRADED (White)
STRENGTH OF EVIDENCE FOR INTERVENTION	1 (strong evidence exists)				
	2 (fair evidence exists)		• Prolonged Resuscitation		
	3 (weak evidence exists)	• NIPPV			

*PEP is the **Canadian Prehospital Evidence-based Protocols Project.** Every clinical intervention is given a recommendation based on the strength of available research evidence (1 = randomized controlled trials and systematic reviews of RCTs; 2 = studies with a comparison group; 3 studies without a comparison group or simulation) and direction of the compiled evidence: **supportive** of intervention; **neutral** evidence for intervention; or **opposing** evidence for intervention). See: **https://emspep.cdha.nshealth.ca/TOC.aspx***

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