

JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE (JTS CPG)



Drowning Management (CPG ID:64)

This guide helps first responders, prehospital emergency medical service personnel, and medical department personnel evaluate, diagnose and manage common in-water pathologies.

Contributors

LT Michael Parenteau, MC, USN
 CAPT Zsolt Stockinger, MC, USN
 LT Stephen Hughes, MC, USN
 CDR Brad Hickey, MC, USN

CDR James Mucciarone, MC, USN
 LT Christopher Manganello, MC, USN
 MAJ Andrew Beeghly, MC, USA

Publication Date: 27 Oct 2017

TABLE OF CONTENTS

Goals	2
Epidemiology of Drowning	2
Pathophysiology of Drowning	2
Prevention	2
Phases of Treatment.....	3
Cold Water Immersion Self Aid	3
Rescue and In-water Resuscitation.....	5
Initial Resuscitation on Land.....	6
Who To Evaluate.....	6
Advanced Prehospital Care.....	7
Cardiac Interventions	7
ED/ICU Care	10
Pulmonary Considerations.....	11
Neurologic Considerations	12
Cardiovascular Considerations	12
Hematologic & Renal (Electrolyte & Metabolic) Considerations.....	13
Swimming Induced Pulmonary Edema (SIPE).....	13
Drowning Flowchart	14
Performance Improvement (Pi) Monitoring.....	15
Population of Interest	15
Intent (Expected Outcomes)	15
Performance/Adherence Metric	15
Data Source	15
System Reporting & Frequency.....	15
Responsibilities.....	15
References.....	16
Appendix A: Medical Definitions and Terminology	18
Appendix B: Additional Information Regarding Off-label Uses in CPGs	21

GOALS

This CPG provides an overview of drowning and associated conditions based on the best available current medical evidence. It should be used as a standardized framework to guide first responders, prehospital emergency medical service personnel, and medical department personnel in evaluating, diagnosing, and managing common in-water pathologies.

EPIDEMIOLOGY OF DROWNING

- Highly skilled swimmers and aquatically adaptable service members such as U.S. Navy Divers, EOD technicians, and SEALs die every year from drowning.
- Responsible for > 500,000 civilian deaths/year worldwide (thought to be greatly underestimated) boating accidents and natural disasters (floods, tsunamis, etc.).
- Leading cause of death worldwide in boys aged 5-14 (2nd most common cause in children, 3rd in most common cause young adults).
- Alcohol is involved in the majority of drowning accidents.
- Leading cause of deaths or contributing factor among scuba divers (100-150/year). In many cases it is difficult to determine if drowning is the primary cause or secondary to an in water emergency such as (1) loss of buoyancy control; (2) entanglement; (3) air supply exhaustion; or (4) medical condition (MI/hypoglycemia/seizure).¹⁻³

PATHOPHYSIOLOGY OF DROWNING

Immersion in water, panic, overexertion/exhaustion, inability to cope with rough water, or effects of hypo/hyperthermia lead to:¹⁻⁵

- Airway below the surface → breath hold breakpoint (inability to resist urge to breath) → hypoventilation → hypercapnia, respiratory acidosis, and hypoxemia → loss of consciousness (LOC) → passive flooding of the airway → cardiopulmonary arrest
- Cold water immersion – water conducts heat 25x faster than air resulting in a rapid drop in core temperature.
 - Shock to system causing sudden gasp for air, tachypnea, vasoconstriction, tachycardia.
 - May progress to arrhythmias, altered mental status, diminished strength and coordination.

PREVENTION

Respect the power of moving water and debilitating effects of cold water on the body.^{1,6,7} Fast moving water should be treated with the same respect as a 1,000 foot cliff.

- Wear a personal flotation device (PFD) and have a PFD available for every person.^{1,6,8}
 - Huddle - if in a group, everyone face inward and huddle with arms interlocked.
 - Get as much of body out of the water as possible (climb onto submerged boat), wind removes less heat than water.^{1,6,9}

- Learn to swim, tread water, or float (not a substitute for PFD) and always swim with others.
- Have a well-developed safety and rescue plan that is exercised and practiced routinely.^{1,6}
- Average vehicle takes 30 seconds to 2 minutes to sink.
- Once even partially submerged, windows and doors become impossible to open or kick out (unlike what is commonly seen in the movies). Do not wait, act immediately to escape.
- Vehicle escape procedure:
 1. Unfasten adult restraints.
 2. Open windows.
 3. Unfasten child restraints.
 4. Children exit youngest to oldest (if multiple children have oldest go first and hold onto vehicle and pass younger children out by the adult still inside the vehicle).^{1,6,7,10}

PHASES OF TREATMENT^{1,6}

1. Rescue and In-water Resuscitation
2. Initial Resuscitation on Land
3. Advanced Prehospital Care
4. ER/ICU Care

COLD WATER IMMERSION SELF AID

Sudden immersion in cold water (< 91.4°F/33 °C) causes panic and reflexive gasp for air and rapid breathing making: ^{1,2,5-7,9,11,12}

- Inhalation/aspiration of water more likely.
- Core temperature drop causing arrhythmias, confusion, incapacitation (diminished strength and coordination) increasing the chance of drowning.
- Water conduct heat away from the body 25 times faster than air leading to immersion hypothermia – impaired meaningful movement usually precedes.^{1,6,11}
- 1 min/10 min/ 1 hour /2 hour Rule 1,3 – steps to survival:
 1. Control your breathing and survive the first minute.
 2. You have 10 minutes to move thoughtfully and carefully before you will become incapacitated by cold.
 3. You have 1 hour before you will become unresponsive due to hypothermia.
 4. You have 2 hours before your heart stops beating.
 5. Assuming you have a floatation device, while awaiting rescue assume HELP (heat escape lessening posture) by bring your knees to your chest and cross your arms over them or Huddle position by grouping together.^{1,6,7,9,17}

Figure 1. Ice rescue training



1. Hold onto the edge of the ice
2. Kick your feet to get horizontal and pull
3. Slide or roll away from the hole **(DO NOT STAND)**

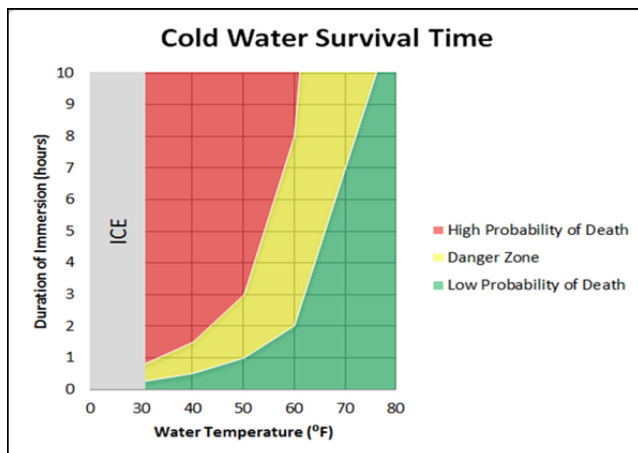
Graphic created by LT Parenteau from USCG video¹³ available at <https://www.youtube.com/watch?v=UzHC8hNlp34>

Table 1. Expected Survival Time in Cold Water

Water Temperature	Time to Exhaustion or Unconsciousness	Expected Survival Time
> 80° F (27° C)	Indefinite	Indefinite
70–80° F (21–27° C)	3–12 hours	3 hours – indefinitely
60–70° F (16–21° C)	2–7 hours	2–40 hours
50–60° F (10–16° C)	1–2 hours	1–6 hours
40–50° F (4–10° C)	30–60 minutes	1–3 hours
32.5–40° F (0–4° C)	15–30 minutes	30–90 minutes
<32° F (<0° C)	Under 15 minutes	Under 15–45 minutes

Volker M., Cold Water Survival, 2022.

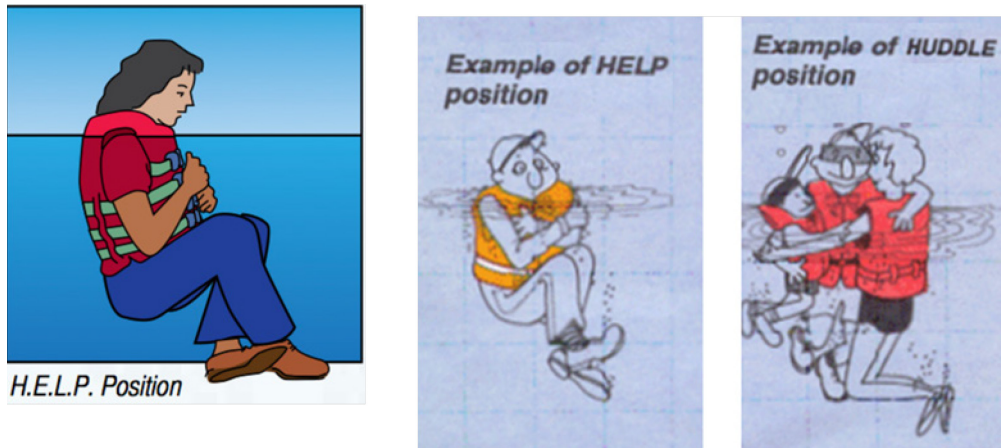
Figure 2. Cold Water Survival Time



Graph created by LT Parenteau based on data in table.9

RESCUE AND IN-WATER RESUSCITATION

1. Identify and locate the victim (ask if there are more than one).^{1,6}
 - Often seen motionless, sinking slightly below the surface.
 - Diving into the water and never surfacing.
2. Goals: initially type of water does NOT matter (salt, fresh, clean, dirty).^{1,6}
 - Alert advanced life support as soon as possible.
 - Accurately record environmental conditions including time of submersion, type and temperature of water and air, scuba diver (depth, time at depth, type of dive rig).
 - Rescuer safety is a priority (avoids more casualties). Rescuers must balance personal safety and removing the drowning victims from the water by the fastest means available by using methods like reach, throw, row, tow, go.^{1,6,14}
 - 1) Reach with an object from the safety of the shore or ship.
 - 2) Throw an object like a rope or flotation devices (this may help the victim stay afloat or the search and rescue team locate the victim.)
 - 3) Row (or paddle) a smaller craft to the victim if they are too far from shore to reach or have a flotation device thrown. The rescuer should ideally stay out of the water.
 - 4) Tow them into shore or away from danger in the water (i.e. swift water rescue).
 - 5) Go into the water (as a last resort) to rescue the victim (highest risk to rescuer).
 - Additional risks to the rescuer include open water, swift water, or ice.
 - In water rescue breaths should only be done when rapid extraction is NOT feasible. In water chest compressions are NOT effective.^{1,3,15,16}
 - Cervical spine injury in drowning victims is low (0.009%). Unnecessary cervical spine immobilization can impede delay delivery of rescue breaths and adequate opening of the airway. Routine stabilization of the cervical spine in the absence of circumstances that suggest a spinal injury (diving, boat accident, and fall from height) is not recommended. If suspected, protect cervical spine by assuming neck injury (use jaw thrust to open the airway).^{1, 4, 6,7,12}
 - Handle patients rescued from cold water gently as possible as rough handling of hypothermic patients may trigger a lethal arrhythmia. Priority remains oxygenation, ventilation, and restoring circulation.

Figure 3. HELP posture

Pictures modified by LT Parenteau^{8,17}

INITIAL RESUSCITATION ON LAND^{1,3,6,7,12}

1. Call for help and encourage patient to move away from danger.^{15,16}
2. Place the patient parallel to the shoreline so that the head and feet are at the same level.
3. CPR: Airway, Breathing, Circulation (not CAB due to respiratory impact of drowning)
 - If unconscious and not breathing, begin with 5 rescue breaths (ABC rather than CAB), then continue with 30:2 (compressions: rescue breaths). Five breaths are used initially because water in the airways can interfere with effective alveolar expansion initially. A drowning patient with only respiratory arrest usually responds after a few rescue breaths.
 - Cardiac arrest from drowning is due primarily to lack of oxygen.
4. Ventilation support with available tools (oxygen, bag valve mask (BVM), etc.)
5. Prepare for vomiting: 65% of victims requiring rescue breathing vomit; 88% of those receiving chest compressions will vomit.

WHO TO EVALUATE^{1,3,6}

- Anyone who required resuscitation : All victims of drowning who require any form of resuscitation (including rescue breathing alone) should be transported to the hospital for evaluation and monitoring, even if they appear to be alert and demonstrate effective cardiorespiratory function at the scene
- Anyone unresponsive in the water
- Anyone exhibiting distress (shortness of breath, persistent cough, anxiety, tachypnea, syncope, foam in the mouth or nose, change in vital signs, abnormal breath sounds, or hypotension).

ADVANCED PREHOSPITAL CARE

Secure airway → improve oxygenation → stabilize circulation → gastric decompression → thermal insulation.^{1,6}

Maintain airway, begin CPR if necessary.

1. Attempt resuscitation unless clear signs of death (dismemberment, rigor mortis, decomposition, decapitation, etc.) or operational requirement.⁴
 - Rare case reports surviving prolonged submersion (especially in ice water).
 - Pulse may be difficult to identify due to hypothermia or hypotension. Do not use as sole indicator of death.
2. Avoid head down positioning or abdominal thrusts as they delay ventilation and increase vomiting, which increases the risk of aspiration and mortality. Heimlich maneuver NO LONGER recommended for drowning.^{7,14,18}
3. If unconscious but breathing, stabilize airway by putting patient in recovery (lateral recumbent) position as vomiting is common and can lead to aspiration.^{1,3}
4. If unconscious and not breathing, begin with 5 rescue breaths (ABC rather than CAB), then continue with 30:2 (compressions: rescue breaths). Five breaths are used initially because water in the airways can interfere with effective alveolar expansion initially. A drowning patient with only respiratory arrest usually responds after a few rescue breaths.^{3,18,19}
5. If no response, assume cardiac arrest.
6. Finger sweep if foreign body (sand, seaweed, etc.).

100% O₂ at 15 liters/min as soon as possible and until discontinued by medical officer.^{1,3}

1. Victim may be able to compensate for drowning insult by ↑ respiratory rate.
2. Consider early intubation/mechanical ventilation/ Positive end-expiratory pressure (PEEP) or Bilevel Positive Airway Pressure (BiPAP). Anticipate patient may vomit, so need to monitor for this and consider rapid sequence intubation (RSI) if available to minimize risk of aspiration
3. Goal arterial oxygen saturation 92-96%: Place pulse oximeter on ear lobe or forehead for more accurate readings due to vasoconstriction.^{20,21}

CARDIAC INTERVENTIONS

- Most common dysrhythmias are asystole and pulseless electrical activity (PEA).^{1,3,4}
- Many ACLS interventions are ineffective with low core body temperatures, including pacing, atropine, lidocaine and defibrillation. Antiarrhythmics should be withheld for core temperatures of < 30 °C (86 °F), with emphasis placed on chest compressions and ventilations to maintain perfusion.¹⁸
- Manage arrhythmia per ACLS protocols.

- If history of unobserved LOC think C-spine precautions, intoxication, arterial gas embolism (AGE) - if history and circumstances suggest it (e.g., scuba diver surfacing unconscious or with neuro complaint)² If AGE is suspected, begin notification of hyperbaric chamber team.
- Consider gastric decompression as many drowning patients swallow water prior to inhaling and between 60-80% will vomit at some point during recovery or resuscitation.
- Keep the victim warm (use core temperature instead of infrared devices).

NOTE: A low range refrigerator thermometer may be necessary). Stabilize body temperature - dry and insulate the patient to prevent heat loss. ^{1,20,21}

- **Mild hypothermia:** > 34°C (>93.2°F): passive rewarming (i.e. warm blankets and environment).
 - Moderate hypothermia: 30-34°C (86-93.2°F): active external rewarming will be required when available (i.e. heating blankets, radiant heat, forced hot air, warmed IV fluids at 43°C (109°F) , warm water packs).
 - Severe hypothermia: < 30°C (86°F): active internal rewarming will be required when available (peritoneal lavage, esophageal rewarming tubes, cardiopulmonary bypass, extracorporeal circulation); consider extracorporeal membrane oxygenation.
 - Withhold ACLS medications until temperature >30°C (86°F).¹⁴
 - Glucose – maintain between 80-140 mg/dL for ventilated patients.
- **IV fluids:** Obtain access, place Foley when appropriate to monitor output.^{1,3}
 1. If oxygenation does not correct hypotension, give IV crystalloid.
 2. Continue monitoring vital signs as drowning patients are often mildly intravascularly dehydrated. This combined with mechanical ventilation using PEEP can increase intrathoracic pressure and decrease central venous return.
 3. Provide sufficient resuscitation to stabilize vital signs as this will also allow inotropic and mechanical ventilation to improve tissue oxygenation.
 4. Careful fluid management is key as drowning victims are at high risk for pulmonary edema.
 5. For hypothermic patients, continue monitoring temperature and use warmed IV fluids at 43°C (109°F) to rewarm.¹²
- **Assess patient history & physical, vital signs,** determine Glasgow coma scale.
 - Lung injury may take up to 6 hours to present and may not be immediately present.
 - Monitor for wet lung sounds, productive cough, rapid shallow breaths, substernal burning, irregular/slow heart rate, altered consciousness.
- **Transport:** Evacuate if victim required resuscitation, was unresponsive in the water, or has dyspnea or other respiratory symptoms.
 - Full neurological recovery has occurred occasionally after prolonged submersion in both icy and warm water.

- Continue resuscitation and transported to higher level of care unless there are obvious signs of death.
- **Brain resuscitation:** The following have not shown benefit: No role for mannitol, diuretics, hypertonic saline (unless hyponatremic), mechanical hyperventilation, barbiturate coma, intracranial pressure monitoring.
- **Terminating resuscitation efforts in the field.^{1,7}**
 - After 1 hour submerged in water rescue should transition to body recovery with appropriate medical examiner evaluation for foul play (longest submerged survival 66 min).
 - Resuscitation may be stopped after 30 minutes of CPR without return of spontaneous circulation if patient is not hypothermic.
 - If there is any uncertainty, continue resuscitation until patient is rewarmed to 30-34 °C/86-93 °F, then continue CPR until asystole has persisted for >20 minutes.
 - Lowest recorded survival with neurologic recovery was core temp of 56.6°F/13.7 °C. However, only 17% of patients who require resuscitation in the ED will have functional recovery with minimal neurologic impairment and the ability to independently perform activities of daily living. If no cardiac activity once re-warmed, stop.
 - Increased duration of submersion increases risk of death or severe neurologic impairment.³
 - 0-5 min – 10%
 - 6-10 min – 56%
 - 11-25 min – 88%
 - >25 min – nearly 100%

Table 2. Duration of cardiopulmonary resuscitation (CPR) in Cases of Drowning³

Duration of cardiopulmonary resuscitation (CPR) in Cases of Drowning	
CPR	Recommendation
When to initiate	<ul style="list-style-type: none"> • Patient with respiratory distress or respiratory arrest • Submerged for < 60 min with no obvious physical evidence of death (dismemberment, rigor mortis, decomposition, decapitation)
Continue until	<ul style="list-style-type: none"> • Signs of life reappear, rescuers are exhausted, or advanced-life-support team takes over, or scene becomes unsafe for rescuer; or
When to terminate	<ul style="list-style-type: none"> • After 30 minutes of high quality CPR without return of vital signs for a patient submerged in warm water (i.e. non-hypothermic) • After patient has been rewarmed to 30-33 °C/86-93 °F (if hypothermic) and asystole has persisted for >20 minutes for a patient submerged in cold water

ED/ICU CARE

- If not done in the field or in route: secure airway → improve oxygenation → stabilize circulation → gastric decompression → thermal insulation^{1,3,7,25}
- Assess mental status using Glasgow Coma Scale:
 - GCS > 13 → Clear cervical spine. Monitor O2 saturations, Observe for 4-6 hours.
 - Normal O2 saturation and lung examination → discharge home
 - O2 saturation < 95% or abnormal lung exam treat as though GCS ≤ 13
 - GCS ≤ 13 or O2 saturation < 95% → Clear cervical spine, monitor O2 saturation
Give supplemental O2 to keep saturation ≥ 95% (non rebreather at 15L/min → CPAP (caution if vomiting is a concern) → intubate and ventilate with low TV (6 mL/kg), low PEEP 5-10 cm H2O (high PEEP may impair venous return resulting in hypotension), and volume ventilation (10 L/min).
- Otherwise, follow [JTS CPG for Acute Respiratory Failure](#).²²
- May require extracorporeal membrane oxygenation.
- Delay weaning from vent for 24 hours (even when gas exchange appears adequate - PaO2/ FiO2 ≥ 250).
- Surfactant washout will take 2-4 days of CPAP and PEEP to regenerate (unique to drowning and important in weaning from the vent).
- Inhaled albuterol and nebulized ipratropium for spasm
- Glucose – maintain between 80-140 mg/dL for ventilated patients.
- Special studies as indicated based on scenario.
 - CXR – regardless of patient’s clinical appearance to be used as baseline.
 - EKG: Normothermic – asystole or cardiac arrest poor prognosis (follow standard protocols)
Hypothermic – asystole and cardiac arrest should undergo prolonged aggressive resuscitation until normothermic or considered not viable.
 - Labs: complete blood count, comprehensive metabolic panel, glucose, Troponin I, PT/PTT, urinalysis, CK, urine myoglobin, urine drug screen, blood alcohol.
- Monitor:
 - Acid base status with arterial blood gas to determine:
 - Alveolar ventilation – acceptable PaCO2 and pH
 - Gas exchange – PaO2 > 60 mmHg on supplemental O2
 - Perfusion – no metabolic acidosis
 - Temperature with core temp (usually rectal)
 - Volume (BP, urine output, CVP, etc.). Initial resuscitation with crystalloid. Echo recommended prior to inotropic or vasopressors.
- Transfer to inpatient or ICU setting.

- Monitor for signs of infection (pulmonary or CNS), which may be due to bacteria, fungus, or ameba depending on water source. No role for prophylactic antibiotics to prevent pneumonia (incidence only 12 % of drowning cases) or steroids to reduce lung or neurologic injury; no need for routine cultures unless clinically indicated.
 - Pneumonia - fever, Gram stain and culture tracheal aspirates, respiratory status changes, chest radiographs. Increased risk while on vent.
 - Meningitis - neck stiffness, headache, change in mental status.
- Consider consults to critical care, trauma, neurosurgery, or hyperbaric medicine specialists.^{23,24}
- Consider and treat precipitating factors of drowning: trauma, spinal cord injury, seizure, MI, arrhythmia, toxin, syncope or hypoglycemia.
- Monitor for sepsis, disseminated intravascular coagulation (DIC), and renal insufficiency/failure.
- CT head and neck: edema or loss of gray-white matter distinction strongly predicts poor outcome, but normal CT is of little prognostic value.
- POST-CPR CARE: consider 12-24 hours of therapeutic hypothermia in patients with return of spontaneous circulation (ROSC) to improve neurological outcomes similar to cardiac arrest.
 - Drowning victims with ROSC who remain comatose should NOT be actively rewarmed above 90-93°F/32-34°C.
 - Drowning victims with ROSC whose core temperature is $\geq 93^\circ\text{F}/34^\circ\text{C}$ should be cooled to 90-93°F/32-34°C as soon as possible.
- Cerebral O₂ consumption decreases 5% for each reduction of 1°C within the range 37-20°C .

PULMONARY CONSIDERATIONS

- **Hypoxemia** – decreased levels of oxygen in the blood. This is the primary and most important physiologic insult due to impaired ventilation and gas exchange.^{1-6,25}
 - Water in lungs washes out surfactant causing atelectasis (alveolar collapse), diminished gas transfer, ventilation perfusion mismatch, and hypoxia.
 - Non-cardiac pulmonary edema, may cause acute respiratory distress syndrome (ARDS) immediately or be delayed (even after normal CXR) necessitating observation for 4-6 hours.
 - Initially due to external water insult, then worsened by microvascular damage activating inflammatory cascade, which results in extravasation of fluid into alveoli worsening ventilation/perfusion (V/Q) mismatch.
 - Shunting –hypoxic pulmonary vasoconstriction increases pulmonary hypertension driving fluid into alveoli.
- **Hypercapnia** – increased levels of carbon dioxide in the blood resulting in acidosis most often due to breath holding or apnea.
- **Contaminated water** (petroleum, sewage, organic, mud, sand, etc.) – may increase lung injury and require bronchoalveolar lavage to cleanse.^{1,6,11}

NEUROLOGIC CONSIDERATIONS

- Central Nervous System (CNS) is most susceptible organ to brief periods of hypoxemia and the major cause of morbidity/mortality.
- Full neurologic recovery rarely happens after: 10 min normothermic submersion or 40 min hypothermic submersion
- Full mentation (time dependent) → unconsciousness → complete brain death
- Highly metabolic areas of the brain are most susceptible – vascular end zones, gray matter, thalamus, hippocampus.

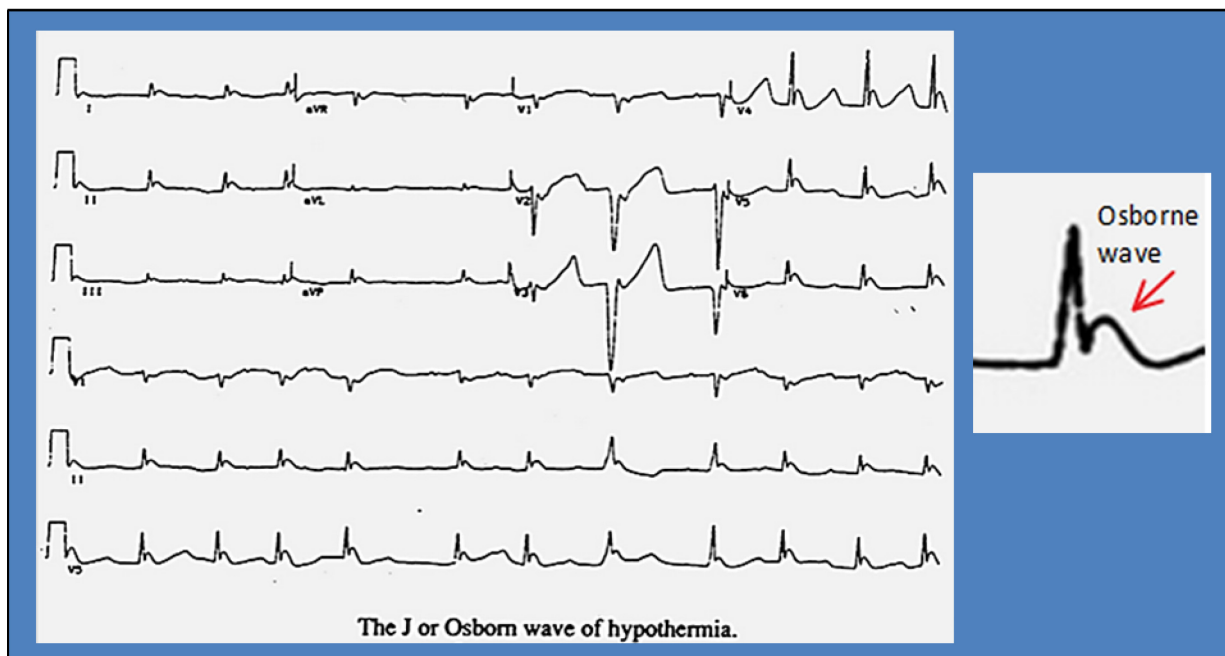
CARDIOVASCULAR CONSIDERATIONS

Major insult is hypoxemia and acidosis (two of the 5 ACLS “H’s and T’s”) causing:

- Arrhythmias (most commonly): Tachycardia → Bradycardia → PEA → Asystole
- Ventricular fibrillation is not uncommon.
- Many ACLS interventions are ineffective with low core body temperatures, including pacing, atropine, lidocaine and defibrillation. Antiarrhythmics should be withheld for core temperatures of $< 30^{\circ}\text{C}$ (86°F), with emphasis placed on chest compressions and ventilations to maintain perfusion.¹⁸

If hypothermic, look for Osborne waves (extra deflection at the end of the QRS complex). See Figure 4.

Figure 4. EKG may demonstrate Osborn Waves (a small notch on the descending R-wave that is associated with hypothermia)



HEMATOLOGIC & RENAL (ELECTROLYTE & METABOLIC) CONSIDERATIONS

- **Metabolic acidosis** – may progress from respiratory to metabolic and be severe.^{1,4,5,3}
- **Electrolyte shifts** – no practical effects in humans (evidence of derangements was from old animal studies).
- **Hemolysis** – no practical effects in humans (evidence of DIC and hyperkalemia were from old animal studies).
- **Diving reflex** – massive vagal nerve stimulation from cold water immersion shunts blood to brain and cardiac tissue, away from skin/extremities/vascular beds and is coupled with bradycardia and decreased metabolic demand which sustains mean arterial pressure (MAP) with decreased cardiac output.^{1,2,4,11}

SWIMMING INDUCED PULMONARY EDEMA (SIPE)

Most commonly presents in individuals conducting sustained strenuous surface swimming in cold water (i.e. NSW, Marine Combatant Divers, MARSOC Critical Skills Operators, Marine combat swimmers, special operators, scuba divers, and triathletes). SIPE is reported in 1.4% of triathletes and recurrence is not uncommon. Symptom severity can range from full recovery within 24 hours to death.

Risk Factors: hypertension, female, swimming ≥ 1.2 miles, prior history of SIPE

Diagnostic Criteria (during or immediately after exertional water immersion/swimming):

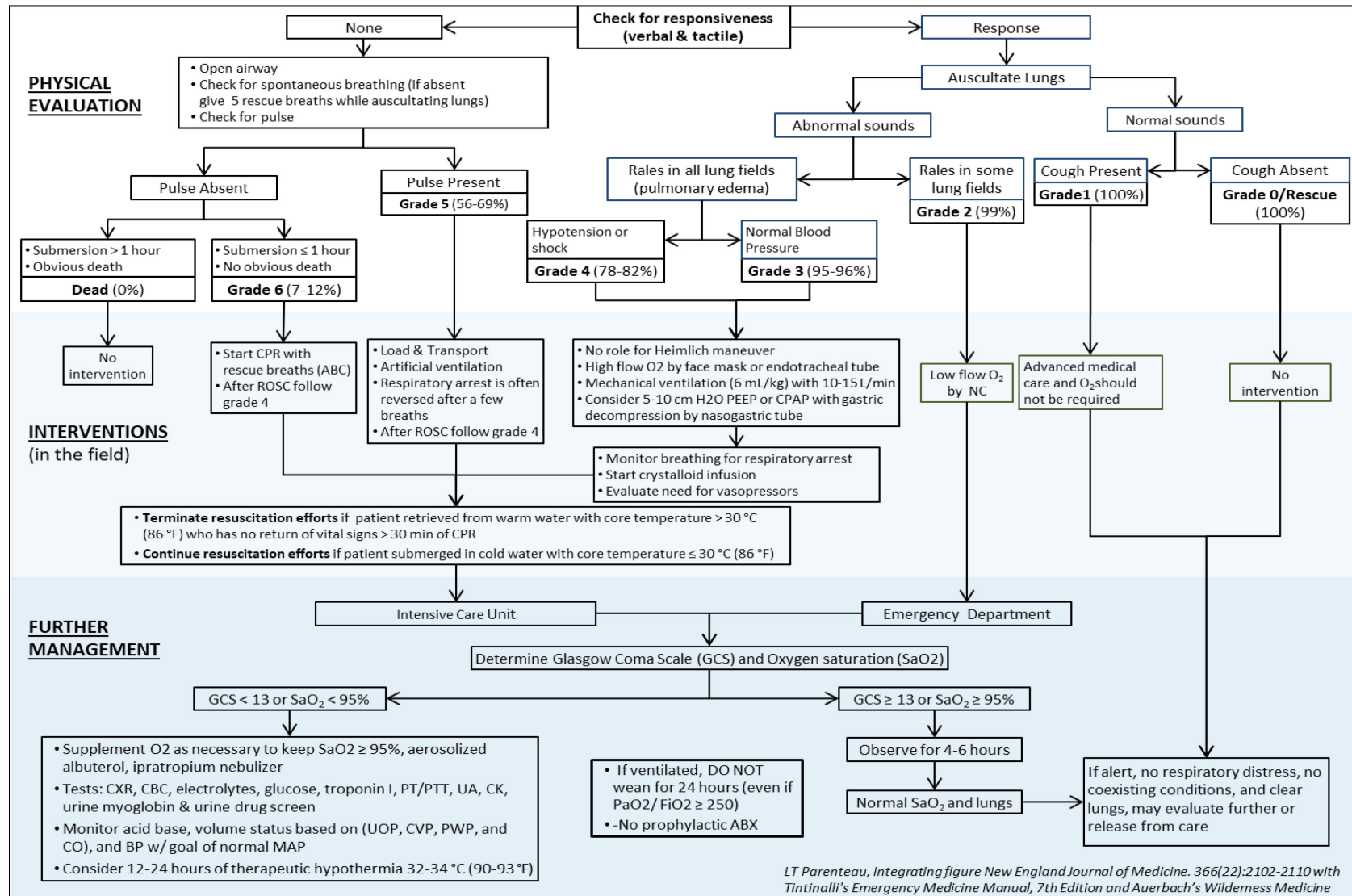
- Dyspnea or cough
- Hypoxemia
- +/- Hemoptysis
- CXR shows pulmonary edema or infiltrates that resolve w/in 48 hours.
- Absence of underlying pulmonary infection or aspiration of water

Pathophysiology: unknown; thought to be due to:

- Elevated pulmonary artery pressure - 'fracturing' pulmonary capillaries due to vascular stress caused by ↑ preload, afterload, and vascular resistance due to central pooling of blood from peripheral vasoconstriction.
- Diastolic dysfunction.

Management: typically resolves with rest within 24-48 hours. Hospitalization with diuretics and supplemental oxygen for severe cases.

DROWNING FLOWCHART



PERFORMANCE IMPROVEMENT (PI) MONITORING

POPULATION OF INTEREST

Drowning casualties

INTENT (EXPECTED OUTCOMES)

Drowning casualties with cardiac arrest/CPR who have return of spontaneous circulation receive targeted temperature management therapy.

PERFORMANCE/ADHERENCE METRIC

Number and percentage of drowning casualties with cardiac arrest/CPR who have return of spontaneous circulation who receive targeted temperature management therapy.

DATA SOURCE

- Patient Record (paper medical record and electronic medical record)
- Department of Defense Trauma Registry (DoDTR)

SYSTEM REPORTING & FREQUENCY

- The above constitutes the minimum criteria for PI monitoring of this CPG. System reporting will be performed annually; additional PI monitoring and system reporting may be performed as needed.
- The system review and data analysis will be performed by the JTS Chief and JTS PI Branch
- The Ustein Uniform Reporting Data form for Drowning will be used.

RESPONSIBILITIES

It is expected that medical department personnel, particularly of the sea services (U.S. Navy, U.S. Marine Corps, U.S. Coast Guard, and U.S. Merchant Marine) will become familiar with these clinical practice guidelines and incorporate them into both operational planning and emergency medical response plans.

REFERENCES

1. Auerbach's Wilderness Medicine, 7th Edition, Paul S. Auerbach, Drowning and Submersion Injuries (Chapter 69) (2016).
2. US Navy Diving Manual, Rev 7, Commander Naval Sea Systems Command (2016) Drowning/Near-drowning (Chapter 3-5.4)
3. Szpilman, D. Drowning. *New England Journal of Medicine*. 2012. 366(22):2102-2110.
4. Prevention and Treatment of Drowning, Mott & Latimer, *Am Fam Physician*, 2016;93(7):576-582.
5. Global report on drowning: preventing a leading killer, World Health Organization (2002).
6. NOLS Wilderness Medicine, 6th Edition, Tod Schimelpfenig, Drowning and Cold-Water Immersion (Chapter 14) (2007).
7. Wilderness Medical Society Practice Guidelines for the Prevention and treatment of Drowning, 236-251 (2016).
8. US Coast Guard Lifesaving Equipment PFD Selection, Use, Wear & Care.
9. U.S. Search and Rescue Task Force, Cold Water Survival.
10. How to Escape a Sinking Car: 4 Simple Steps, Water Smart Collier.
11. GMO Manual A Medical Reference for the Operational Medical Officer 4th Edition, LT Denis Ashley.
12. American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular: Hypothermia, *Circulation* 2010;122:S768–S786.
13. Coast Guard ice rescue techniques. U.S. Coast Guard, YouTube 2014.
14. American Heart Association, Special Circumstances of Resuscitation, 202 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, 3.10.
15. American Red Cross Life Guarding Manual 2012.
16. American Red Cross Life Guard Management course.
17. Man Overboard! National Park Service blog, 2018.
18. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, Part 10.3: Drowning. *Circulation* 112:IV-11-IV-135.

19. United States Lifesaving Association 2010 CPR Changes Not for Drowning.
20. Macleod DB, et al: The desaturation response time of finger pulse oximeters during mild hypothermia. *Anaesthesia* 2005; 60: pp. 65
21. Kober A, Scheck T, Lieba F, et al: The influence of active warming on signal quality of pulse oximetry in prehospital trauma care. *Anesth Analg* 2002; 95: pp. 961
22. Joint Trauma System, Acute Respiratory Failure CPG, 23 Jan 2017.
23. *Diving Medicine*, 4th Edition, Alfred A. Bove and Jefferson Davis (2003), Near Drowning (Chap 14)
24. *Bennett and Elliotts' Physiology and Medicine of Diving*, 5th Edition(2003), Drowning and Nearly Drowning (Chapter 6)
25. *Tintinalli's Emergency Medicine Manual*, 7th Edition, David M. Cline et al., Near Drowning (Chapter 124) (2012).

APPENDIX A: MEDICAL DEFINITIONS AND TERMINOLOGY

WORLD HEALTH ORGANIZATION DEFINITIONS^{1,2}

- **Immersion:** “some portion of the body is covered in water” (i.e. head is out of the water)
- **Submersion:** “during submersion, the entire body, including the airway, is under water” (i.e. head is in the water)
- **Submersion injuries:** “water-related conditions that do not involve the airway and respiratory systems
- **Drowning:** “the process of experiencing respiratory impairment from submersion/immersion in liquid.” The drowning process begins with respiratory impairment as the person’s airway goes below the surface of the liquid (submersion) or water splashes over the face while being completely in a liquid (immersion).¹⁻³ Subdivided into 3 categories:
 - **Fatal drowning:** “person dies at any time as a result of submersion/immersion with respiratory impairment.”
 - **Non-fatal drowning with morbidity:** “person is injured at any time as a result of submersion/immersion with respiratory impairment, but survives.”
 - **Non-fatal drowning without morbidity:** “person survives uninjured from submersion/immersion event with respiratory impairment, but survives.”
- **Water rescue:** “submersion or immersion incident without evidence of respiratory impairment.”¹⁻⁴
- **Shallow water blackout:** “hyperventilating to decrease hypercapnic drive to breathe and prolong ability to stay under water such that hypoxemia results in unconsciousness.” The compulsion to breathe from hypercapnia (acidosis) is physiologically more potent than hypoxemia (except when subverted by hyperventilation – i.e. lowering CO₂).⁵
- **Asphyxia:** “a condition where breathing stops and both hypoxia and hypercapnia occur simultaneously due to: (1) the absence of gas to breathe; (2) the airway being completely obstructed; (3) respiratory muscles being paralyzed; or (4) respiratory center failing to send impulses to breathe.” Running out of compressed air is a common cause of asphyxia in SCUBA diving.^{1,5,6}
- **Drowning after shallow water diving:** Diving into shallow water makes concussion, head injury, and cervical spine (C-spine) injury more common, so rescuer must balance C-spine precautions against time of extraction (normally in drowning C-spine precautions are not required because the risk is < 0.5%). Also consider drug/alcohol impairment.^{1,6}
- **Warm water drowning:** Unplanned submersion → panic and violent struggle → gulping / swallowing of air and water → breath holding until hypoxia leads to unconsciousness → gag reflex relaxing resulting in passive influx of water → drowning if PFD does not keep airway out of the water.¹
- **Cold water drowning:** Impacts every organ system similar to complex trauma. Sudden immersion in cold water (< 91.4°F/33 °C) causes panic, reflexive gasp for air and rapid breathing making:^{1-5, 8-10}
 - Inhalation/aspiration of water is more likely.
 - Core temperature drop causing arrhythmias, confusion, incapacitation (diminished strength and coordination) increasing the chance of drowning.

- Water conduct heat away from the body 25 times faster than air leading to immersion hypothermia – impaired meaningful movement usually precedes.^{1,6,8}

TERMS NOT TO USE

Terms NOT to use as they do not have diagnostic or therapeutic distinctions (although still widely used by medical professionals and the lay public, so important to be familiar with them).^{1,4,5,7,8,11}

- **Wet drowning:** “Fluid is aspirated into the lungs.” Aspiration of water occurs in only 80-90% of cases and does not change the treatment or management.
- **Dry drowning:** “Fluid is not aspirated; death is due to laryngospasm and glottis closure.” Asphyxia still occurs secondary to laryngospasm occurring in 10-20% of cases, but no change in management. Difference is only relevant at autopsy.
- **Secondary drowning/Delayed onset of respiratory distress:** Varied definitions with death occurring from 1-72 hours after initial resuscitation due to acute respiratory distress syndrome (ARDS). Fifteen percent of victims conscious at initial resuscitation subsequently die from ARDS.
- **Near drowning:** “Suffocation by submersion in a liquid with at least temporary survival. Death from near drowning occurs after 24 hours.” Caused confusion because it had 20 different published definitions, most commonly if the person is rescued at any time, thus interrupting the process of drowning.
- **Immersion syndrome:** “Sudden death immediately following submersion in very cold water” thought to be caused by vagal nerve stimulation resulting in overwhelming bradycardia.
- **Active drowning:** Witnessed drowning
- **Passive drowning:** Unwitnessed drowning
- **Fresh water vs. salt water drowning:** Typical human aspiration during drowning is 4 mL/kg. To change blood volume requires 8mL/kg, or to alter electrolytes require 22 mL/kg. Therefore, not clinically significant and instead focus remains on hypoxemia, acidosis, and pulmonary injury rather than electrolyte or volume status.
 - **Freshwater:** Hypervolemia (in animal models only, not humans, so no clinical relevance)
 - **Saltwater:** Hypovolemia with hypernatremia (in animal models only, not humans, so no clinical relevance)

REFERENCES

1. Auerbach’s Wilderness Medicine, 7th Edition, Paul S. Auerbach, Drowning and Submersion Injuries (Chapter 69) (2016).
2. Global report on drowning: preventing a leading killer, World Health Organization (2002).
3. Wilderness Medical Society Practice Guidelines for the Prevention and treatment of Drowning 27, 236-251 (2016).
4. Szpilman, D. et al. 2012. Drowning. New England Journal of Medicine. 366(22):2102-2110.

5. US Navy Diving Manual, Rev 7, Commander Naval Sea Systems Command (2016) Drowning/Near-drowning (Chapter 3-5.4)
6. NOLS Wilderness Medicine, 6th Edition, Tod Schimelpfenig, Drowning and Cold-Water Immersion (Chapter 14) (2007).
7. Global report on drowning: preventing a leading killer, World Health Organization (2002).
8. GMO Manual A Medical Reference for the Operational Medical Officer 4th Edition, LT Denis Ashley, Submersion injuries.
9. U.S. Search and Rescue Task Force, Cold Water Survival.
10. American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular. *Circulation* 2010;122:S768–S786.
11. Prevention and Treatment of Drowning, Mott & Latimer.

APPENDIX B: ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

PURPOSE

The purpose of this Appendix is to ensure an understanding of DoD policy and practice regarding inclusion in CPGs of “off-label” uses of U.S. Food and Drug Administration (FDA)–approved products. This applies to off-label uses with patients who are armed forces members.

BACKGROUND

Unapproved (i.e. “off-label”) uses of FDA-approved products are extremely common in American medicine and are usually not subject to any special regulations. However, under Federal law, in some circumstances, unapproved uses of approved drugs are subject to FDA regulations governing “investigational new drugs.” These circumstances include such uses as part of clinical trials, and in the military context, command required, unapproved uses. Some command requested unapproved uses may also be subject to special regulations.

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

The inclusion in CPGs of off-label uses is not a clinical trial, nor is it a command request or requirement. Further, it does not imply that the Military Health System requires that use by DoD health care practitioners or considers it to be the “standard of care.” Rather, the inclusion in CPGs of off-label uses is to inform the clinical judgment of the responsible health care practitioner by providing information regarding potential risks and benefits of treatment alternatives. The decision is for the clinical judgment of the responsible health care practitioner within the practitioner-patient relationship.

ADDITIONAL PROCEDURES**Balanced Discussion**

Consistent with this purpose, CPG discussions of off-label uses specifically state that they are uses not approved by the FDA. Further, such discussions are balanced in the presentation of appropriate clinical study data, including any such data that suggest caution in the use of the product and specifically including any FDA-issued warnings.

Quality Assurance Monitoring

With respect to such off-label uses, DoD procedure is to maintain a regular system of quality assurance monitoring of outcomes and known potential adverse events. For this reason, the importance of accurate clinical records is underscored.

Information to Patients

Good clinical practice includes the provision of appropriate information to patients. Each CPG discussing an unusual off-label use will address the issue of information to patients. When practicable, consideration will be given to including in an appendix an appropriate information sheet for distribution to patients, whether before or after use of the product. Information to patients should address in plain language: a) that the use is not approved by the FDA; b) the reasons why a DoD health care practitioner would decide to use the product for this purpose; and c) the potential risks associated with such use.