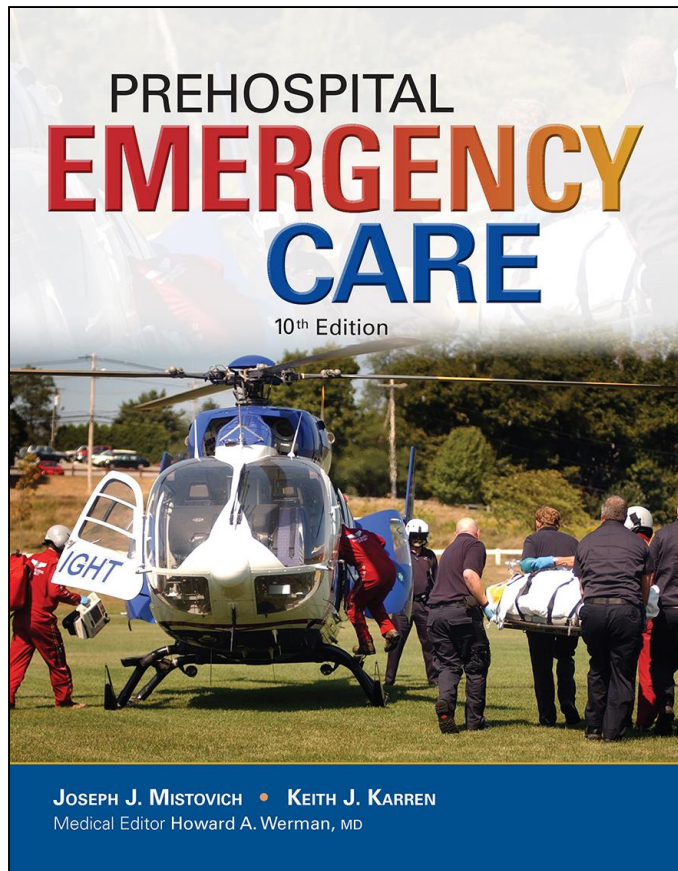


# PREHOSPITAL EMERGENCY CARE

TENTH EDITION



## CHAPTER 25

### Submersion Incidents: Drowning and Diving Emergencies

# Learning Readiness

- EMS Education Standards, text p. 713

# Learning Readiness Objectives

- Please refer to page 713 of your text to view the objectives for this chapter.

# Learning Readiness

## Key Terms

- Please refer to page 713 of your text to view the key terms for this chapter.

# Setting the Stage

- Overview of Lesson Topics
  - Water-Related Emergencies
  - Scuba or Deep-Water Diving Emergencies

# Case Study Introduction

EMTs Jacob Stilts and Lydia Huse are responding to a report of a child drown in a backyard pool. When they arrive, they see a woman performing CPR on a toddler. The initial report from family members is that the child was not seen for five to ten minutes before being discovered on the bottom of the pool. The patient was pulled from the pool by a family member, who immediately began CPR.

# Case Study

- What are some ways in which this incident could have been prevented?
- What factors will influence the patient's chances of survival?

# Introduction

- Water-related emergencies include drowning, diving, deep-water diving, and boating and skiing injuries.
- Many deaths could be prevented by the use of personal flotation devices (PFDs).



# Water-Related Emergencies

- Prevention measures
  - All pools should be fenced.
  - Constantly supervise children who are in the area of any body of water or large container of water.
  - Do not use alcohol when engaged in water activities.

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# Water-Related Emergencies

- Prevention measures
  - Always wear a PFD when boating.
  - Do not dive into shallow or unexplored bodies of water.
  - Patients with seizure disorders must use extreme care around water.

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# Water-Related Emergencies

- Definition
  - Drowning is an incident in which someone is submerged or immersed in a liquid that results in a primary respiratory impairment.
  - The liquid prevents the patient from breathing air.
  - The patient may live or may die from the event.

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# Water-Related Emergencies

- Incidence
  - 4,500 drowning deaths per year in U.S.
  - 40% of deaths are of children younger than 5 years old.
  - The second-highest incidence is among teenagers.
  - 85% of drownings are in males.
  - Alcohol is frequently involved in drowning.

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# Water-Related Emergencies

- Conditions that can lead to submersion
  - Hypoglycemia
  - Myocardial infarction
  - Cardiac dysrhythmia
  - Syncope
  - Seizure
  - Suicide attempt

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# Water-Related Emergencies

- Conditions that can lead to submersion
  - Anxiety or panic disorder
  - Arthritis, Parkinson's disease, poor body control
  - Exhaustion
  - Hypothermia
  - Alcohol or drug use
  - Trauma

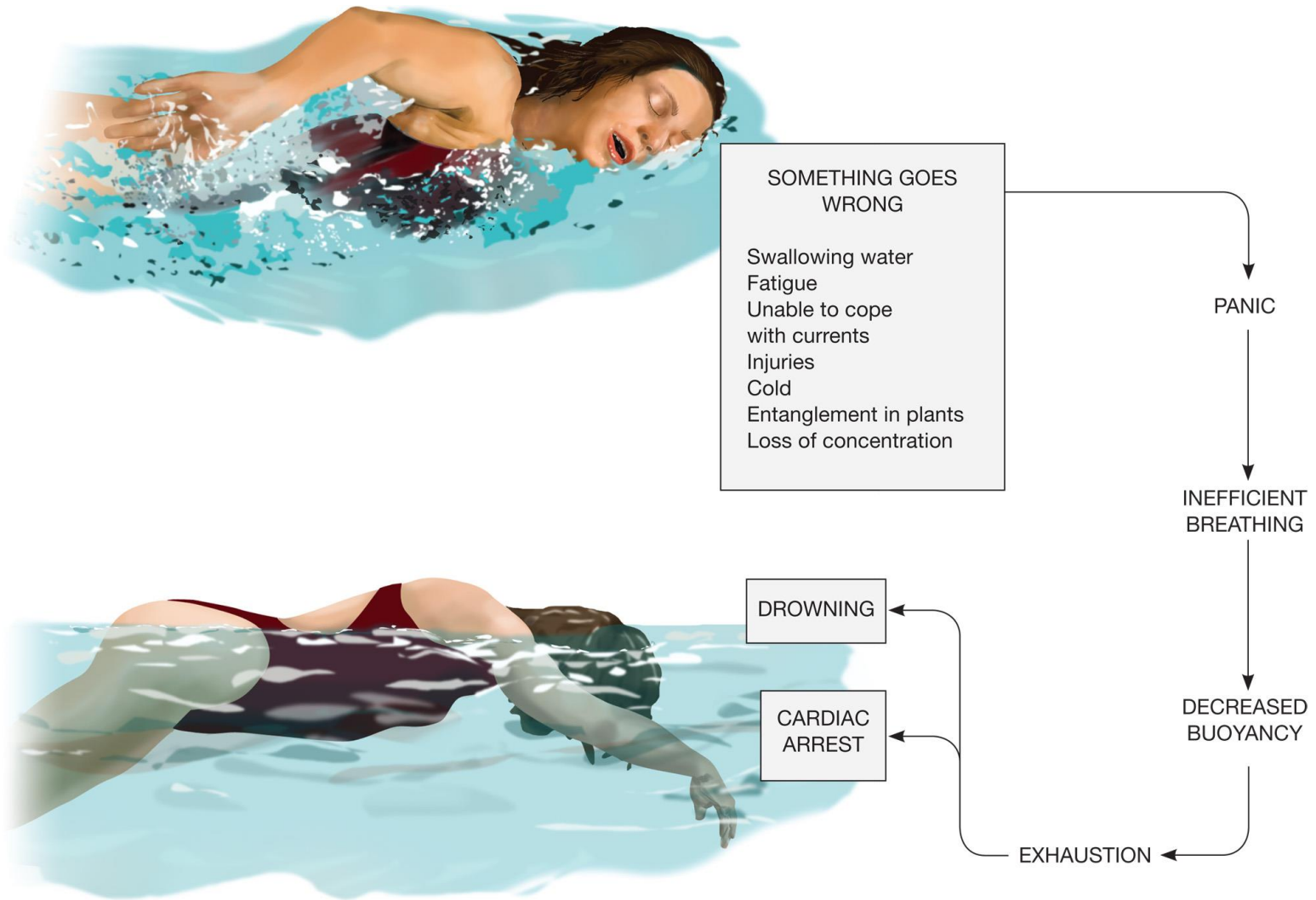
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# Water-Related Emergencies

- Water sports pose a risk of drowning and of head and spinal trauma.
- Scuba accidents may involve exertion, inexperience panic, and poor judgment.

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Panic can often contribute to the death of the person who loses self-control.



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# Water-Related Emergencies

- Chances of survival are greatest in patients with two or fewer of these characteristics:
  - Age 3 years or older
  - Submerged >5 minutes
  - Resuscitation delayed >10 minutes after rescue
  - Comatose on arrival at the ED
  - Arterial blood pH <7.10

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# Water-Related Emergencies

- Pathophysiology of drowning
  - Submersion results in aspiration of water or laryngeal spasms, leading to suffocation.
  - Hypoxia and acidosis lead to brain damage and death.

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# Water-Related Emergencies

- Pathophysiology of drowning
  - In dry drowning, laryngeal spasm prevents water from entering the lungs.
  - When water does enter the lungs, the amount is small, and it is usually absorbed into the bloodstream.

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# Water-Related Emergencies

- Pathophysiology of drowning
  - Whether drowning is in fresh water or salt water, water in the lungs washes out surfactant.
  - When surfactant is washed out, the alveoli collapse.
  - Alveolar-capillary damage leads to pulmonary edema and acute respiratory distress syndrome (ARDS).

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# Water-Related Emergencies

- Pathophysiology of drowning
  - Hypothermia results from submersion in cold water, and may play a protective role.
  - Complications of hypothermia include hypovolemia from increased capillary permeability, and cardiac dysrhythmias.

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# Water-Related Emergencies

- Factors that influence the seriousness of drowning:
  - Persistent cough
  - Dyspnea or apnea
  - Altered mental status during submersion
  - Vomiting
  - Drug or alcohol use

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# Water-Related Emergencies

- Factors that influence the seriousness of drowning:
  - History of seizures, diabetes, or neuromuscular disorder
  - Hypothermia
  - Duration of cardiac or respiratory arrest
  - Age of the patient
  - Pre-existing diseases or conditions

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# Water-Related Emergencies

- Diving emergencies
  - Usually occur in pools or other shallow water
  - Head and spine injuries may occur, as well as fractures of the extremities or ribs.
  - Assume neck and spine injuries in diving emergencies.

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# Water-Related Emergencies

- Safety measures
  - Unless the emergency involves open, shallow water with a stable uniform bottom, do not attempt rescue unless you meet all of these criteria:
    - You are a good swimmer
    - You are specially trained in water rescue techniques

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# Water-Related Emergencies

- Safety measures
  - Unless the emergency involves open, shallow water with a stable uniform bottom, do not attempt rescue unless you meet all of these criteria:
    - You are wearing a PFD
    - You are accompanied by other rescuers

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# Water-Related Emergencies

- Safety measures
  - If the patient is close to shore, use the reach, throw, row, go strategy

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Use an object that floats and is unlikely to break tied to the end of a rope to pull the patient to shore.



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Don't become a patient yourself. Use a boat to reach an unresponsive patient.



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# Water-Related Emergencies

- Suspect spinal injury if:
  - There was a diving accident
  - The patient may have been struck by a skier, surfboard, or other object
  - The swimmer was using a water slide
  - There is suspicion of intoxication
  - There is evidence of traumatic injury

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# Water-Related Emergencies

- Resuscitation
  - The mammalian diving reflex may be activated in cold water drowning.
  - The mammalian diving reflex results in a drastic decrease in the metabolic rate.
  - The patient may be able to be resuscitated even after prolonged submersion.

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# Water-Related Emergencies

- Assessment-based approach
  - Scene size-up
    - Ensure your own safety.
    - If you are within 10 feet of the edge of the water, wear a PFD.
    - Take Standard Precautions.
    - Request additional resources, as needed.

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# Water-Related Emergencies

- Assessment-based approach
  - Primary assessment
    - Form a general impression.
    - Assess the mental status.
    - Consider the possibility of spinal injury.
    - Establish a patent airway.

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# Water-Related Emergencies

- Assessment-based approach
  - Primary assessment
    - Positive pressure ventilation for inadequate breathing.
    - Maintain oxygenation.
    - Assess for bleeding and hypoperfusion.
    - Determine priority for transport.

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# Water-Related Emergencies

- Assessment-based approach
  - Secondary assessment
    - Perform a physical exam.
    - Obtain a history.

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# Water-Related Emergencies

- Signs and symptoms
  - Airway obstruction.
  - Absent or inadequate breathing.
  - Pulselessness.
  - Spinal or head injury.

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# Water-Related Emergencies

- Signs and symptoms
  - Soft tissue injuries.
  - Musculoskeletal injuries.
  - External or internal bleeding.
  - Shock.

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# Water-Related Emergencies

- Signs and symptoms
  - Hypothermia.
  - Alcohol or drug abuse.
  - Drowning or submersion.

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# Water-Related Emergencies

- Categorize drowning patients as one of these four categories:
  - Asymptomatic
  - Symptomatic
  - Cardiac arrest
  - Obviously dead

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# Water-Related Emergencies

- Asymptomatic
  - No signs or symptoms

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# Water-Related Emergencies

- Symptomatic
  - Altered mental status
  - Altered vital signs
  - Respiratory distress or arrest
  - Dyspnea
  - SpO<sub>2</sub> <94%
  - Persistent cough

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# Water-Related Emergencies

- Symptomatic
  - Wheezes or crackles in the lungs
  - Hypothermia
  - Vomiting, diarrhea
  - Anxiety

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# Water-Related Emergencies

- Cardiac arrest
  - No pulses
  - Apnea

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# Water-Related Emergencies

- Obviously dead
  - Rigor mortis
  - Dependent lividity

# Case Study

Jacob directs another rescuer to take over CPR from the family member, and quickly verifies the absence of a pulse as the switch is made.

Lydia makes observations of the scene to determine if there are any other mechanisms of injury or important factors to consider. She questions family members to try to determine exactly how long the child was submerged, and to find out about the child's medical history.

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# Case Study

- What are the steps in managing this patient?

# Water-Related Emergencies

- Emergency medical care
  - Remove the patient from the water as quickly and safely as possible.
  - If spinal injury is suspected, protect the spine.

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## Water rescue, possible spinal injury.



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# Water-Related Emergencies

- Emergency medical care
  - If there is no spinal injury, place the patient on his left side (if the patient is breathing and has a pulse).
  - Be prepared to suction.
  - For absent or inadequate breathing, establish an airway and begin ventilations with supplemental oxygen.

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# Water-Related Emergencies

- Emergency medical care
  - Maintain an SpO<sub>2</sub> of 94% or greater.
  - If the patient is pulseless and apneic, begin CPR and apply the AED.
  - If gastric distention interferes with ventilation, decompress the stomach.

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# Water-Related Emergencies

- Emergency medical care
  - Manage any other medical or traumatic conditions present.
  - Transport with resuscitation continuing.

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# Water-Related Emergencies

- Always transport a drowning patient, even if he is not experiencing symptoms. Complications can arise up to 72 hours after the incident.

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# Water-Related Emergencies

- Reassessment
  - Repeat the primary and secondary assessments and vital signs
    - Every 5 minutes for unstable patients
    - Every 15 minutes for stable patients

# Scuba and Deep-Water Diving Emergencies

- Dysbarism results from the effects of changes in pressure on gases within the the body.
- Basic laws of physics explain the changes.

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# Scuba and Deep-Water Diving Emergencies

- Boyle law
  - At a constant temperature, the volume of a gas is inversely related to the pressure.
    - As the pressure increases, the volume of the gas decreases.
    - As the pressure decreases, the volume of the gas increases.

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# Scuba and Deep-Water Diving Emergencies

- Dalton law
  - The total pressure of a mixture of gases equals the sum of the partial pressures of the individual gases that make up the mixture.
    - As a diver descends, the pressure of each component gas in the air increases proportionately.
    - As the pressure of nitrogen increases, it begins to dissolve into the blood.

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# Scuba and Deep-Water Diving Emergencies

- Henry law
  - At a constant temperature, the amount of gas that dissolves in a liquid is proportionate to the pressure of the gas around it.
  - With increasing depth, gases that have dissolved into the blood will dissolve into and accumulate in the body fat and tissues.

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# Scuba and Deep-Water Diving Emergencies

- Charles law
  - All gases expand equally upon being heated.
    - As a diver descends into colder water temperatures, the inhaled and dissolved gases contract.
    - As the diver ascends, the temperature increases and the gases expand.

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# Scuba and Deep-Water Diving Emergencies

- Decompression sickness
  - Occurs as the result of the bubbles formed by the expansion of nitrogen in the blood and tissues.

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# Scuba and Deep-Water Diving Emergencies

- Decompression sickness
  - The bubbles have two primary effects on the body:
    - They act as emboli and cause obstruction in the circulation.
    - They compress or stretch the blood vessels and nerves.

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# Scuba and Deep-Water Diving Emergencies

- Factors that predispose to decompression sickness
  - Flying or going to a high altitude too soon after a dive.
  - Failure to take the necessary safety stops while ascending from a dive.
  - Inadequate surface intervals.

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# Scuba and Deep-Water Diving Emergencies

- Factors that predispose to decompression sickness
  - Inadequate decompression or passing the no-decompression limit.
  - Diving at depths for too long a period of time.
  - Repeated dives at depth on the same day.

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# Scuba and Deep-Water Diving Emergencies

- Physical factors that predispose to decompression sickness
  - Poor physical condition
  - Obesity
  - Age
  - Dehydration

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# Scuba and Deep-Water Diving Emergencies

- Physical factors that predispose to decompression sickness
  - Heart or lung diseases or conditions
  - Pre-existing musculoskeletal injury
  - Fatigue

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# Scuba and Deep-Water Diving Emergencies

- Environmental factors that predispose to decompression sickness
  - Cold water
  - Rough seas
  - Heated diving suits
  - Heavy work

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# Scuba and Deep-Water Diving Emergencies

- Categories of decompression sickness (DCS)
  - Type I DCS
  - Type II DCS
  - Arterial gas embolism (AGE)

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# Scuba and Deep-Water Diving Emergencies

- Type I DCS signs and symptoms
  - Pain
  - Pruritus and burning of the skin
  - Skin rash
  - Orange peel appearance of skin
  - Painless pitting edema

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# Scuba and Deep-Water Diving Emergencies

- Type II DCS signs and symptoms
  - Nervous system
    - Low back pain progressing to weakness, paralysis, numbness, tingling, loss of sphincter control, and abdominal pain
    - Headache, visual disturbances, dizziness, tunnel vision
    - Altered mental status
    - Nausea, vomiting, vertigo, tinnitus, partial deafness

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# Scuba and Deep-Water Diving Emergencies

- Type II DCS signs and symptoms
  - Respiratory system
    - Substernal burning on inhalation
    - Nonproductive cough
    - Respiratory distress

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# Scuba and Deep-Water Diving Emergencies

- Type II DCS signs and symptoms
  - Circulatory system
    - Signs of hypovolemic shock
    - Thrombus formation

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, look for:
  - Fatigue
  - Signs and symptoms of shock
  - Pupillary changes
  - Pallor of the tongue
  - Bloody sputum
  - Nasal flaring, retractions, accessory muscle use

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, look for:
  - Tachypnea
  - Crackles in the lungs
  - SpO<sub>2</sub> <94%
  - Vomiting
  - Urinary bladder distention

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, look for:
  - Seizure
  - Uncoordinated movements, weakness, motor and sensory deficits
  - Joint pain, decreased range of motion
  - Edema
  - Cyanosis, pallor, itching, mottling, marbling

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, ask the following:
  - Where did the patient dive?
  - What was the deepest depth, and for how long?
  - What were the other depths and times?
  - What was the rate of ascent?
  - What has the patient done since the dive?

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, ask the following:
  - What did the patient do in the 72 hours before the dive?
  - Did the patient do work during the dive?
  - What gases were used during the dive?
  - Did the patient have any problems during the dive?

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# Scuba and Deep-Water Diving Emergencies

- In assessment for DCS, ask the following:
  - What was the patient's physical condition before, during, and after the dive?
  - Was any first aid provided?

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# Scuba and Deep-Water Diving Emergencies

- Arterial gas embolism
  - An artery is obstructed by a bubble or cluster of bubbles.
  - Rapid ascent with breath-holding can cause alveolar rupture, allowing air to enter the bloodstream.
  - Signs and symptoms have a rapid onset.

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# Scuba and Deep-Water Diving Emergencies

- AGE signs and symptoms
  - Itchy, blotchy, mottled skin
  - Difficulty breathing
  - Dizziness
  - Chest pain
  - Severe, deep aching pain in muscles, joints, tendons

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# Scuba and Deep-Water Diving Emergencies

- AGE signs and symptoms
  - Blurred or distorted vision
  - Partial deafness
  - Nausea, vomiting
  - Numbness, paralysis
  - Weakness or numbness on one side of the body
  - Staggering gait or lack of coordination

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# Scuba and Deep-Water Diving Emergencies

- AGE signs and symptoms
  - Frothy blood in the nose or mouth
  - Swelling and crepitus in the neck
  - Loss or distortion of memory
  - Coma
  - Cardiac or respiratory arrest
  - Behavioral changes

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# Scuba and Deep-Water Diving Emergencies

- Barotrauma
  - During ascent or descent, pressure becomes too great within the body's air-filled cavities, such as the sinuses or middle ear.

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# Scuba and Deep-Water Diving Emergencies

- Barotrauma signs and symptoms
  - Pain in the affected area
  - Clear or bloody discharge from the nose or ears
  - Extreme dizziness
  - Nausea
  - Disorientation

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# Scuba and Deep-Water Diving Emergencies

- Emergency medical care for diving emergencies
  - Consider the need for spinal stabilization.
  - Keep the patient supine or in lateral recumbent position.
  - Establish an airway and assess breathing.

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# Scuba and Deep-Water Diving Emergencies

- Emergency medical care for diving emergencies
  - Administer oxygen 15 lpm by nonrebreather mask if breathing is adequate.
  - Assist ventilations with supplemental oxygen for inadequate breathing.

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# Scuba and Deep-Water Diving Emergencies

- Emergency medical care for diving emergencies
  - Initiate CPR and apply the AED, if indicated.
  - Transport immediately.

Click on the mechanism that explains the reduction in metabolic rate associated with cold water drowning.

A. The mammalian diving reflex

B. The Boyle law

C. Dissolved nitrogen in the bloodstream

D. Laryngospasm

# Case Study Conclusion

The patient, a two-year old girl, was most likely submerged between five and seven minutes. There does not appear to be a reason to suspect spinal injury.

Jacob is particularly concerned with providing a patent airway and adequate ventilation and oxygenation. He opens the airway with a head-tilt, chin-lift, and places a folded towel beneath the patient's shoulders. He suctions the airway, and inserts an oropharyngeal airway as another EMT continues chest compressions.

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# Case Study Conclusion

Meanwhile, Lydia dries the patient and applies the AED. However, no shock is indicated. Jacob performs positive pressure ventilation with supplemental oxygen, but he finds that there is increasing resistance to ventilation. The patient's stomach appears very distended, so the EMTs position her on her side and decompress the stomach, suctioning away the stomach contents to prevent aspiration.

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# Case Study Conclusion

The EMTs begin immediate transport, and request intercept with an ALS unit because of their 20-minute transport time.

The patient regains a pulse prior to arriving at the emergency department, but remains unresponsive. She is admitted to pediatric critical care, where she is carefully monitored for neurological damage and respiratory complications. Currently, her prognosis for recovery is uncertain.

# Lesson Summary

- Drowning is immersion in a liquid that impairs the ability to breathe.
- Drowning causes a significant number of deaths, but is preventable.
- In some cases, drowning is associated with the possibility of spinal injury.

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# Lesson Summary

- Scuba diving emergencies can be explained by basic gas laws.
- Treatment of drowning and diving emergencies focuses on airway, ventilation, oxygenation, and, if the pulse is absent, CPR and AED.