

Chapter 13: Exposure/Environment

1 Extremes of temperature

1.1 Learning objectives

By the end of this lesson you will be able to:

- State the normal temperature range for an adult
- Explain the terms 'hypothermia' and 'heat-related illness'
- Describe the appropriate management for a patient with signs of hypothermia and heat-related illness.

1.2 Introduction

Despite being exposed to a wide range of environmental temperatures, the human body maintains a stable temperature of around 37°C and is maintained in the range 35.8–38.2°C. Normal fluctuations of about 1°C occur over a 24-hour period, with highest temperatures recorded in the afternoon and early evening, and lowest temperatures in early morning [Marieb, 2013].

Thermoregulation is primarily the job of the hypothalamus, which receives sensory information from peripheral and central thermoreceptors. This is necessary because the different body regions have differing temperatures [Tortora, 2008]:

- Core: Consisting of organs within the skull, thorax and abdomen
- Shell: The skin.

By controlling the flow of blood to the shell, the hypothalamus can control the amount of heat generated and lost.

Heat-promoting mechanisms

When the external temperature falls, the heat-promoting centre is activated. This maintains core body temperature by [Marieb, 2013]:

- Constricting peripheral cutaneous blood vessels
- Causing shivering – involuntary contractions of skeletal muscle, which generates heat
- Increasing the body's metabolic rate.

In addition, there are a number of behavioural changes that can be promoted:

- Putting on warmer clothes
- Drinking hot fluids
- Increasing physical activity.

Heat-loss mechanisms

Most heat loss occurs via the skin by dilation of cutaneous blood vessels and/or enhanced sweating, allowing for heat loss to occur by [Marieb, 2013]:

- Radiation: Infrared waves (thermal energy)
- Conduction: Direct contact with cooler objects (such as cold water)
- Convection: Since warm air expands and rises, warm air around the body is constantly replaced with cooler air, which absorbs the heat. This process can be enhanced by moving air more rapidly across the body surface, for example by the use of a fan
- Evaporation: As water absorbs heat from the body, it becomes energetic enough to escape the body as a gas, called water vapour.

1.3 Hypothermia

Hypothermia is defined as a core body temperature of less than 35°C. It is classified into three categories, based on temperature [AACE, 2013]:

- Mild: 32–35°C
- Moderate: 28–32°C
- Severe: Less than 28°C.

However, without a low-reading thermometer, it can be difficult to record accurate core body temperatures. Therefore, it is important to suspect that hypothermia might be a factor in the following [AACE, 2013]:

- Older patients (over 80 years of age)
- Children
- Some medical conditions: For example, hypothyroidism and stroke
- Intoxicated patients: Alcohol and/or recreational drugs
- Drowning
- Patients suffering from exhaustion
- Injured and immobile patients
- Decreased level of consciousness.

As patients succumb to hypothermia, they move through five stages [Durrer, 2003]:

1. Conscious and shivering
2. Decreased level of consciousness and not shivering
3. Unconscious
4. Not breathing
5. Death due to irreversible hypothermia.

1.3.1 Management

The mainstay of treatment is to prevent further heat loss. In the mildly hypothermic patient, this is likely to be enough, but severely hypothermic patients will require active rewarming, which realistically can only be performed in hospital [Nolan, 2012]. Adopt the following principles when managing a patient with hypothermia [AACE, 2013]:

- If using a foil blanket, ensure that you wrap the patient in a fabric blanket first
- Give the patient hot drinks if they are conscious, but NOT alcohol
- Do not rub the patient's skin – as with alcohol, this leads to peripheral vasodilation, which worsens hypothermia
- Avoid rough handling as it can cause arrhythmias and cardiac arrest
- If intravenous fluids are required, ensure they are warmed prior to administration
- Patients with a decreased level of consciousness should not be encouraged to walk, but managed horizontally.

1.4 Heat-related illness

Heat-related illnesses can occur as a result of external factors such as the sun, or internal factors such as drugs and exercise. It presents on a continuum, with heat stress the least serious heat-related illness, through to multi-organ dysfunction and even death at the other extreme [AACE, 2013]:

- Heat stress
- Heat exhaustion
- Heat stroke
- Multi-organ dysfunction.

Heat stress

This is a mild form of heat-related illness and is characterised by [Soar, 2010]:

- Normal temperature or mild temperature elevation
- Heat oedema: Swelling of feet and ankles
- Heat syncope: Vasodilation causes hypotension
- Heat cramps: Depletion of salts leads to muscle cramps.

Heat exhaustion

This is a more severe form of heat-related illness, with symptoms mostly as a result of fluid loss and electrolyte imbalances [Soar, 2010]:

- Systemic reaction to prolonged heat exposure (hours to days)
- Core body temperature over 37°C and less than 40°C
- Headache, dizziness, nausea and vomiting, tachycardia, hypotension, sweating, muscle pain, weakness and cramps
- Can progress quickly to heat stroke.

Heat stroke

Heat stroke is a systemic inflammatory response to a core body temperature of 40.6°C or more, and is associated with altered level of consciousness and organ dysfunction [Soar, 2010]. It comes in two types: non-exertional heat stroke, which is caused by high external temperatures and/or high humidity; and exertional heat stroke, which is caused by excess heat production. Non-exertional heat stroke tends to occur in the elderly, very young and chronically ill, whereas exertional heat stroke is more typical in active groups such as athletes, manual workers and military recruits [AACE, 2013].

Clinical features include [Soar, 2010]:

- Core body temperature 40.6°C or more
- Hot dry skin (although sweating is present in around half of all cases)
- Early signs and symptoms: Extreme fatigue, headache, fainting, facial flushing, vomiting and diarrhoea
- Arrhythmias and hypotension
- Respiratory distress
- Liver and kidney failure.

14.1 Management

Heat stress and exhaustion

The management of patients with heat-related illness broadly consists of cooling the patient and replacing lost fluid and electrolytes. For patients with signs and symptoms of heat stress consider the following [Lipman, 2013]:

- Remove the patient from the heat source
- Passively cool – move the patient into the shade or an air-conditioned ambulance. Loosen or remove tight-fitting clothing
- Provide oral isotonic fluid replacement
- Elevate oedematous extremities.

If the patient has developed heat exhaustion, similar management principles apply, except that depending on the patient's level of consciousness, fluid rehydration may have to be intravenous. In addition, cooling should be active, using conductive, evaporative and convective methods. Cold-water immersion is ideal for the ambulant, co-operative patient, but may not be practical otherwise. Alternatives include removing the patient's clothes and spraying or dousing the patient with water. Air movement can be augmented by fanning the patient [Lipman, 2013].

Heat stroke

While supporting the patient's airway, breathing, circulation and disability, begin rapidly cooling the patient while en route to hospital [Soar, 2010]. Ice water immersion is useful, but not practical, so consider the same techniques as for heat exhaustion to cool the patient. Ice packs are useful if they cover the body, not just the neck, axillae and groin, but should not be applied directly to the skin [Lipman, 2013]. Rehydration is safest intravenously as an altered level of consciousness increases the chance of aspiration [Soar, 2010].

2 Drowning

2.1 Learning objectives

By the end of this lesson, you will be able to:

- Explain the pathophysiology and management of drowning.

2.2 Introduction

The definition of drowning has been complicated in the past and so in 2002 (at the World Congress on Drowning, held in Amsterdam) a single definition was agreed. As a result, drowning is now defined as a process resulting in primary respiratory impairment from submersion/immersion in a liquid [Idris, 2003]. Whether the victim lives or dies after this process is not important, they have still drowned. If they do not survive, then they have fatally drowned [Szpilman, 2012].

2.3 Pathophysiology

When a drowning victim is unable to keep water (the most common liquid in drowning incidents) from their mouth, it is spat out or swallowed. If still conscious, victims will then attempt to hold their breath, but this is likely to continue for less than a minute, depending on levels of panic and the temperature of the water. Once the inspiratory drive is too high to resist, the victim will take a breath and water will be aspirated into the airways [Szpilman, 2012]. Laryngospasm may occur, but this is rapidly terminated by cerebral hypoxia, and active ventilation, with aspiration of water, will resume. It was once thought that laryngospasm might be responsible for drowning victims who were found not to have aspirated (so called dry-drowning). The theory was that the victim died due to hypoxic cardiac arrest because of laryngospasm or breath-holding [Layon, 2009]. However, autopsy studies have concluded that this is unlikely, as water does not passively seep into the lungs [Modell, 1999; Piette, 2006]. To drown therefore requires active ventilation while the victim is submerged (i.e. under the water and still alive).

Whether due to laryngospasm or breath-holding, with no gas exchange the victim becomes increasingly hypoxaemic, hypercarbic and acidotic. Unless they are rescued, the victim will succumb to hypoxaemia, leading to loss of consciousness and apnoea [Layon, 2009]. The cardiac rhythm deteriorates, usually following a sequence of tachyarrhythmias, bradyarrhythmias, pulseless electrical activity (PEA) and asystole [Szpilman, 2012].

Immersion in cold water (10°C or less) produces large and rapid reductions in skin temperature,

which in turn leads to cold shock. This term refers to a collection of physiological responses including an inspiratory gasp (which can result in drowning if the victim's airway is submerged), hyperventilation, hypocapnia, tachycardia, peripheral vasoconstriction and hypertension [Datta, 2006]. Cold shock is thought to be caused by stimulation of cutaneous cold thermoreceptors, which result in an excessive sympathetic nervous system response. The magnitude of the cold shock response is reduced by the victims' clothing, their habituation to cold (regular winter swimming in just your Speedos, for example) and orientation on immersion [Shattock, 2012].

If the victim is fully submerged in cold water, the diving response may be activated. This is caused by cooling of the cold thermoreceptors on the face, which are innervated by the trigeminal nerve. This results in a profound sinus bradycardia due to parasympathetic nervous system stimulation of the heart, an expiratory apnoea due to inhibition of central respiratory neurons, and sympathetic nervous system mediated vasoconstriction of the trunk and limbs. A similar response is also possible by stimulation of vagal receptors in the pharynx and larynx [Angell-James, 1975].

It has been suggested that this simultaneous stimulation of both sympathetic and parasympathetic pathways of the autonomic nervous system results in an 'autonomic conflict', leading to life-threatening arrhythmias that may result in death in susceptible individuals (Figure 2.1) [Shattock, 2012].

Although the tonicity of the water (for example sea water versus fresh water) was once thought to be important, the effect on the lungs is ultimately the same, although with a different osmotic gradient. The fragile alveolar-capillary membranes are disrupted, leading to increased permeability and movement of fluid, plasma and electrolytes [Orlowski, 1989]. Clinically, this leads to significant amounts of blood-stained pulmonary oedema and decreasing gaseous exchange of oxygen and carbon dioxide. Following drowning, the presence of additional fluid in the lungs and the loss of surfactant lead to increasing areas of the lungs becoming regions of low, or no, ventilation and perfusion (pulmonary shunting), and there is widespread

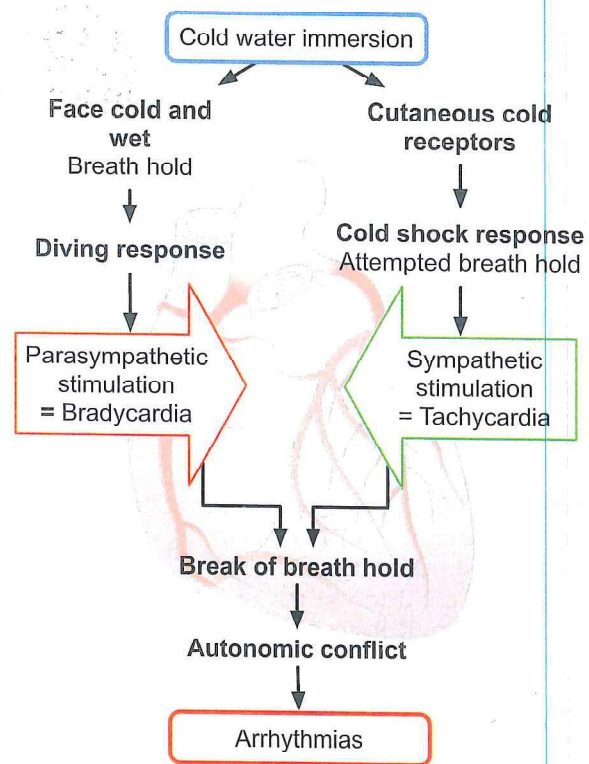


Figure 2.1 Autonomic conflict

atelectasis and bronchospasm [Layon, 2009]. Similarly, the haemodynamic and cardiovascular effects seen in drowning are not related to tonicity either, but primarily are a consequence of anoxia [Orlowski, 1989].

2.4 Management

Try to avoid getting wet. You should only go into the water to rescue a drowning victim as a last resort and only if you are adequately trained and equipped. Many victims who are drowning can help themselves with firm coaching, or will have already been rescued by bystanders or professional rescuers, who can have a dramatic impact on the victim's outcome. On beaches with a lifeguard, for example, less than 6% of victims will require hospital treatment and only around 0.5% will require cardiopulmonary resuscitation (CPR) [NWSF, 2012]. This is in stark contrast to the 30% of victims requiring CPR when rescued by untrained bystanders [Venema, 2010].

If you need to rescue the victim, remember to 'call, reach, throw, wade and row'. As previously mentioned, encourage victims to self-rescue first.

Next, try to reach them with an object such as a pole, tree branch or even items of clothing. Consider throwing something that is buoyant, ideally a rescue ring with a lifeline attached. Wading into the water is the next possibility as long as someone on the shore has hold of you, the water is shallow enough to stand in and the victim is within reach. Alternatively, use a boat, if available.

Resuscitation is limited while in the water and should consist of ventilations only. Chest compressions are futile in deep water, so wait until the patient is on a firm surface, such as the shore or the deck of a boat [Szpilman, 2004]. The incidence of spinal injuries is very low (around 0.5%) and spinal immobilisation delays effective resuscitation, so only do this when there is a clear mechanism of injury that could cause spinal injury (such as diving into shallow water or water ski-ing) [Watson, 2001; Soar, 2010].

Get the victim out of the water as soon as possible and place them supine (on their back), with head and torso at the same level, and check for breathing. If they are breathing but unconscious, provide high-flow oxygen via non-rebreathing mask as per clinical guidelines and place them in the recovery position. They are at high risk of gastric regurgitation, so ensure that you have suction available [AACE, 2013].

Victims of prolonged immersion in water (typically 30 minutes or more, but less as water temperature decreases) may also suffer the added complication of circum-rescue collapse [Golden, 1997]. This is due to the increased hydrostatic pressure from the water on the victim's legs and torso increasing venous return and cardiac output. Central baroreceptors mistake this for hypervolaemia resulting in increased diuresis. In addition, peripheral vasoconstriction will occur as the water is cold relative to the body, which magnifies this response [Lord, 2005]. Once the victim is removed from the water, the hydrostatic pressure is lost, exacerbating the hypovolaemia. This can also be compounded by hypothermia and physical effort [if the victim attempts to remove him- or herself from the water, for example]. The sudden drop in venous return can reduce coronary perfusion enough to induce cardiac arrest. For this reason, it is advised to remove victims horizontally from the water if possible [Szpilman, 2012].

Hypothermia is likely to occur and wet clothes should be cut off to minimise movement. Hypothermic patients are at risk of cardiac arrhythmias, including ventricular fibrillation, even with minor movement [Althaus, 1982]. Get the patient covered with blankets and in a warm ambulance as soon as possible.

Near Drowning



Scott McClurg / Journal-World Photo



Near Drowning

- If a Patient is rescued before the Point of Death, or at least temporary survival, this is described as Near Drowning
- Consider Complications such as:
 - Trauma/Alcohol/Poisoning
 - Hypothermia

Drowning

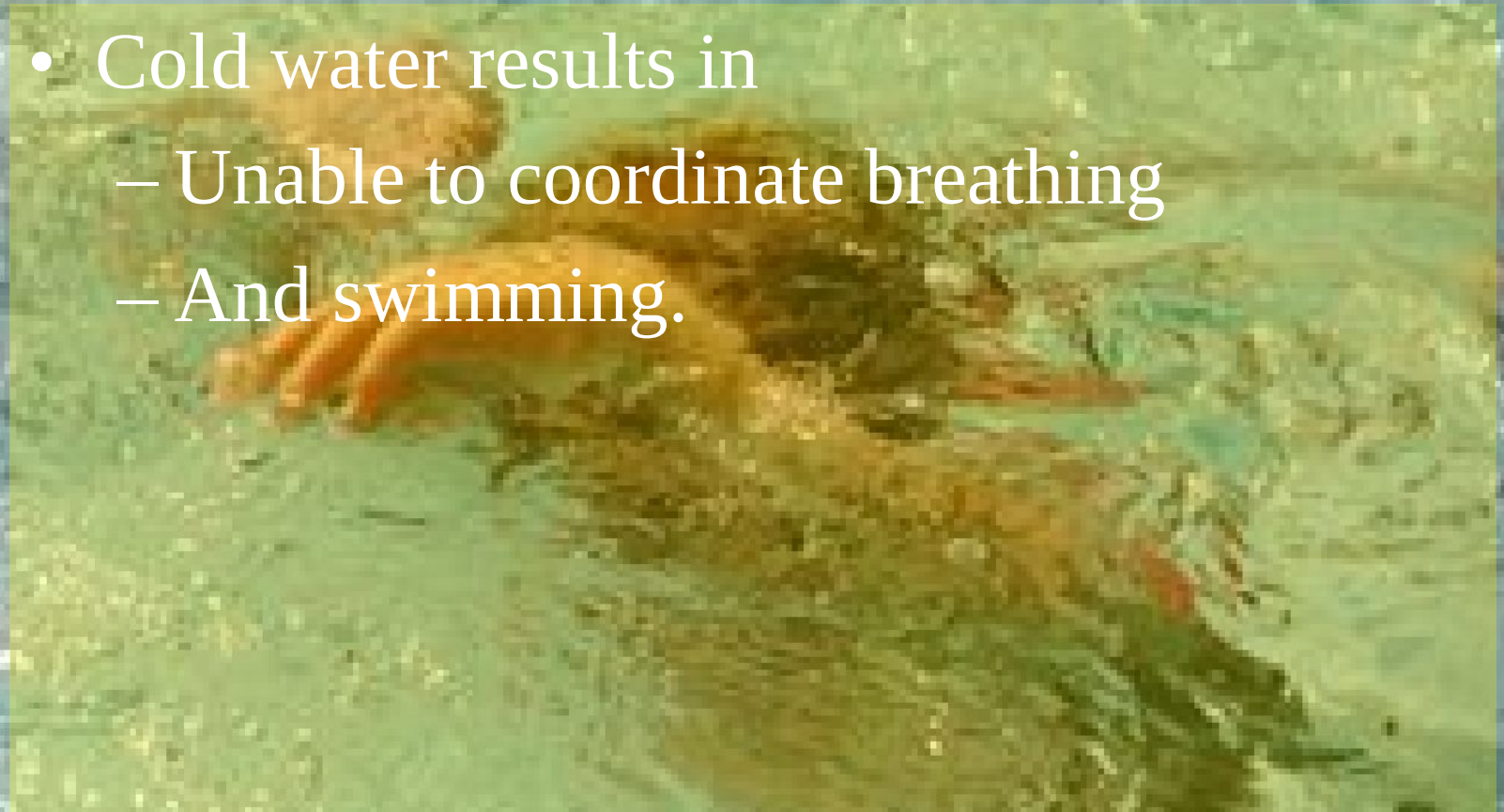
- Statistics
- Physiology
- Types of drowning
- Complications of drowning
- Management of drowning
- General points to consider

Physiology

- Sudden immersion on cold water can cause a sudden intake of breath resulting
 - Panic breathing
 - & frequent submersion
- Compounded respiratory distress results in
 - Compromised buoyancy
 - May sink
 - Also swallow large amounts of water.

Physiology (Cont.)

- Cold water results in
 - Unable to coordinate breathing
 - And swimming.



Physiology (Cont.)

- Water prevented from entering the lungs by:
 - Repeated swallow action
 - Laryngeal spasm
 - Leads to
 - Hypoxemia
 - Loss of consciousness
 - Ultimately death
 - Water does not enter until after death when larynx relaxes.

Types of drowning

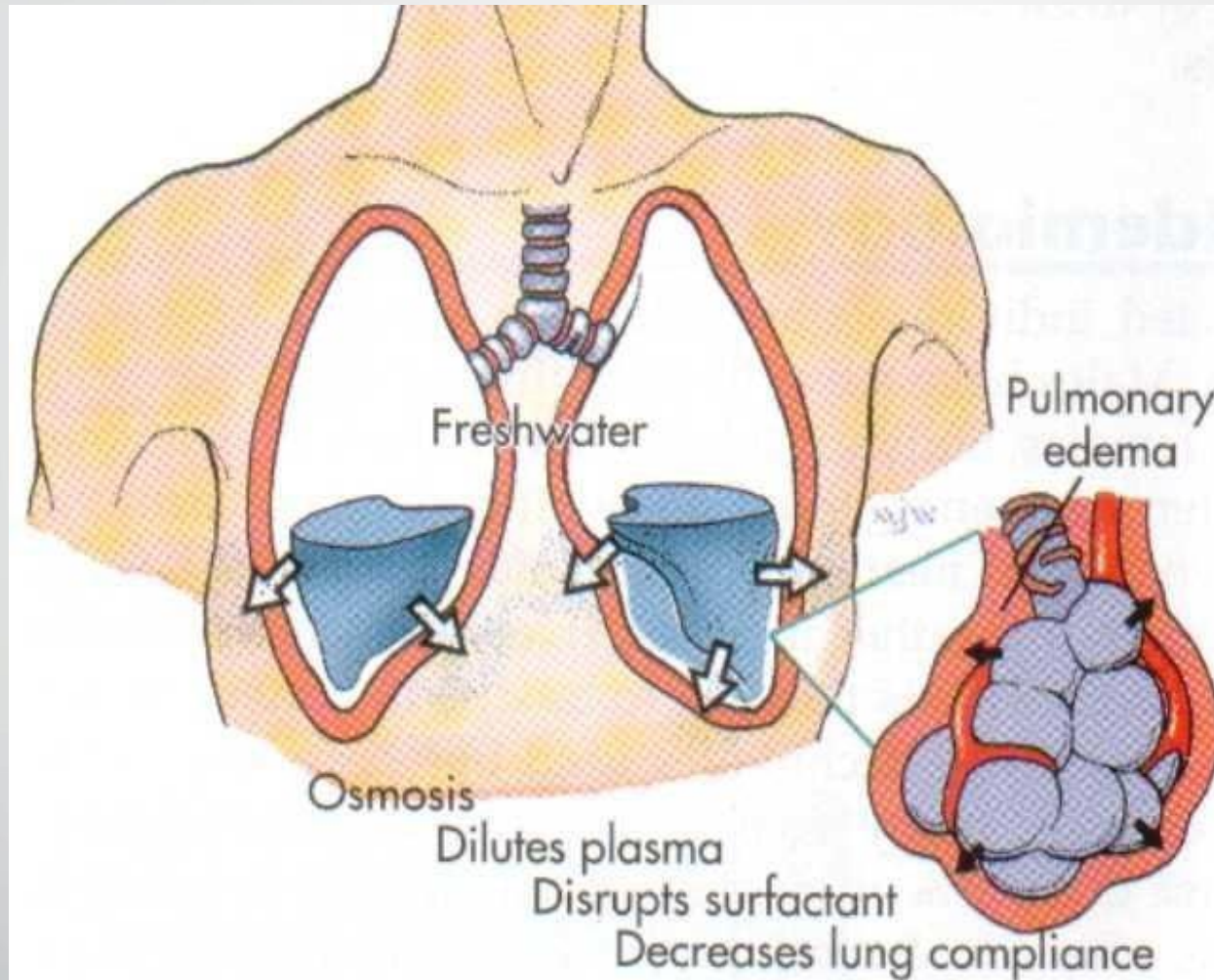
- Dry drowning
 - Patient sinks, unconsciousness deepens
 - They continue to try to breath
 - Water triggers larynx & epiglottis to close
 - Trachea protected water is diverted to stomach
 - Often less than one litre of fluid in the lungs
 - May be several litres in the stomach
 - Dry lungs found in approximately 10% of incidents.

Types of drowning (Cont.)

- Fresh water drowning
 - Water will interfere with the process of external respiration
 - Prevents the passage of gases between the alveoli & pulmonary capillaries
 - Haemodilution is the rapid absorption of water into the blood
 - Distorts the PH value of the blood
 - Cardiac arrest may occur within 2 - 4 minutes after rescue.

Types of drowning (Cont.)

- Fresh water drowning



Types of drowning (Cont.)

Salt water drowning

Opposite effect from water but same result

Salt water more soluble than blood

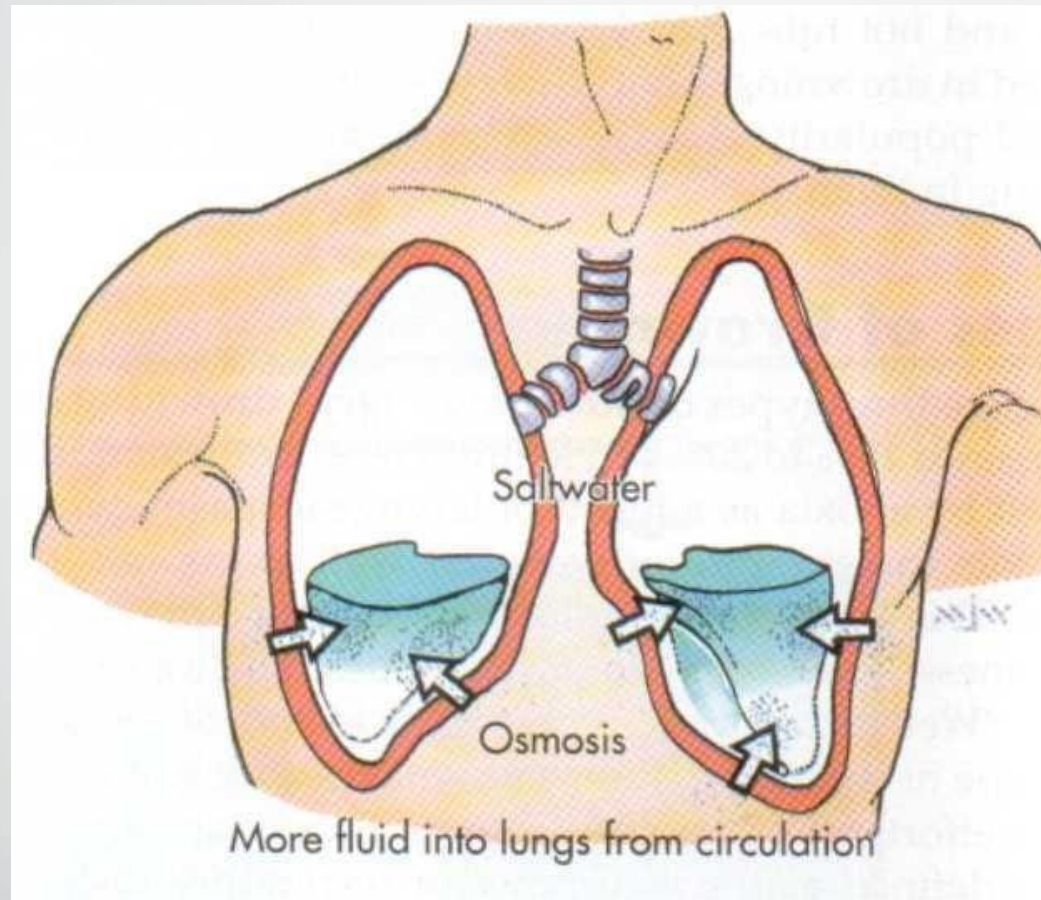
Water is drawn into the alveoli from the blood stream Increasing the volume of fluid in the lungs

Increase the viscosity of the blood causing sluggish circulation

- Which leads to the heart slowing
- Then finally into arrest
- May occur up to 12 minutes after rescue.

Types of drowning (Cont.)

- Salt water drowning



Types of drowning (Cont.)

- Secondary drowning
 - May appear to be fully recovered
 - Water in the stomach rapidly absorbed by the blood stream
 - Death could occur up to 72 hours later

Types of drowning (Cont.)

- In the case of salt water
 - Secondary may occur from residual water in the lungs
 - This draws fluid from the blood stream causing pulmonary Oedema or Shocked lung syndrome
- May occur many hours after the event.

Complications of drowning

- Hypothermia
 - Must be considered in all cases of near drowning
 - May mimic signs of cardiac arrest
 - E.g Dilated pupils
 - Imperceptible pulse & respiration.

Complications of drowning (Cont.)

- Alcohol
 - Speeds the onset of hypothermia
 - Slows reactions
 - Increases risk of vomiting.

Complications of drowning

- Mammalian diving reflex
 - Feature of some drownings
 - Particularly in the young
 - Little understood reflex
 - Caused when victim is plunged into icy water face first
 - Immediate effects
 - Near total shutdown of
 - Respiratory system
 - Nervous system

Complications of drowning

Near total shutdown of

- Respiratory system
- Nervous system
- Suspended animation
- Victims have been known to make a complete
- recovery after 38 hours submerged and 16 hours of resuscitation.

Complications of drowning (Cont.)

- Prolonged immersion
 - Assuming survival from hypothermia float vertically
 - In the vertical position water exerts pressure on the legs which in turn massages the veins
 - Maintains an adequate venous return
 - When rescued pressure is lost and gravity prevents blood returning to the heart
 - This leads to syncope or sudden death.



Management of drowning

- Ensure an open airway
- Commencing CPR when required with 100% oxygen
- Checking pulses at two different points especially where hypothermia is present
- Lift horizontally from water
- Do not let them walk
- Transport with feet slightly elevated
- Consider possibility of spinal injury or neck injury.

Management of drowning CPG 22

- Request ALS where possible
- Remove patient from liquid
 - *If it is safe to do so*
- Remove horizontally if possible
 - *Consider C-spine injury*
- Complete primary survey
 - *CPR if appropriate*

Management of drowning

- Oxygen therapy
- SPo2 & ECG
- Monitor
 - Pulse
 - Respirations
 - BP
 - Check blood Glucose
 - Correct hypothermia

Management of drowning

- Transport to ED
 - Secondary drowning insult
- ALS - IV access
- ALS - Consider Salbutamol 5mg nebule for bronchospasm

Trauma in drowning



History of :

- Diving
- Trauma
- Water slide use
- Alcohol intoxication

“c” spine control



Airway opening with “c” spine



Rescue breaths, with “c” spine



Secure patient to board



Removal from water



Management of drowning (Cont.)

- **DO NOT**
 - **Apply direct heat to the victim**
 - Re-warm slowly
 - Core temperature very important
 - Do not rewarm hands or feet
 - **Perform abdominal thrusts**
 - Displaces water from stomach to lungs

General points to consider

- Note the length of time in the water
- Thoroughly assess the casualty's condition
 - Remember hypothermia can mimic an arrest
- Do not waste time trying different techniques to evacuate the lungs
 - Only aspirate what you can see
 - In the event of a scuba dive incident do not adjust any valve settings. Ensure that dive computer accompanies patient. Remember to check any dive buddies!

General points to consider (Cont.)

- Unless death is obvious (decomposition) initiate and maintain CPR all the way to hospital
 - Even where muscle rigidity seem evident
- Ensure personal safety at all times
 - Do not attempt rescue unless you are trained and it is safe to do so

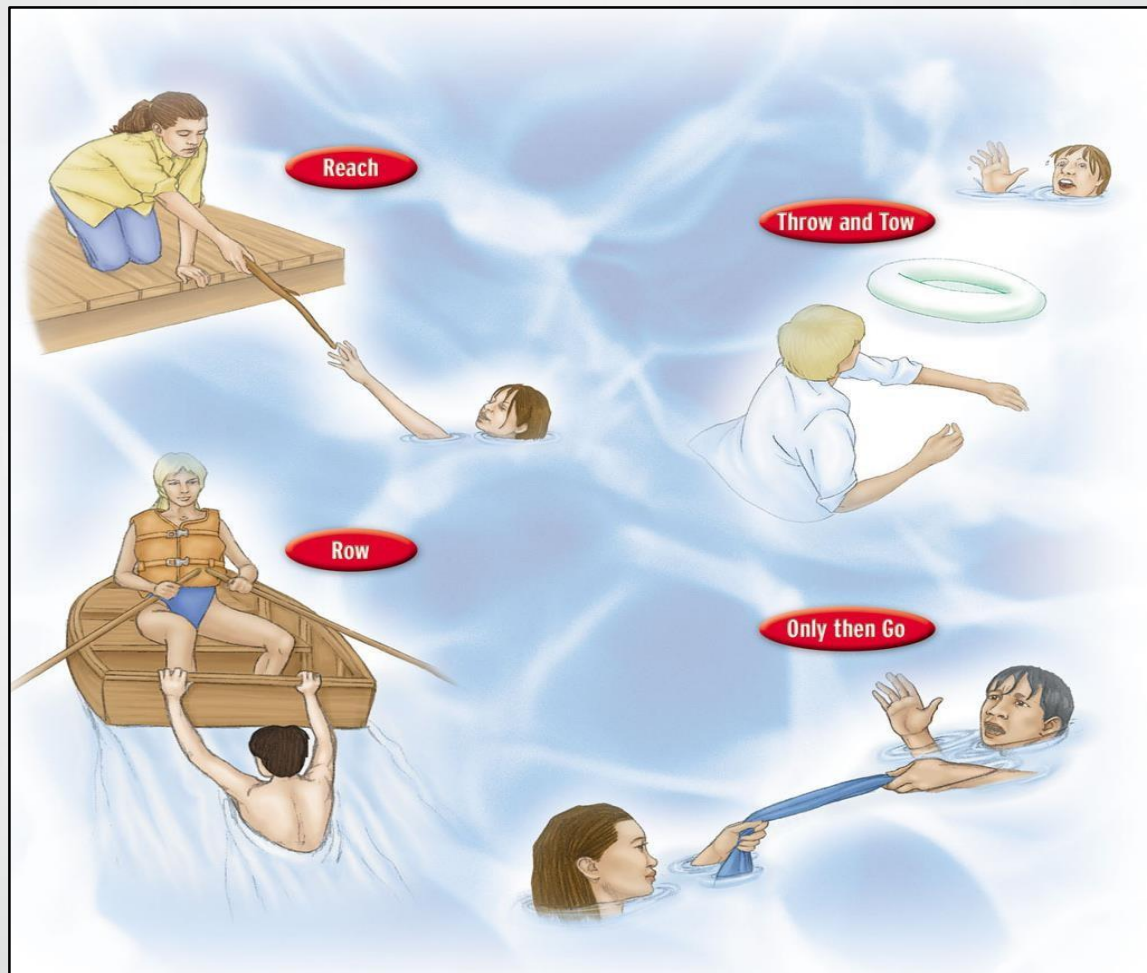
Water Rescue

Reach

Throw

Row

Go



Near Drowning Conclusion

- Consider Complications
- Priorities – Scene Size-up, Patient Assessment
- Consider C-Spine Injury
- Signs can mimic Cardiac Arrest
- Continue CPR
- Above all else **your safety is Paramount**



Summary

- Statistics
- Physiology
- Types of drowning
- Complications of drowning
- Management of drowning
- General points to consider

Questions?



