Don't Forget The Bubbles

DROWNING

Facilitators Guide

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PRE-READING/WATCHING

Please read / watch some of these resources before the session:

https://litfl.com/drowning/

APLS – drowning/ALS

https://dontforgetthebubbles.com/drowning/

https://emergencymedicinecases.com/pediatric-drowning-hypothermia/

https://patient.info/doctor/drowning-and-near-drowning

https://www.evelinalondon.nhs.uk/resources/our-services/hospital/south-thames-retrieval-service/drowning-mar-2018.pdf

https://www.rch.org.au/clinicalguide/guideline_index/Drowning/

IAEM Clinical guideline: Management of drowning in children

PHYSIOLOGY AND EPIDEMIOLOGY

Drowning is the third leading cause of death worldwide (WHO, 2020).
Sadly age is a major risk factor; globally the highest drowning rates are among children aged 1-4 followed by 5-9 year olds.
70% of children survive drowning when BLS is provided at the scene, whereas only 40% survive without early resuscitation.

In the UK drowning is the third highest cause of accidental death in children with 31 deaths in 2018 attributed to drowning representing approximately 12% of sudden unexpected, unexplained deaths in children (National Water Safety Forum, 2018) .

“Drowning” is the respiratory impairment from being in or under liquid. Terms such as “dry drowning” or “wet drowning” or differentiating between submersion/immersion have fallen out of vogue and are not useful in management or treatment.

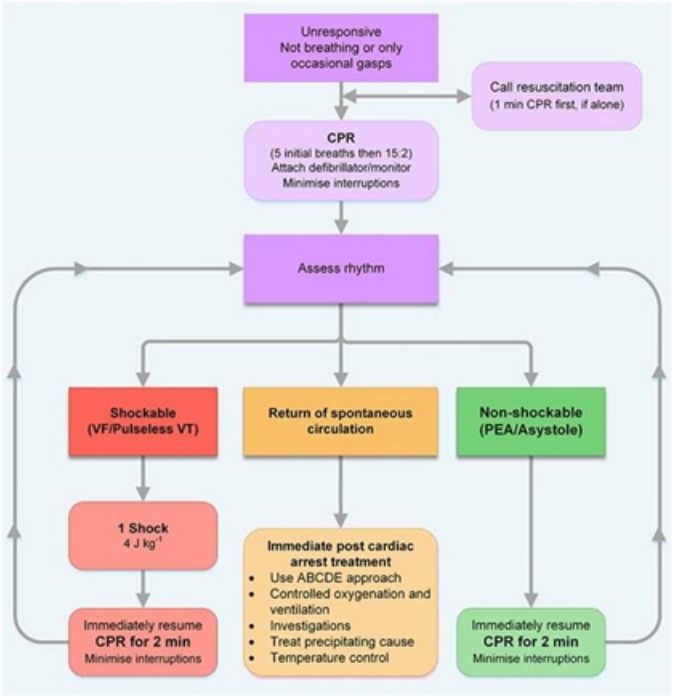
Shortly after entering the water the diving reflex causes apnoea and bradycardia. As apnoea continues, hypoxia and acidosis causes tachycardia and a rise in blood pressure. Breathing occurs between 20 seconds and 5 minutes later, breaking this reflex. Water is inhaled and on touching the glottis causes immediate laryngospasm; this is short lived and water then enters the lungs causing pulmonary oedema and alveolitis. Hypoxia is by this time severe and the patient loses consciousness. Bradycardia and other dysrhythmias can also occur (and may be fatal). Hypoxia is thus the key pathological process that ultimately leads to death and needs to be corrected as quickly as possible. The sequelae from this are respiratory failure, leading to hypoxia, followed by cardiac arrest.

PREHOSPITAL MANAGEMENT

Optimal prehospital care is a significant determinant of outcome in drownings worldwide.
Key principles of management are maintaining adequate oxygenation, preventing aspiration and stabilising body temperature.
Vomiting is common in drowning victims and aspiration of gastric contents is a major complication. Spontaneously breathing children should initially be placed in the lateral decubitus position.

For a person who is unconscious and not breathing, in water rescue breaths can be attempted by a trained rescuer - in those with purely respiratory arrest this usually results in recovery rapidly. **(https://youtu.be/dvOxAAFxK18 skip to 1:05)**
CPR should not be attempted in water as is ineffective and will delay rescue.
Consider immobilisation of neck for concurrent c-spine injury (this should not slow the removal from the water)
There is some debate over whether a vertical removal or a horizontal removal from the water is better (vertical = less chance of aspiration, horizontal = decreased risk of causing BP drop and precipitating VF). In reality, the fastest way out of the water is the most important.

For interest, a video on methods of recovering casualties from the water can be found here.



(APLS 6e)

SCENARIO 1

A family presents to the Emergency Department with their 5 year old. The parents were inside when they witnessed their 5 year old child struggle in the swimming pool and disappear under the water. They quickly got her out, with a submersion time of less than 1 minute. She had one rescue breath, with no CPR before coughing water at her parents.

She is happy and playing in the waiting room, her only concern is that her throat is sore.

1. How should you manage this case?

2. Where could you direct the parents for further water safety advice?

3. Does this need a social care referral?

Key learning points in this scenario:

- Children who are asymptomatic only require a period of observation prior to discharge home - how long is hospital dependent but most sources suggest 8 hours is sufficient
- Water safety is one of the most important messages to get across here - why did the child have access to a pool with no adult supervision? Do they have safety barriers around their pool? Sending the parents home with written water safety advice is a key element of good management.
- Careful history taking and exploration will determine the need for the involvement of social care. There is no "blanket" advice on what needs to be explored further with Children and Family Services.

History:

- As always, does the story match the developmental age/presentation?
- Are they usually a good swimmer?
- Consider other reasons for failing to keep head above water
  - Seizures
  - Arrhythmias
  - Alcohol
- What was the temperature of the water?
- Timeline

- How long were they in the water?
- Time from when they were noticed to be missing to when BLS started
- Time to first breath/attempted breath

Prevention:

- Though this is a session on management of drowning we would be remiss if we did not explore the extensive work that has gone into water safety and drowning prevention
- There are multiple free resources to direct parents to:
- https://swimsafe.org.uk/
- https://www.rlss.org.uk/pages/category/water-safety-information
- The national water safety forum has released a strategy aiming to reduce water related deaths by 50% before 2026. Key elements of their strategy include:
  - Access to swimming and water safety lessons as part of the national curriculum
  - Extra focus on communities with a local water safety risk

SCENARIO 2

A 10 year old is brought in by ambulance. They were playing in the marshes and fell into a pond. Luckily they were pulled out quickly by their friends and a passing dog walker started CPR quickly. After a single round of CPR they achieved ROSC. On your assessment the patient is drowsy but responsive, they have a temperature of 30°C and other observations are normal.

1.What are the important first steps in management?
2.Does this patient need antibiotics?

Key learning points in this scenario:

- This child has lots of good prognostic factors: short time in water, quick BLS, quick ROSC
- In the conscious patient passive rewarming is sufficient, although if his GCS was lower, active rewarming should be considered
- There is no role of empirical antibiotics in drowning - if infection is suspected then sputum samples/alveolar washings should be sent.

Antibiotics

- Prophylactic antibiotics have not been shown to be helpful, though are often given when immersed in particularly contaminated/dirty water.
- Fever is common during the first 24 hours but is not necessarily a sign of infection, which usually becomes manifest later.

Steroids

- There is no evidence for the routine use of steroids

SCENARIO 3 - ADVANCED

You are in the paediatric emergency department. A parent runs in with their 6 month old baby who is cyanosed. She says they slipped in the bath 10 minutes ago and hasn't started breathing yet.

1.What should you do?
2.What elements should you focus on in the history?

The child is intubated at 10 minutes. At 40 minutes since submersion a gas shows a pH of 6.9 and a pO_2 of 7.5 . What needs to be considered at this point?

Key learning points in this scenario:

- Initial resuscitation focuses on ABCDE approach as per APLS
- The history in this story raises safeguarding concerns - why was a 6 months old in the bath alone? How long were they alone for?
- Poor prognostic factors in drowning include no respiratory effort after 40 minutes
- When is it appropriate to think about stopping resuscitation in a child?

Prognostication:

- There is no perfect prognostication tool.
- Immersion time – if immersion was for more than 10 minutes there is a small chance of intact neurological recovery/survival; consider also the time to BLS – starting at the scene reduces mortality whereas a delay of more than 10 minutes is associated with a poor prognosis.
- Time to first respiratory effort – within 3 minutes after CPR is started is associated with a better prognosis; no respiratory effort after 40 minutes is associated wit little or no chance of survival.
- Core temp – rapid cooling after submersion or pre-existing hypothermia seems to have a protective effect on organs. A temperature less than 33°C on arrival and water temperature less than 10°C have been associated with increased survival.

  - Hypothermia decreases metabolic and electrical action in the brain, slowing oxygen consumption and delaying anoxia and ATP depletion. There is an approximately 5% reduction in oxygen consumption for each degree of hypothermia (from 37 to 20°C)
- The type of water has no bearing on prognosis.
- ABG/VBG: pH <7.1 or pO_2 <8 despite treatment confers a poor prognosis.
- GCS – persistent GCS <5 carries a poor prognosis.

Stopping resuscitation

Patients arriving at the Emergency Department in cardiopulmonary arrest, unconscious, or apnoeic or with fixed-dilated pupils after a warm-water submersion have a very poor prognosis. The benefits of resuscitative efforts should be continuously reassessed in such situations. The clinical course of a drowning episode is primarily determined by the duration of the episode and the speed and adequacy of the initial resuscitation. Consideration of withdrawal of care is informed by the prognostic factors mentioned above although none of these individually are predictive of outcomes.

Guidance regarding withdrawal and withholding of care can be found in the RCPCH document **"Making decisions to limit treatment in life-limiting and life-threatening conditions".** It seeks to lay out the ethical and legal issues surrounding withdrawal of care.

Organ donation ought to be considered in this situation and the parents and the parents should be sensitively approached about it. Bringing this up can be daunting and is best achieved with the help of a specialist nurse for organ donation.

SCENARIO 4 - ADVANCED

You are covering resus in winter. You receive a pre-alert for an out of hospital cardiac arrest. A 5 year old child was lost for 30 minutes and has been found in a pond. They are currently receiving CPR. They are 10 minutes away .

1.What are things you should prepare in anticipation of this child arriving?
2.What are the important considerations in resuscitating in hypothermia?
3.What are examples of active rewarming?

Key learning points in this scenario:

- Consider c-spine injuries and prepare to manage this.
- Rapid cooling in drowning has a protective effect - this increases the chance of survival.
- A patient should be actively re-warmed until they reach at least 32°C (APLS 6e) - in practice most people will continue to warm to 34°C.
- Active re-warming is necessary in a patient that is too cold to shiver - NG/urinary/thoracic lavage combined with a warming blanket and warm packs at large artery sites.
- Bradycardia is a common physiological response to hypothermia - is there a low volume pulse present? Do we have POCUS to see if there is output from the heart?

Hypothermia

- Remove wet clothes and dry the patient, use warming blankets and warmed fluids.
- Arrhythmias are often refractory below 30°C. Limit to 3 shocks and do not give drugs. Use active core rewarming measures (gastric/bladder lavage, peritoneal lavage, pleural or pericardial lavage, ECMO).
- Between 30-35°C double the dose interval for drugs.
- Resuscitation should be continued until core temperature at least above 32°C, or is not increasing despite active measures.
- Once ROSC is achieved warming should be slowed to 0.25-0.5°C/h in order to reduce haemodynamic instability.
- Bradycardia is a common side effect of hypothermia - APLS advises to start CPR if pulse <60 but it should be noted that this could precipitate VF. POCUS can be useful here in determining whether there is an organised heart pumping blood (albeit slowly). If in doubt start CPR.
- Post ROSC, ECMO may be used to manage hypothermia.

Therapeutic hypothermia

- The role of therapeutic hypothermia post ROSC is dependent on your local PICU preferences.
- The large multi-centre RCT Therapeutic Hypothermia After Paediatric Cardiac Arrest (THAPCA) trial compared normothermia with mild hypothermia (32-34°C) and showed no statistically significant difference in 1year functional outcome. However, it also showed no difference in incidence of infection/bleeding/ arrhythmia suggesting therapeutic hypothermia is not harmful.

Other injuries

- C-spine injuries must be considered in diving accidents as a significant load can be transmitted through the head when making contact with water.

Foreign bodies

- In patients who are difficult to ventilate, water may not be the only thing that got into the lungs - seaweed, rocks, and even a fish have been pulled from tracheas and bronchi.
- Patients may develop pulmonary oedema, termed “secondary drowning”, due to “rinsing” of surfactant off the alveoli by inhaled water.

Rhabdomyolysis

- Monitor creatinine kinase (CK) levels as some drowning victims progress to rhabdomyolysis after exertion or muscle hypoxia.

SIMULATION SCENARIO

Scenario Overview	6 year old fell through ice into 2°C degree lake and required CPR at scene, ongoing on arrival in ED. They arrive at hospital with an assumed 20 minute downtime. The team is given the pre-alert with 5 minute ETA to allow them to set up to receive the child and then manage complications as they arise. ROSC is achieved.
Set Up	Scenario takes place in ED resus. Child manikin required, on ED trolley with monitoring and defibrillator available. Access to IV/IO equipment. Access to advance airway equipment including endotracheal intubation. Additional faculty or simulation participant should play part of ED nurse and anaesthetic SpR who is happy to intubate. Senior support available on telephone.
Prop List	WET FLAG prompt: - W - (6x3) +7 = 25kg (or: (age+4) x 2) - E - 100J - T - 4.5 - F - 250ml (10ml/kg) 500ml (20ml/kg) - L - 2.5mg - A - 2.5ml of 1:10,000 - G - 50ml of 10% Guidelines for resuscitation in hypothermic state

Console (or faculty prompt if not using console)		A	B	C	D
		Initial presentation	**After continued CPR and basic rewarming**	**If no rewarming measures taken**	**Basic rewarming measures taken, discussion held re. when to give drugs**
	RR	no resp effort -	Intubated and ventilated – easy to ventilate	Intubated and ventilated – easy to ventilate	Intubated and ventilated – easy to ventilate
	SPO_2	unrecordable	85% in 100% FiO2	unrecordable	90% in 100% Fi02
	HR	SR on monitor, no pulses palpable (PEA)	SR on monitor, no pulses palpable (PEA)	SR on monitor, no pulses palpable (PEA)	SR with pulse
	BP	unrecordable	unrecordable	unrecordable	90/47
	Rhythm	PEA	PEA	PEA	SR with pulse (ROSC)
	Temp	28 degrees	30 degrees	28 degrees	33 degrees
	Eyes	pupils equal, size 4, sluggishly reactive	pupils equal, size 4, sluggishly reactive	pupils equal, size 4, sluggishly reactive	pupils equal, size 4, sluggishly reactive

Expected Actions	Continue CPR and adjust approach for hypothermia (rewarm to >30 degrees, double interval for drugs) Ensure patient is intubated – patient can either arrive intubated with pre-hospital team or be intubated during scenario by anaesthetic SpR participant or plant. Maintain c-spine immobilisation Correct low blood glucose
End Point	ROSC achieved if approach to rewarming discussed - warmed fluids, gastric lavage, peritoneal lavage: stop scenario Discussion held re. how long to continue CPR with seniors

Participant briefing

A 6 year old boy was witnessed to fall into the icy river this morning and was pulled out immediately by onlookers. He was unconscious and bystander CPR was started straight away. Paramedics were on scene and continued CPR on route to hospital. His estimated downtime on arrival in the ED is 20 minutes. His parents witnessed the event and are on route to the hospital.

Patient PMHx

Previously fit and well 6 year old. No apparent trauma or incident preceded the fall into the river, Onlookers report he appeared to accidentally slip a few feet down a river bank while chasing his dog.

Investigations & results

Initial gas acidotic, hypoxic, BM low:
Venous gas on arrival: pH 6.9, pCO_2 8, pO_2 5.3, Lact >20, Bic 14, BE – 6, Na 142, K 5.7, iCal 1.2, Hb 120, Glu 3.
Gas improves if adequate re-warming, ventilation, management of hypoglycaemia and CPR continues:
pH 7.2, pCO_2 5, pO_2 8, Lact 14, Bic 14, BE – 5, no change to electrolytes and Hb, Glu 6

Plant Briefing

ED nurse: can prompt to use hypothermia guidelines and is aware of how to warm fluids, prompts use of Bair Hugger and removal of wet clothes.

On Examination

	A	B	C	D
		After continued CPR and basic rewarming	**If no rewarming measures taken**	**After continued CPR and basic rewarming has achieved Temp of 33 degrees**
Skin	Pale, grey	Some improvement	Pale, grey	Pale, starting to gain colour around face
CRT	7 seconds	4	8	4
GCS	3	3	3	3
Pain Score	unresponsive	unresponsive	unresponsive	unresponsive
Abdomen	Soft, non-distended, no injuries			

Plant can confirm no previous medical history as reported by parents to paramedic crew.

Life Savers	Plant can point out need to re-warm with gastric lavage etc and prompt use of hypothermia guidelines with regards to using drugs in resuscitation at various core temperatures.
Telephone Assistance	ED SpR should call either ED consultant, paediatric consultant or anaesthetic consultant for advice. Advice should be given regarding rewarming, continuing CPR until body temperature at least 33 degrees, and make sure using correct resuscitation approach with increasing drug intervals. Senior will attend but is 20 minutes away. Advises, if asked, to maintain C-Spine precautions and can give fluid resuscitation if indicated.
Debriefing	Discussion of differences in resuscitating the drowned hypothermic child – this is a hypoxic arrest and principles of management are to improve and maintain oxygenation, prevent aspiration of stomach contents by prompt intubation, and stabilise body temperature while adjusting arrest protocols appropriately as per APLS. CPR may be continued for longer in the hypothermic child than participants may be used to in other arrest situations. How would you go about re-warming a child? Discussion of basic interventions such as Bair Hugger, over-head heated lamp, removal of wet clothes and drying patient, all of which can be done even if participant is not sure of how to perform gastric, bladder, chest or peritoneal lavage. Post resus care can be discussed, including: - Slow warming to 0.25-0.5°/h - Consideration of therapeutic hypothermia - Consider c-spine imaging + CT head as baseline - Aim normoglycaemia/normocapnia Further discussion may be generated around precipitating events – is there any suggestion that this child fell in the water following a seizure or a cardiac event, for example? What investigations should be carried out? Additionally, safeguarding always needs to be considered. Was this child unsupervised inappropriately? Are there other concerning findings on examination?
References	APLS 6th Edition
Curriculum mapping	It is useful to map scenarios to your local paediatric curriculum. In the UK, the RCPCH progress+ curriculum map is here (PEM sub-speciality syllabus).

SKILLS

Bladder/gastric lavage:

- Insert catheter/NG tube.
- Aspirate contents.
- Instill normal saline at 42°C into the bladder. There is no perfect amount of time (most literature says around 10 minutes for a litre of fluid to become cold - but this is all dependent on the core temperature).
- Aspirate cooled saline and repeat.

Peritoneal lavage:

- This is not used often in clinical practice. For facilitators who want to incorporate this into deliberate practice skills, **this video demonstrates the technique**
  - N.B. Use warmed fluids to hang and then drain out; in the absence of having a suitable catheter a normal urinary catheter will suffice.

Pleural lavage:

- insert 2 large chest drains - **this video is a good guide**, and this **DFTB post has more information.**
- Instill normal saline at 42°C. This often needs to be done under a bit of pressure to counteract the thoracic pressure.
- Exchange fluid until it reaches an acceptable core temp.
- Be aware that this will obviously make the patient harder to ventilate.

MCQ

Question 1.

When resuscitating a drowned child who is hypothermic you should:

A: Not deliver shocks below 30°C

B: Actively rewarm if temperature 32°C

C: Double the dose interval of drugs below 30°C

D: Deliver 3 shocks below 30°C then wait until warmer to shock

E: Double the drug interval between 30-35°C

APLS advises not giving drugs or shocking below 30°C, then doubling the dose interval of drugs between 30°C and 35°C.

Question 2.

Poor prognostic factors include:

A: Drowning in sea water compared to freshwater

B: Drowning in water <10°C

C: Initial recovery from water and BLS within 5minutes

D: Respiratory effort after five rescue breaths

E: GCS of <5 at 40 minutes post start of resuscitation

Take-home messages

1. The old adage "you're not dead until you're warm and dead" is true – though once you hit 32°C careful consideration should be taken about whether it is appropriate to continue.
2. Good EARLY initial resuscitation greatly improves outcome – this is why there are CPR posters at every swimming pool/beach.
3. No antibiotics needed.
4. There is no difference between salt and freshwater.

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