



## Background

Drowning is the third leading cause of death worldwide (WHO, 2024).<sup>1</sup> 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.<sup>2</sup>

## Definition:

Drowning is defined as the process of experiencing respiratory impairment from submersion/immersion in liquid. Terms such as 'near drowning', 'wet drowning', 'dry drowning', whilst used historically are no longer used.

## Pathophysiology

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.

## Pre-Hospital Management

- Early bystander CPR dramatically affects chance of survival.
- **If cardiac arrest: APLS algorithm and adjust if hypothermic.**
- <30o C: Aggressively rewarm (see Rewarming);
- avoid adrenaline/amiodarone and max 3 defib attempts until >30o C
- 30-35o C: Defibrillate as usual; resus drugs every 8 mins .
- Continue CPR until >32o C or temp not risen despite active re-warming

## Investigations:

- Blood gas & glucose
- FBC & Coagulation
- U&E's: correct any electrolyte abnormalities
- CK (may be ↑↑ if child has struggled in hypoxic conditions)
  - LFT's & C-reactive protein
  - Serum osmolality
- Consider drug and alcohol screen
  - Chest x-ray
- CT Scan (head & C-Spine)/ MRI brain
  - 12 lead ECG

**Call KIDS NTS if progressing to Rapid Sequence Induction (RSI), and/or further specialist advice needed:**

## Indicators Of Poor Outcome

- Age < 3 Years.
- Immersion Time >10 Mins.
- Time To Basic Life Support >10 Mins.
- Time To First Respiratory Effort >40 Mins (Indicator Of Good Prognosis If <3 Mins).
- Persistent Gcs Of < 5
- Requirement For Cpr
  - Initial Ph <7.00.

## Resuscitation & Stabilisation

### Airway

- If spontaneously breathing administer oxygen by face mask oxygen
- Target SpO2 88-92%
- Consider early intubation and ventilation, using cuffed ET tube
- Insert gastric tube and empty stomach.
- No evidence for surfactant or steroids
- No evidence for antibiotics unless grossly contaminated water.

### Breathing

- Target tidal volumes 6-8mls/kg but try to; limit PIP to 30cmH2O
- Permissive hypoxia - aim SaO2 88-92%
- Permissive hypercapnia (caution if head injury present)
- Optimise PEEP to achieve oxygenation - may need PEEP > 10cmsH2O

### Circulation

- Actively treat hypovolaemia and hypotension
- Obtain adequate vascular access - min x 2 IV/IO
- Consider inotropic support if not fluid responsive
- May need higher mean BP for neuroprotection

### Disability

- Neuroprotection:
  - 30° head up
  - pCO2: 4-5 kPa
  - Blood sugar 4 - 10 mmol/l
  - paO2 >8 kPa (arterial) / SpO2 88-92%
- Hypertonic saline if signs of raised ICP - 5 mls/kg of 2.7 Or 3% or 3mls/kg of 5% - aim Na+ 145 - 150mmols
- C-spine protection until cleared
- Check temperature, avoid hyperthermia.
- Avoid seizures - Load with Keppra 40mg/kg

## Re-Warming

- If Cvs Stable - Aim To Rewarm At 0.5°C Per Hour To 35°C
- Passive External: Careful Handling; Remove Wet Clothes; Warm Blankets
- Active External: Air Blanket Re-Warmer; Radiant Heat
- Active Internal: Warmed Intravenous Fluids (40-44°C); Pleural/Bladder (10ml/Kg)/Stomach/Peritoneal Lavage

## Rapid Sequence Induction

### Use Local Rsi Checklist

- Suggested Induction: Ketamine 1-2 Mg/Kg +/- Muscle Relaxant: Rocuronium 1-2 Mg/Kg
- Maintenance: Morphine, Midazolam And Rocuronium Infusions
- Refer To Kidsnts Drug Calculator

## Key Messages

1. The saying "you're not dead until you're warm and dead" is actually 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.

1. WHO, 2024. [Online] Available at: <https://www.who.int/news-room/fact-sheets/detail/drowning> [Accessed 03 March 2024].  
 2. Jessica Brittain-George . Drowning Module, Don't Forget the Bubbles, 2022. Available at: <https://doi.org/10.31440/DFTB.49708>  
 3. Semple-Hess J, Campwala Pediatric Submersion Injuries: Emergency Care and Resuscitation. Pediatric Emergency Medicine Practice. June 2014. Vol 11 No 6.