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APPROACH TO DROWNING

Developed by Angie Salomon and Dr. David Jerome for PedsCases.com.
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Introduction (4:07)

A: Ah, it's finally summertime! Laying in your backyard, you hear the smell of a sizzling barbecue, you feel the warmth of the sun on your skin, and you hear a child splashing in your neighbour's backyard pool. Hang on – the splashing stopped, and someone is crying for help! You run over to your neighbor's place to find their 2-year-old daughter Marina has fallen into the pool and is face down in the water, unresponsive. Her 10-year-old brother Malik stands helpless on the deck, crying.

Do you know what to do in the event of a submersion injury or drowning? How about assessing the severity of a drowned patient, and the risk of long-term sequelae? How would you counsel new parents on the importance of water safety for their child – and themselves?

My name is Angie Salomon, and I'm a 4th year medical student at Queen's University in Kingston, Ontario. I'm joined by Dr. David Jerome, a rural family physician with faculty positions at NOSM University and the University of Alberta, and today we are going to discuss all these concepts and more. Hi Dr. Jerome, thanks for helping me out with this podcast!

D: Hey Angie, it's great to be here!

A: Alright, without further ado - let's dive right in!

D: Just let me grab my flippy-floppies and let's go!

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A: Alright, let's start off with some important definitions. Drowning, as defined by the World Health Organization, is "the process of experiencing respiratory impairment from submersion or immersion in liquid." According to this definition, drownings can be fatal or non-fatal¹. This is important, as most incidences of drowning do **not** actually lead to death. Furthermore, terms like "non-drowning", "near drowning" "delayed drowning", or "wet or dry drowning" are generally misleading and should not be used with patients, caregivers, or your medical colleagues².

In 2019, an estimated 236,000 people died from drowning, making it a major public health concern worldwide¹. While the majority of these deaths occurred in low- and middle-income countries, drowning still represents one of the leading causes of accidental deaths in Canada, including amongst children^{3,4}. Furthermore, the burden of drowning is likely highly underestimated, given that, as mentioned previously, most drownings are non-fatal, and many are even non-reported.

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In Canada, Risk of **fatal** drowning follows a tri-modal age distribution. In infants and young children less than 5, drowning tends to occur because the child was alone or unsupervised by water. In 15–25-year-old males, drowning is often a result of improper or lack of use of a life jacket during water activities, consumption of alcohol and other intoxicants, or being in or on water after dark^{5, 6}. Finally, in ages 65 and up, cardiovascular disease including chronic conditions as well as sudden acute cardiac events was reported as an associated contributing factor for 55% of fatal drownings⁶.

Certain demographics in Canada are also at an increased risk including males, rural populations, and Indigenous peoples including First Nations, Inuit and Metis.⁷ In fact, drowning amongst Indigenous children is reported to be 15 times higher than the Canadian average.⁷ More research is needed to understand risks and rates of drowning amongst Indigenous people and also newcomers to Canada. Future public health and educational initiatives to address drowning amongst these populations must be reflective and respectful of local communities' traditional knowledge, land- and water-based practices, and cultural environments.

Thankfully, rates of drowning fatalities are decreasing over time in Canada, in large part thanks to public health campaigns encouraging water safety and water skills, use of personal flotation devices, and knowledge of CPR.

Nevertheless, drowning remains an important clinical and public health challenge, and today we hope to equip you with the skills to manage drowning treatment and drowning prevention in the ER, the clinic, and your backyard.

So, with that - Dr. Jerome, can you tell us what our objectives are for this episode?

D: Absolutely.

- Number 1: Understand the pathophysiology behind fatal and non-fatal drowning, and potential outcomes.
- Number 2: Classify a drowned patient according to the severity of their symptoms
- Number 3: Learn the key “do’s” and “don’t’s” of management for a patient presenting with drowning
- And number 4: Learn about the most effective strategies to prevent pediatric drowning, and how to counsel parents and caregivers.

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Pathophysiology/potential outcomes (2:30)

A: Objective 1 - pathophysiology and potential outcomes

A: Dr. Jerome, what is drowning and how does it happen?

D: Simply put, drowning is the aspiration of water into the airways leading to hypoxia, due to a combination of laryngo- and bronchospasm, direct cellular injury, surfactant washout, and hypoxic vasoconstriction.

A: What actually happens to cause people to aspirate water in this way?

D: This really depends on the scenario. For young children, it's often a lack of strength or coordination that means they cannot avoid or get out of dangerous conditions around water, such as somewhere with waves or a strong current. More rarely, another medical condition such as a cardiac arrhythmia, hypoglycemia or a seizure can lead to a decreased level of consciousness which in turn leads to a drowning event.⁸

A: So, for some reason or another, liquid enters the airway, causing hypoxia. That's a key takeaway – drownings are hypoxic events. The patient's first reaction may be to cough, sputter, and maybe even try to hold their breathe. The water can cause a temporary laryngospasm, or spasm of the vocal cords. This, in combination with continued aspiration, leads to hypoxemia and loss of consciousness.

D: That's right. It only takes 1 minute of submersion and hypoxemia to lose consciousness, and 10 minutes until death. While unconscious, the airway is mostly protected, but the swallow reflex is intact, meaning large quantities of water can enter the stomach. This is an important consideration because 90% of drowning patients will vomit during resuscitation.

A: You mentioned something about surfactant washout – what's that?

D: Well, if you remember way back to physiology 101, surfactant is the soap-like substance that decreases the surface tension of the alveoli and keeps them from collapsing. When water enters the lungs, it mixes with the “soap-like” surfactant and creates non-cardiogenic pulmonary edema, similar to what happens in acute respiratory distress syndrome, or ARDS.

A: And, just like when you mix soap with water, you get bubbles, right?

D: That's right. The quantity of edema, also called “foam”, can be so large that it bubbles up into the visible airway and even spills out of the mouth. It can really look like foamy dish soap.

A: That's super interesting. We'll learn later about how to (and how not to) manage this upper airway foam. Can you wrap this section up by talking about drowning's effect on the heart?

D: Absolutely. Initially during a drowning, the patient experiences sinus tachycardia, then as the cardiac tissues experience hypoxia, the rhythm develops into bradycardia, pulseless electrical activity, and eventually asystole. You do **not** often see ventricular fibrillation or ventricular tachycardia, thus, defibrillators are not particularly useful in the resuscitation of a patient who has drowned.

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Classification of Severity (1:30)

D: Objective 2 – classification of severity

D: drowning severity can be assessed using just 5 simple indicators: inspection of the upper airway, pulmonary auscultation, blood pressure, pulse, and respiratory effort.

A: Using these metrics, we can assess drowning severity on a scale of 1 to 6.⁸

- Grade 1 is a patient with a mild cough that resolves in a few minutes, has no rales on pulmonary auscultation, and has no foam in the airway. They can be managed “in the field” with rest and warmth.
- Grade 2 through 6 should be assessed in an emergency department.

- Grade 2 is a patient with a persistent cough, some rales in the lungs, and a small amount of airway foam.
- Grade 3 is a patient with a cough, significant rales, large amount of foam, but is maintaining adequate blood pressure
- Grade 4 is a patient with cough, rales, large amounts of foam, and hypotension
- Grade 5 is a patient in respiratory arrest – i.e., not breathing but with a pulse
- And finally, Grade 6 is a patient in cardiac arrest, i.e., pulseless.

D: That's right. So to review, Grade 1 drownings are mild and spontaneously resolve. Grade 2 drownings are patients who have persistent but mild symptoms. Grade 3 drownings are patients with persistent severe respiratory symptoms, but they aren't experiencing any decompensation from hypoxia, such as low blood pressure. Grade 4 drownings are patients with severe respiratory symptoms and low blood pressure. Grade 5 drownings are patients in respiratory arrest, and Grade 6 drownings are patients in cardiac arrest.

Mortality can be estimated using this grading scale. For example, someone with grade 1 drowning has a 0% risk of mortality, whereas patients with grade 3 drownings have a 5.2% mortality rate, and patients with grade 6 drownings have a 93% mortality rate.

A: Assessment of severity is also useful to determine the level of necessary management... we'll get into that next.

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Management (5:30)

D: Objective 3 - Management

A: Alright, it's time to talk management, what you all came here for. Let's return to our neighbor's child Marina, who is unresponsive in her backyard pool. You've pulled her out and laid her flat on the deck. You feel a pulse, but it is slow, and she is not breathing. Isolated respiratory arrest places Marina in Grade 5 drowning. Remembering your Basic Lifesaving Training, you immediately begin providing rescue breaths, while you instruct Marina's brother to call an ambulance.

D: This is a really good start, as the priority during resuscitation is effective oxygenation in order to prevent or reverse cerebral hypoxia. Even if the patient is also in cardiac arrest, resuscitation must include ventilations. This is not the time to employ compression only CPR! .⁹

A: while you are bent over Marina, you start to notice large volumes of bubbly foam spilling out of her mouth and nose! There is no vomit. Your instinct is to scoop the foam out, but you remember that this is just a product of the water mixing with the surfactant and doesn't have to be cleared from the airway.

D: That's right. **This is a key clinical pearl and bears repeating: "foam" is non-cardiogenic pulmonary edema and should not be suctioned, as suctioning is both ineffective and delays effective oxygenation. There is actually only a very small component of water in this foam, and the rest is surfactant and air bubbles. So the foam is not toxic to lung tissues. So the**

appropriate management of foam is to give positive pressure ventilation or rescue breaths and push the foam back into the lungs.

A: Your hard work pays off! Marina takes a gasp and begins to cough, just as the ambulance arrives. You introduce yourself as a medical student and the EMTs ask you what the mechanism of injury was, and if Marina should be placed in a c-spine collar. What do you think, Dr. Jerome?

D: Definitely not. The incidence of cervical spine injuries in drowning is estimated to be as low as 0.5%². For a patient like this, with no likely cause of trauma preceding the drowning, a c-spine collar would just impede access to the airway which makes it more difficult for us to support oxygenation and ventilation.

A: That makes sense. Alright, so supplemental oxygen at FiO₂ 100% is supplied and she is rushed to the ED. Now, Marina has a large amount of foam, rales in all lung fields, but a normal blood pressure, putting her at Grade 3 of drowning severity. Dr. Jerome, what do you do when you see a patient like this in the ED?

D: We continue to focus on resuscitation with hi-flow supplemental oxygen and mechanical ventilation, such as biPAP or sometimes intubation. Anybody grade 3 or higher should also be moved to the ICU.

A: Are there any laboratory or radiological tests that would help guide management?

D: It's definitely a good idea to get an arterial blood gas and a chest x-ray. On the other hand, a CBC, lytes panel, and kidney function test such as creatinine don't give us much helpful information⁹. It used to be thought that ingestion of saltwater would cause electrolyte or hematological abnormalities, but lots of studies have shown that isn't the case in humans. The only other lab investigations to consider would be to look for medical conditions that may have caused a decreased level of consciousness before drowning, such as hypoglycemia or intoxication.

A: How about antibiotics, Dr. Jerome? Surely ingestion and even aspiration of dirty lake water contaminated with pseudomonas, cryptosporidium, and who knows what else would frequently lead to pneumonia, right?

D: You are right that there are high levels of microbes in most outdoor bodies of water. But studies have shown that giving prophylactic antibiotics to patients who drown in these environments doesn't decrease the rate of pneumonia in the immediate post-drowning period. In fact, prophylactic use of antibiotics can cause harm by selecting out more resistant and aggressive organisms⁹. In rare and severe cases, ventilator-associated pneumonia can occur and is generally seen between 48-72 hours after submersion.⁹ So it's safe to wait and treat a pneumonia if it presents clinically.

A: Alright, fair enough, no antibiotics. How about diuretics – y'know, to flush all of that water out?

D: Nope, there also isn't any indication for diuretics. And just to quickly run through other medications that are sometimes considered in these scenarios, there is no benefit of prophylactic corticosteroid use, vasopressors can be used in cases of refractory hypotension, And at this time, the use of artificial surfactant or nitric oxide of drowning victims are experimental and based on case reports only.⁹

A: Alright, let's keep it sweet and simple then. Everything has gone smoothly in the ED, and Marina is breathing well, with an oxygen saturation of 99% on room air. Her arterial blood gas has normalized with a pH of 7.4, PaO₂ of 100mmHg, and a PaCO₂ of 40 mmHg. She did not require intubation, but you had an anesthesiologist on stand-by just in case. Her parents and Malik are filled with relief, and your attending congratulations you on a job well done.

Man, it seems as though we've been doing a lot of myth-busting in this episode. Here's a quick summary of some common misconceptions, and the truths behind them:

D: Myth Correction 1 - C-spine injuries during drowning are rare and c-spine precautions interfere with airway management, so don't use c-spine precautions unless there are specific signs and symptoms of a c-spine injury.

A: Myth Correction 2 - pulmonary edema, or foam, is not the same as vomit, and should not be suctioned or removed from the airway.

D: Myth Correction 3 - the type of water that the patient drowned in (i.e., fresh vs. salt) is unlikely to have any effect on their outcome, and definitely should not affect management.

A: Myth Correction 4 - likewise, electrolyte or hematological abnormalities as a result of water aspiration are extremely rare. The only standard necessary investigations are a CXR and arterial blood gas, and anything else to look for another medical condition that may have contributed to the drowning event, such as a low glucose level.

D: And finally, myth correction number 5 – prophylactic antibiotics are not indicated to prevent pneumonia in the immediate post-drowning period.

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Prevention (2:30)

D: Objective 4 - Prevention

A: As the saying goes, “An ounce of prevention is worth a pound of cure”. This is certainly the case for drowning and submersion injuries, too. The Canadian Pediatric Society's “Caring For Kids” resource⁴ outlines essential precautions on water safety. You can use these tips when talking to parents about how to protect their children. Let's see how this might play out in our clinic. You are a medical student meeting with Mr. Lake, father to a 5-year-old and a 2-year old. Mr. Lake's family has a big backyard pool and a cottage by the lake.

Mr. Lake, is it okay if we talk about some ways that you can keep your children safe around water?

D: Of course. What sort of things should I think about?

A: the first things to keep in mind pertain to your children themselves. Your toddler should always be within arm's reach when they're in or around water. This includes pools, bathtubs, and beaches. Both children should always be supervised by an adult, with a ratio of 1 adult for every 2 young children.

D: Okay, that makes sense. Could I put them in some water wings to keep them afloat?

A: The best kind of protection is a life jacket, which will turn the person from face down to face up in the water. This is followed by personal flotation devices, or PFDs, which keep people afloat but not necessarily upright. Water wings, neck rings, and bathing suits with flotation are **not adequate** safety devices. Check the label to ensure that your child's PFD or lifejacket meets current national safety standards.

D: I was thinking about just enrolling my children in swimming lessons. That way, I don't have to worry about them!

A: Swimming ability and confidence in aquatic environments are definitely important. However, there isn't good evidence to show at what age kids can learn adequate life-saving swimming techniques. Also, it can't be the only solution. It's important to recognize that providing swimming lessons can give parents a false sense of security in their child's swimming ability, which might actually increase their risk of drowning.

D: Alright, so swimming lessons are important, but not sufficient on their own. Anything else my family should keep in mind in terms of water safety?

A: The next thing to think about is the environment. Your swimming pool should be fenced on all four sides, with a gate that is self-closing and self-latching. Any small portable pools should be emptied after use – this will also protect against mosquito colonies! It's also super important for you and all adults that might be supervising your children be trained in basic first aid and CPR – just in case something goes wrong.

D: That's a great idea. Who knows when it might come in handy!

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A: And that's it! Today we talked about the pathophysiology behind fatal and non-fatal drowning, how to classify a drowned patient according to the severity of their symptoms, how to manage a drowned patient, and how to counsel parents on preventing drowning incidence in their children.

Thanks so much for listening, and thank you, Dr. Jerome, for developing this podcast with me.

D: Thanks Angie, and good luck out there, medical students!

----- outro music -----

REFERENCES

1. World Health Organization. Drowning 2021 [Available from: <https://www.who.int/news-room/fact-sheets/detail/drowning#:~:text=Drowning%20is%20the%20process%20of,death%2C%20morbidity%20and%20no%20morbidity>.
2. Schmidt AC, Sempstrott JR, Hawkins SC et al. Wilderness medical society clinical practice guidelines for the treatment and prevention of drowning: 2019 update. *Wilderness & environmental medicine* 2019;30(4):S70-S86.
3. Clemens T, Tamim H, Rotondi M et al. A population based study of drowning in Canada. *BMC Public Health* 2016;16(1):1-8.
4. Canadian Pediatric Society: Caring for Kids. Water Safety for Young Children 2017 [Available from: https://caringforkids.cps.ca/handouts/safety-and-injury-prevention/water_safety.
5. Lifesaving Society Canada. Canadian Drowning Report. *Drowning Prevention Research Centre Canada*; 2016.

6. The Canadian Red Cross Society. Deaths by immersion and other water-related injuries in Canada, 2011-2015. 2020.
7. Drowning Prevention Research Centre. Canadian Drowning Prevention Plan. 2022.
8. Jerome D. Just the facts: drowning. *Canadian journal of emergency medicine* 2022;24(3):263-5.
9. Szpilman D, Morgan PJ. Management for the drowning patient. *Chest* 2021;159(4):1473-83.