HOT WET COLD

Summertime badness

Words of the day

Hot

Immersion

Delirious

Asphyxia

Wet

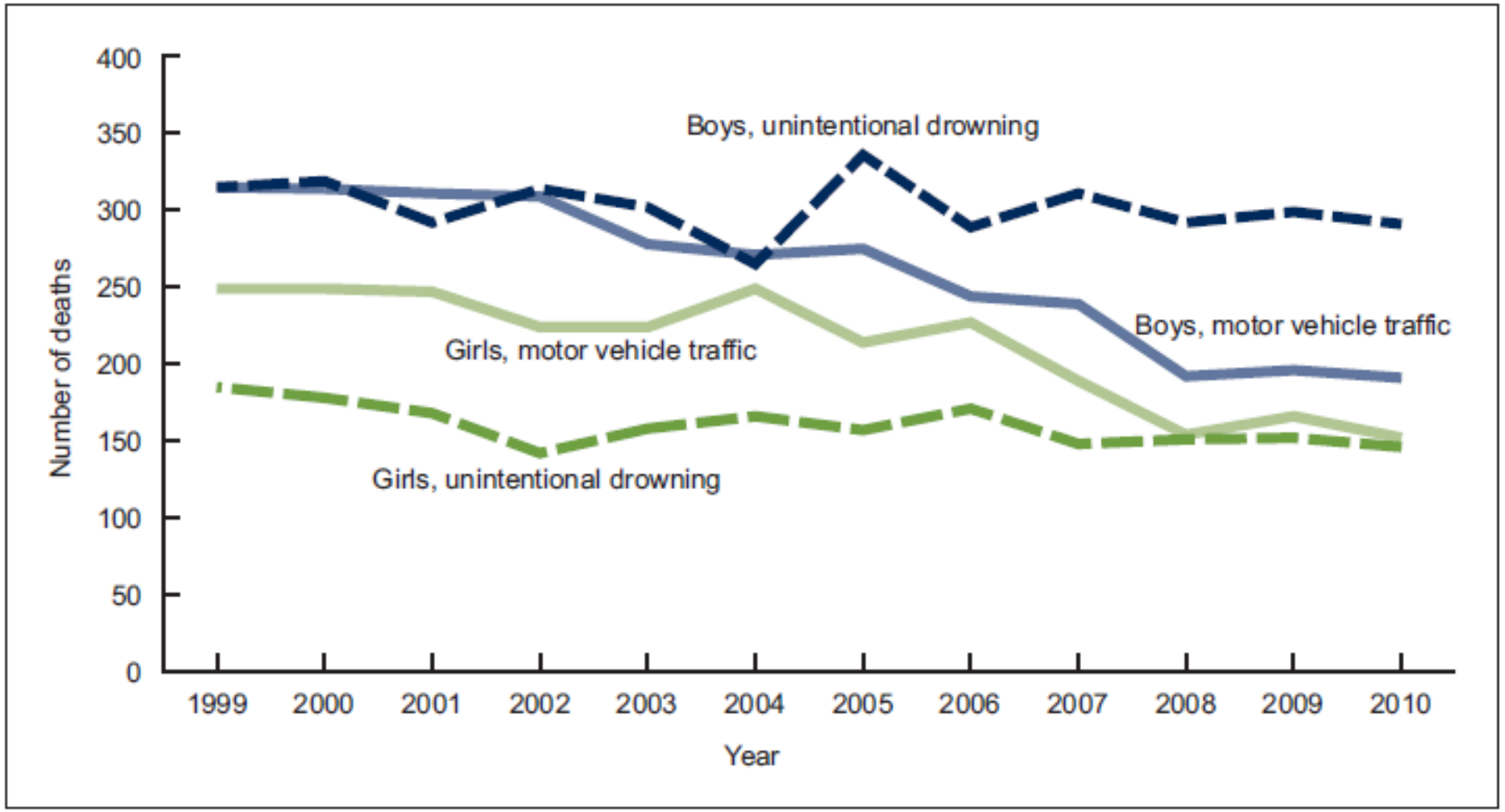
Cold

Acidosis

Hypoxia

Submersion

Figure 5. Deaths from two leading causes of unintentional injury for children aged 1–4 years, by sex: United States, 1999–2010



NOTE: Access data table for Figure 5 at: http://www.cdc.gov/nchs/data/databriefs/db149_table.pdf#5.
SOURCE: CDC/NCHS, National Vital Statistics System, Mortality.

Definitions

- Drowning: water submersion with resultant asphyxiation and death within 24 hours
- Near drowning: resuscitation has extended survival beyond 24 hours

- Fatal drowning
- Water rescue
- Immersion
- Submersion
- Survival
  - Neurologic function
- Death from drowning
  - Specific proximal cause

Scary to think about but important…

- What happens when a drowning person can no longer keep the airway clear….
  - Water entering nose is spat out or swallowed
  - Next conscious response is to hold one's breath (time limited)
  - Some water is aspirated (inspiratory drive is too high to resist)
  - Coughing
  - Laryngospasm (may be terminated by asphyxia)
  - Aspiration continues leading to hypoxemia
  - Loss of consciousness and then apnea
  - Tachycardia → bradycardia → PEA or asystole

Is cold really protective?

- Yes (maybe) but only if
  - Immersion hypothermia develops rapidly or before compromise of oxygenation
  - Onset of hypothermia is more rapid in the young, those struggling in or swallowing icy water
  - If aspiration happens before hypothermia, then any protective effects likely moot

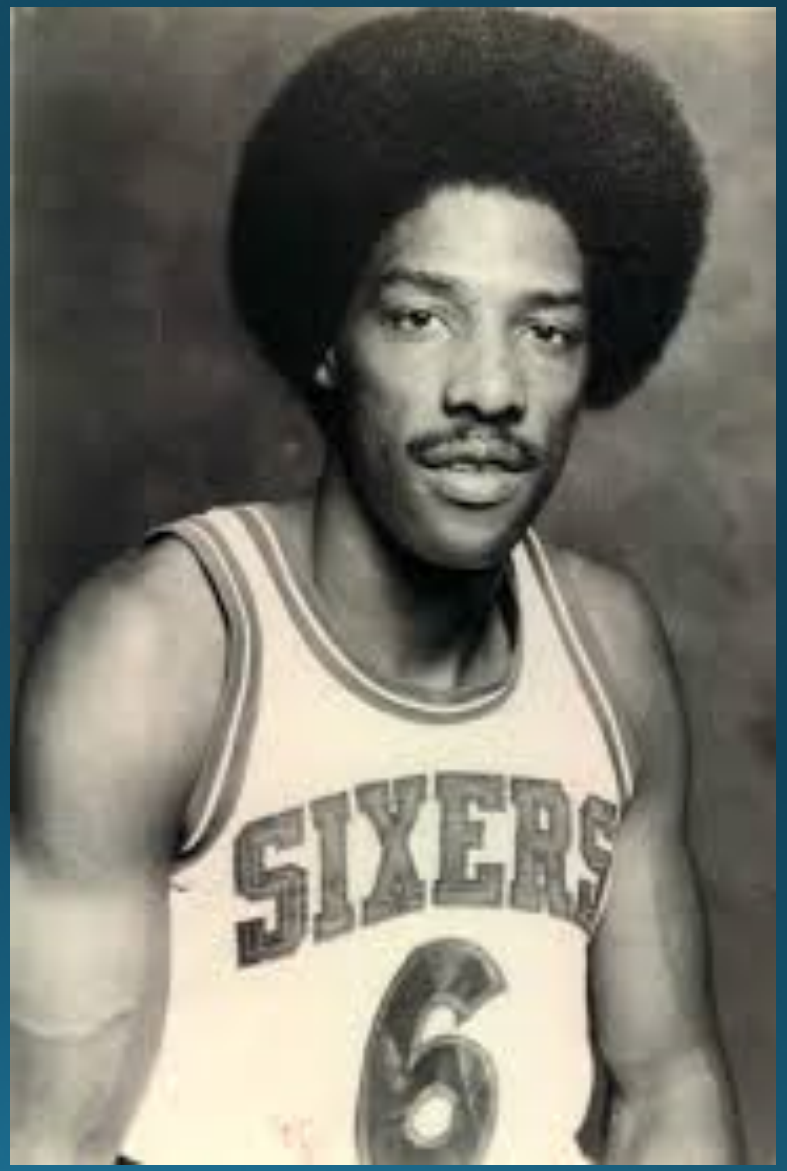
Multivariate predictors for good outcome in open water drowning victims.

Characteristics	Adjusted RR (95% CI)
Age (years)	
0–4	1.34 (1.01, 1.79)
5–14	1.33 (0.96, 1.85)
15+	1.0
Submersion duration (minutes)	
<6	1.0
6–10	0.39 (0.23, 0.65)
11+	0.02 (0.01, 0.04)
Water temperature (°C)	
<6	1.0
6–16	1.13 (0.84, 1.52)
17+	0.97 (0.71, 1.33)

The chicken and the egg

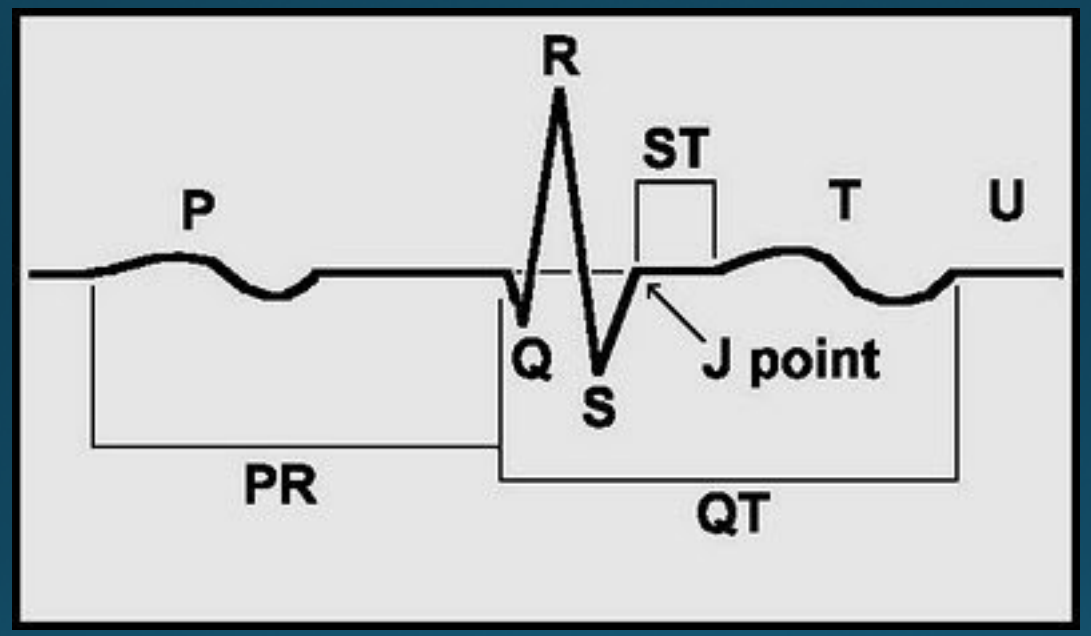
Cold and dead (or appearing to be dead)

Dead and cold (a natural consequence of death)


SIXERS
6


V1
V5

Osborn wave



A positive deflection at the J point is termed a J wave (Osborn wave) and is characteristically seen with hypothermia.

Pathophysiology of drowning

- Think through the mechanism of injury
- What systems are involved and how severely
- What will this likely mean for decisions and actions
  - Laboratory testing
  - Treatment
  - Procedures
  - Destination

Respiratory management

- What options do you have and what does the patient need

  MORE OXYGEN TO VITAL TISSUES

  - 100% oxygen delivered at a high flow rate
  - Positive pressure ventilation and sufficient PEEP
  - Restoration of adequate ventilation and oxygenation often sufficient along with judicious fluids to address acidosis

EMS just called and they are

- Bringing in a 2 year old found in a kiddie pool, apneic at scene but with a pulse, neighbor gave rescue breaths, currently making some respiratory effort with assisted ventilations. ETA 3 minutes.

Planning and priorities

- What are likely vitals going to be?
- What equipment do we need?
- What laboratory abnormalities might we expect if we test?
- What treatment priorities should we focus on?
- What will not be helpful?

On arrival

- GCS 9, T 32 C, HR 130, RR 50, BP 82/50 02 sat 80% with mask oxygen and one very distraught mother keening and moaning
- Ronchi and rales on chest exam.
- Perfusion: cold extremities, cap refill 4 seconds
- Some purposeful movement

It's you, 2 nurses, 1 RT, 1 medic

"you're the doctor, what do you want to do…."

EMS just called again and they are

- Bringing in a 6 year old who was pulled from the deep end by the lifeguard at the local swimming pool, initially making minimal respiratory effort but alert and spontaneously breathing on EMS arrival. ETA 10 minutes.

On arrival

- GCS 14, T 36 C, HR 120, RR 24, BP 102/50 02 sat 98% with mask oxygen and one very distraught mother keening and moaning
- Clear lung fields on chest exam.
- Perfusion is normal
- Alert, able to talk, no neurologic deficits

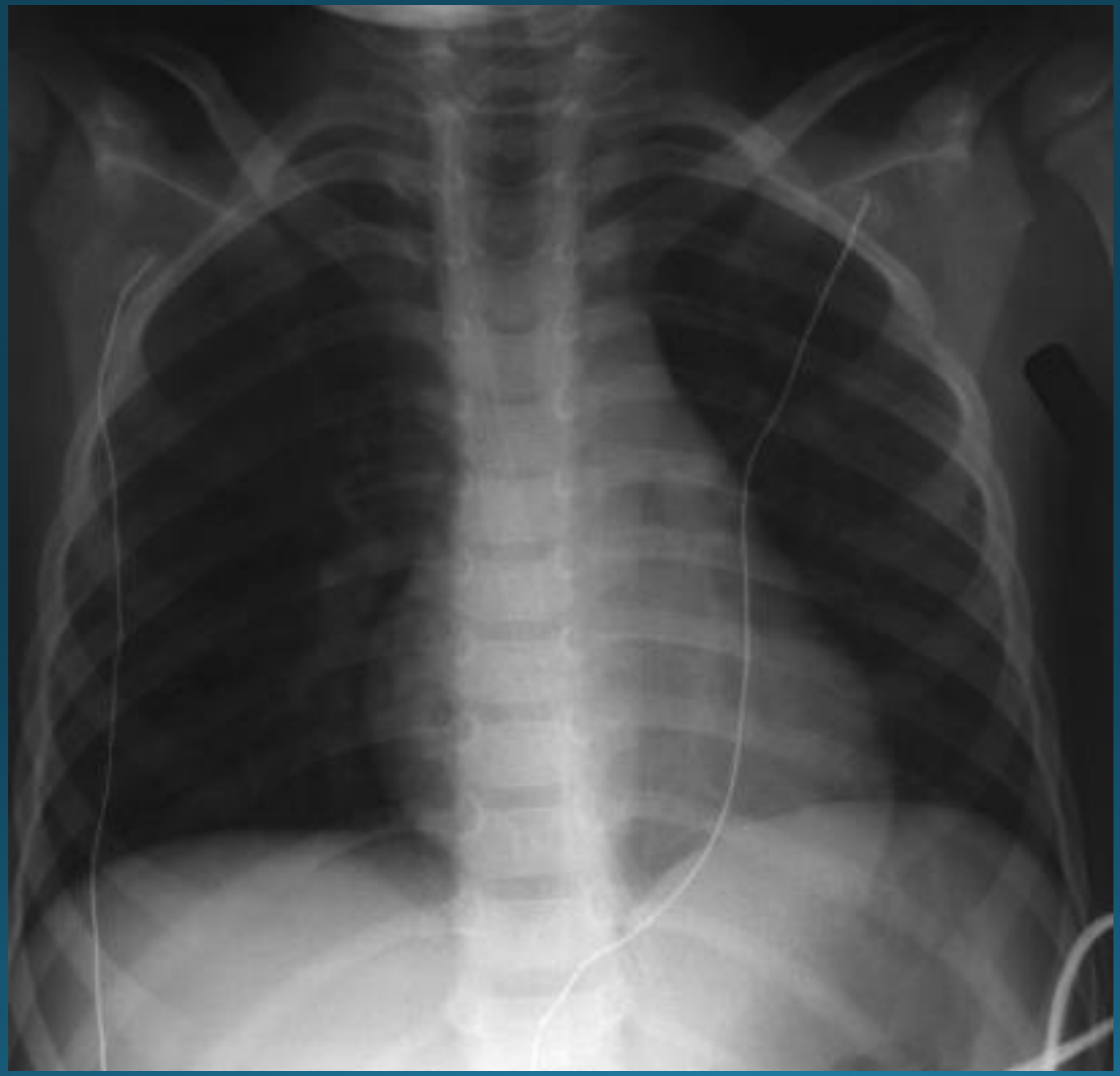


Table 2. Important Facts and Predictors of Outcome in Resuscitation of a Person Who Has Drowned.

Early basic life support and advanced life support improve outcome[21,24,33,54]

During drowning, a reduction of brain temperature by 10°C decreases ATP consumption by approximately 50%, doubling the duration of time that the brain can survive[55]

Duration of submersion and risk of death or severe neurologic impairment after hospital discharge[19,21,24,32]

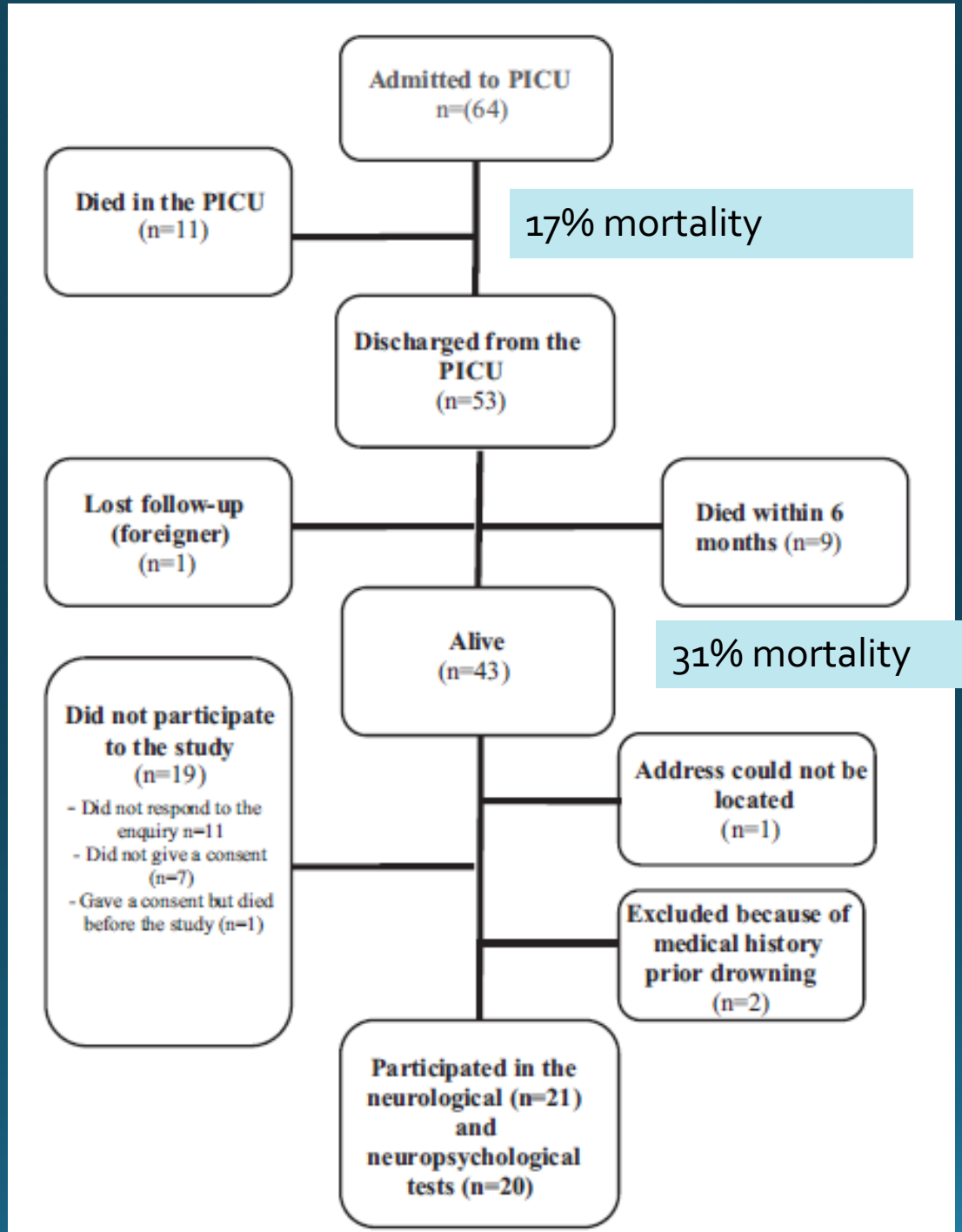
- 0–5 min — 10%
- 6–10 min — 56%
- 11–25 min — 88%
- >25 min — nearly 100%

Signs of brain-stem injury predict death or severe neurologic sequelae[21,24,33,41]

Prognostic factors are important in the counseling of family members and are crucial in informing decisions regarding more aggressive cerebral resuscitation therapies[51]

What do you tell the parents?

- If the child is comatose but with a pulse?
- If the rhythm is asystole?
- If the child is needing oxygen but otherwise looks good?


Admitted to PICU
n=(64)
Died in the PICU
(n=11)
17% mortality
Discharged from the PICU
(n=53)
Lost follow-up (foreigner)
(n=1)
Died within 6 months (n=9)
Alive
(n=43)
31% mortality
Did not participate to the study
(n=19)
- Did not respond to the enquiry n=11
- Did not give a consent (n=7)
- Gave a consent but died before the study (n=1)
Address could not be located
(n=1)
Excluded because of medical history prior drowning
(n=2)
Participated in the neurological (n=21) and neuropsychological tests (n=20)

A comparison of patients who participated to neurocognitive follow-up examinations and non-participants ($n = 40$).

	Participants ($N = 21$)	Non participants ($N = 19$)	P-value
Age at the time of accident (years)	2.4 (1.8, 5.5)	5.1 (1.5, 6.8)	0.542
Submersion time (min)	5.0 (3.0, 11.3)	2.0 (1.0, 3.0)	0.002
Water temperature (°C)	16.2 (9.3, 20.6)	21.0 (10.5, 27.0)	0.309
Resuscitation by layperson (n)	15	18	0.053
Received CPR by EMS unit (n)	11	3	0.015
Intubated at the scene (n)	15	5	0.004
First core temperature[a] (°C)	30.8 (29.0, 33.1)	34.0 (32.2, 36.3)	0.007
pH[a]	7.2 (7.0, 7.3)	7.3 (7.2, 7.3)	0.080
Base excess[a] (mmol/l)	−14.2 (−20.4, −5.7)	−7.1 (−11.9, −4.6)	0.048
Blood glucose[a] (mmol/l)	10.1 (8.3, 13.8)	9.9 (8.3, 12.7)	0.716
Mechanically ventilated at PICU (n)	16	6	0.005
Ventilation time (days)	2.5 (1.0, 4.0)	2.0 (1.0, 4.0)	0.653
Length of PICU stay (days)	3.0 (1.0, 5.3)	1.0 (1.0, 1.0)	0.006
POPC at hospital discharge (n)	11	17	0.011
Normal (POPC = 1)	10	2	
Mild to severe deficit (POPC ≥2)			

The data are given as median (interquartile range) or number.

P-values determined by Mann Whitney U test or Chi square test.

Abbreviations: °C, Celsius; POPC, Pediatric Overall Performance Category Scale; EMS, emergency medical services.

[a] On arrival to the emergency room.

The incidence of neurological dysfunction in children who survived drowning ($n = 21$).

Cluster of dysfunction and signs according to Hadders-Algra[12]	The number of patients (percent) with cluster abnormality
Dysfunctional muscle tone regulation (≥1 deviations) Muscle tone Posture during sitting, crawling, standing and walking	4 (19.0%)
Reflex abnormalities (≥2 signs) Abnormal intensity and/or threshold or asymmetry in: biceps reflex, knee and ankle jerk Foot-sole response: uni- or bilateral Babinski sign	2 (9.5%)
Choreiform dyskinesia (≥1 movements) Spontaneous motor behavior Movements of face, eyes, tongue	1 (4.8%)
Co-ordination problems (≥2 tests) Finger-nose test, fingertip touching test, diadochokinesis, Romberg, tandem gait, standing one foot	11 (52.4%)
Fine manipulative ability (≥2 tests) Finger opposition test: smoothness and transition Quality of hand and arm movements Pincher grasp Tremor	9 (42.9%)
Rarely occurring miscellaneous disorders (≥1 signs) Motor behavior of face, eyes, pharynx and tongue Associated movements during DDK, finger-opposition test, walking on toes or heels At least one of the following: Mild cranial nerve palsy and excessive associated movements	4 (19.0%)

Variables associated with neurological outcome after drowning accident ($n = 21$).

	Neurologically intact ($N = 9$)	Minor or major neurological deficit ($N = 12$)
Age at the time accident (years)	2.1 (1.5, 3.5)	3.0 (2.1, 7.6)
Age at the time of examination (years)	13.4 (9.5, 19.7)	10.8 (7.8, 19.0)
Submersion time (min)	4.0 (2.0, 6.3)	7.5 (4.0, 19.0)
Water temperature (°C)	12.3 (3.0, 21.0)	14.9 (6.7, 17.9)
First core temperature[a] (°C)	33.0 (29.3, 34.3)	30.7 (26.5, 32.4)
pH[a]	7.2 (7.1, 7.3)	7.1 (6.9, 7.2)
Base excess[a] (mmol/l)	−7.6 (−15.3, −4.0)	−17.0 (−23.2, −10.6)
Blood glucose[a] (mmol/l)	9.6 (8.5, 11.7)	11.5 (8.0, 14.5)
Mechanical ventilation time (days)	1.0 (1.0, 1.0)	3.0 (2.0, 7.0)
Length of PICU stay (days)	1.0 (1.0, 2.0)	5.0 (3.0, 7.5)

How hot is too hot?

- Doctor how high does the temperature have to be before we should be worried?
  - "Billy's brain will not melt or explode from a fever, there really is no number except an almost very high number like 42C that would make us worried"

How hot is too hot?

- Doctor how high does the temperature have to be before we should be worried?
  - "A temperature above 40C in the setting of changes in mental status and heat exposure is a threat to life and requires immediate care and treatment"

EMS just called again and they are

- Bringing in a 14 year old boy from who collapsed during soccer practice after school. They report that he is very groggy, has a HR of 140 and a temperature of 41 C. ETA 3 minutes.

Management challenge in heat stroke

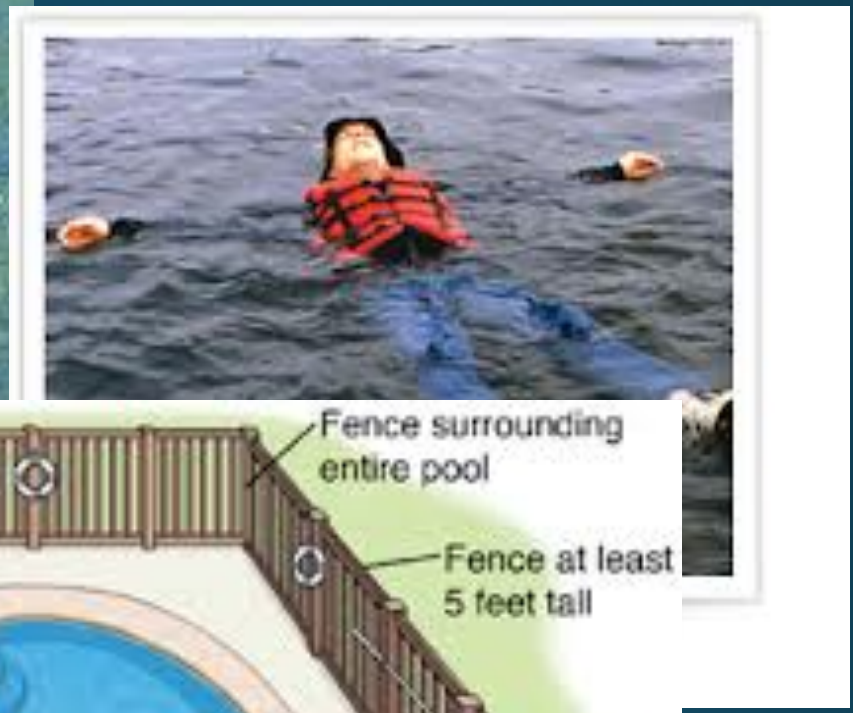
- Hypotension in addition to hyperpyrexia and coma
  - How much fluid is needed?
  - If you had to choose a pressor agent, which one makes sense?

Basic advice around heat exhaustion

https://www.youtube.com/watch?v=JQcaHA4_SIQ

Please note: The use of hand motions in addition to talking is clearly a sign of intelligence

"Get out of the heat, drink fluids, active cooling, rest"




Fence surrounding entire pool
Fence at least 5 feet tall
Self-closing gate with self-latching lock