Submersion injuries

T Kent Denmark, MD FAAP FACEP
Chair, Pediatric Emergency Center
Saint Francis
Pediatric drowning is the leading cause of unintentional death in which age group?

a. 1-4 years
b. 5-9 years
c. 10-14 years
d. 15-17 years
A distressed/drowning toddler makes how much noise?

a) 30 dB (whisper quiet library at 6 feet)
b) 65 dB (normal conversation at 3 feet)
c) 85 dB (city traffic inside of car)
d) 90 dB (truck traffic)
Risk factors for submersion injury include all except:

a) Male
b) African-American
c) Being at home
d) Adult supervision compromised by alcohol, drugs, distraction or sleepiness
e) Decreasing bystander CPR with increasing age
f) Seizure disorder
g) Being Arthur Curry

h) Parental perception of strong swimming ability
Arthur Curry... or Aquaman
Racial disparities
Proportion of all fatal pool drownings, 2005-2014

Age group:
- 0-4 years
- 5-9 years
- 10-14 years
- 15-17 years

- Friend's House
- Relative's House
- Home

(n=1009)
<table>
<thead>
<tr>
<th>Layers of protection</th>
<th># Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR Performed (n=1098)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4 years</td>
<td>762</td>
<td>94.9</td>
</tr>
<tr>
<td>5-9 years</td>
<td>148</td>
<td>90.2</td>
</tr>
<tr>
<td>10-14 years</td>
<td>60</td>
<td>88.2</td>
</tr>
<tr>
<td>15-17 years</td>
<td>50</td>
<td>79.4</td>
</tr>
<tr>
<td>Total</td>
<td>1020</td>
<td>94.0</td>
</tr>
<tr>
<td>911 Called (n=1330)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1316</td>
<td>99.0</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Parents’ perception of their child’s swimming ability by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Strong swimmer*</th>
<th>Adequate/fair/poor swimmer</th>
<th>Non-swimmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 years</td>
<td>16%</td>
<td>31%</td>
<td>52%</td>
</tr>
<tr>
<td>3-4 years</td>
<td>17%</td>
<td>21%</td>
<td>62%</td>
</tr>
<tr>
<td>5-12 years</td>
<td>27%</td>
<td>70%</td>
<td>3%</td>
</tr>
</tbody>
</table>

n = 1,003
Percent of drowned children age 10-17 years who were able to swim

<table>
<thead>
<tr>
<th></th>
<th>0-15%</th>
<th>16-30%</th>
<th>31-45%</th>
<th>46-60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>b)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>c)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>d)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Figure 4. Nearly half of 10-17 year olds who drown in pools reportedly know how to swim\textsuperscript{7,19}

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Proportion of Children, 2005-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4 years</td>
<td>98% (2%)</td>
</tr>
<tr>
<td>5-9 years</td>
<td>85% (15%)</td>
</tr>
<tr>
<td>10-14 years</td>
<td>56% (44%)</td>
</tr>
<tr>
<td>15-17 years</td>
<td>50% (50%)</td>
</tr>
</tbody>
</table>

Could not swim
Could swim
(n=1,085)
Counseling on pediatric water safety includes which of the following?

a) Alcohol should not be considered a risk factor in adolescent drowning

b) Air-filled swimming aides (water wings) may be used as a substitute for approved personal flotation devices

c) Pool alarms and rigid pool covers may be used in place of 4-sided fencing

d) Adults supervising children should be in the water or within arm’s length of infants, toddlers and weak swimmers
Figure 3. Age is a driving factor in parents’ decision to leave children unsupervised at pools

Proportion of parents who have left their child without supervision at a pool by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Never</th>
<th>Less than 2 minutes</th>
<th>More than 2 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 years</td>
<td>60%</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>3-4 years</td>
<td>53%</td>
<td>24%</td>
<td>22%</td>
</tr>
<tr>
<td>5-12 years</td>
<td>32%</td>
<td>25%</td>
<td>44%</td>
</tr>
</tbody>
</table>
Research shows children are 3-5x more likely to survive neurologically intact if 2 things happen:

a) CPR within 3 minutes and EMS arrival in < 15 minutes
b) CPR within 1 minute and EMS arrival in < 9 minutes
c) CPR within 1 minute and EMS arrival in < 15 minutes
d) CPR within 3 minutes and EMS arrival in < 9 minutes
Figure 11. Despite acknowledging its importance, almost 4 out of 10 parents do not have CPR training.
The “instinctive drowning response” is:

a) Glottic closure following aspiration

b) Loud, erratic splashing and flailing when in distress

c) Bradycardia, central venous engorgement and resulting hypothermia in icy water

d) Arm extension laterally with attempts to push downward
Mechanisms contributing to intrapulmonary shunting after a drowning include:

a. Bronchospasm
b. Inactivated, diluted and/or diminished surfactant
c. Alveolar and interstitial edema
d. All of the above
Common metabolic derangements in drowning include which of the following:

a) Hypocarbia
b) Hypoxemia
c) Alkalosis
d) Hypernatremia
Drowning process

• Struggle for 20-60 seconds
• First aspiration - coughing reflex – laryngospasm
• No longer gas exchange – hypoxia, hypercarbia & acidosis
• Significant alterations in arterial oxygenation with 1-2 mL/kg of aspirated water
• Decreased arterial $O_2$ leads to relaxation of laryngospasm – more aspiration
• Progressive hypoxia and acidosis leads to arrythmias and myocardial dysfunction contributing to CNS ischemia
Your neighbors 2 year old is found face down in the backyard swimming pool after being missing for < 5 minutes. While having someone call 911, your first action is:

a) Cervical spine immobilization

b) Abdominal thrusts to remove fluid from the lungs

c) Clearing the airway and delivering rescue breaths

d) Chest compressions
Of these patients, who needs cervical spinal immobilization?

a. 8 month old male submerged in a bucket
b. 13 year old female swimming in an open lake
c. 17 year old male diving athlete
d. All of the above
Watson, Cummings et al. Cervical spine injuries among submersion victims. J of Trauma 2001

- 2,244 submersion injuries
- 11 (0.5%) had cervical spine injuries
- All 11 occurred in open bodies of water
- All had clinical signs of cervical spine injury
- All had a history of either diving, motorized vehicle crash or fall from height
Which is a significant indicator of poor neurological outcome in pediatric submersion victims?

a) GCS of 8 or less on arrival in the ED

b) Submersion time > 25 minutes

c) Age > 10 years

d) CPR > 60 minutes
"Miraculous" cold water submersion survival seems more likely below what water temperature?

a) $< 20^\circ C$

b) $< 15^\circ C$

c) $< 10^\circ C$

d) $< 0^\circ C$
In severe hypothermia (<28 C), do all the following **EXCEPT:**

a) CPR per PALS guidelines

b) Defibrillate per PALS repeatedly as needed

c) Add CK and coagulation studies to evaluation

d) Perform passive and active rewarming
During rewarming, at what core body temperature do you begin to administer resuscitative medications?

a) 28 C  
b) 30 C  
c) 32 C  
d) 34 C  

e) Bonus: What do you do differently with the medications at this body temperature?

20% 20% 20% 20% 20%
A toddler is submerged in one of the ocean/salt pools at the Aquarium for 10 minutes. You expect his serum sodium to be:

a) Hypernatremic  

b) Hyponatremic  

c) Normal  

d) Normal then hypernatremic
Which factors are **NOT** related to non-accidental infant/toddler bathtub?

a) Maternal history of mental illness

b) Child outside of 8-24 month age group

c) Youngest child in the family

d) Previous history of abuse or social needs
A submersion patient needs antibiotics:

a) Empirically

b) If the water was stagnant

c) With abnormal chest x-ray

d) With tachypnea and an abnormal chest x-ray

e) With fever, tachypnea and an abnormal chest x-ray
In a neurologically intact toddler, assuming all parameters are normal, when is it safe to discharge from the ED?

a) Immediately upon arrival to the ED
b) 2 hours post-submersion event
c) 4 hours post-submersion event
d) 6 hours post-submersion event
e) 24 hours post-submersion event
f) 48 hours post-submersion event
g) 18th birthday
Summary

- Prevention is key
- Drowning is quick and silent
- Immediate CPR and early 911 activation
- While mortality has improved, neurologic morbidity has not changed
- Always take responsibilities seriously....
Thank you