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Near-Drowning and Drowning

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Program Manager, Afghanistan Health Care Sector Reconstruction Project
Center for Disaster and Humanitarian Assistance Medicine
Professor of Military and Emergency Medicine
Uniformed Services University
Bethesda, Maryland, U.S.A.
Drowning: Definitions

- Drowning: death by suffocation after submersion in a liquid (pt. dies within 24 hours of submersion)
- Near drowning: survival (short or long term) following asphyxia secondary to submersion
- Secondary drowning (or delayed drowning or postimmersion syndrome): death more than 24 hours post submersion from complications related to submersion (pulmonary injury, sepsis, renal failure, etc.)
Controversies or Unclear Points

Drowning

- Should the Heimlich maneuver be a routine part of resuscitation?
- Should patients without symptoms after submersion be taken to an ED and admitted?
- Should patients arriving in the ED in cardiac arrest continue to have resuscitation attempted?
- Does ICP monitoring do any good?
- Does surfactant administration help?
Drowning: Epidemiology

- Third leading cause of accidental death in U.S. (2nd in children)
- 8000 deaths / year
- Most involve teenage boys and toddlers (male to female ratio = 5 : 1)
- Most urban drownings are in private swimming pools
- Most non-urban drownings are in rivers or canals (ocean drownings are actually rare)
### Locations & Types of Submersion in Drowning Accidents (in the U.S.A.)

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Water</td>
<td>1 to 2%</td>
</tr>
<tr>
<td>Fresh Water:</td>
<td>98%</td>
</tr>
<tr>
<td>Swimming pools: private</td>
<td>50%</td>
</tr>
<tr>
<td>public</td>
<td>3%</td>
</tr>
<tr>
<td>Lakes, rivers, streams, storm drains</td>
<td>20%</td>
</tr>
<tr>
<td>Bathtubs</td>
<td>15%</td>
</tr>
<tr>
<td>Buckets of water</td>
<td>4%</td>
</tr>
<tr>
<td>Fish tanks or ponds</td>
<td>4%</td>
</tr>
<tr>
<td>Toilets</td>
<td>1%</td>
</tr>
<tr>
<td>Washing machines</td>
<td>1%</td>
</tr>
</tbody>
</table>
Human Near-drowning Sequence

1. Violent struggle to reach the surface
2. Period of calmness and apnea
3. Swallowing large amounts of fluid, followed by vomiting
4. Gasping respirations and aspiration
5. Convulsions, coma, and death
**Typical Human Response to Unexpected Submersion**

- **"Wet drowning"** (85 to 90%)
  - Laryngospasm aborted: Aspiration and Swallows H₂O

- **"Dry drowning"** (10 to 15%)
  - "Dry drowning"

**Stage 1**
- (0 to 2 minutes)

**Stage 2**
- (1 to 2 minutes)

**Stage 3**
- (Variable)

Jim Holliman, Uniformed Services University
Initial & Delayed Effects of Water Aspiration

- Pulmonary Compliance
- Surfactant Production
- Diffusion
- Atelectasis
- Intrapulmonary shunting
- Hypoxemia
Initial & Delayed Effects of Water Aspiration (cont.)

- Pulmonary Edema
- Capillary Injury
- Infection

Aspiration Pneumonitis

Diffusion Deficit, V/Q

Hypoxemia

Jim Holliman, Uniformed Services University
Mammalian Diving Reflex
(may operate if submersion in cold water)

- Apnea
- Bradycardia

Redistribution of blood supply:
- Skin -> heart
- Muscle -> lung
- Gut -> brain
Drowning: Important Aspects of the History

- Estimated time of submersion
- Type and temperature of water
- Amount and type of water contamination
- How and when victim was rescued
- Whether vomiting occurred
- How soon after rescue the victim first gasped
- How soon and what type of resuscitation measures
- How soon the patient was transported
- History of epilepsy, drugs or alcohol
- Possibility of child abuse (especially in bathtub drownings)
"Shallow Water Blackout"

- Normal duration voluntary apnea:
  - 87 seconds
  - Then PCO2 = 51, PO2 = 73

- Hyperventilation followed by exercise & breath hold:
  - 87 seconds
  - Then PCO2 = 43, PO2 = 34 to 43

- Therefore can cause loss of consciousness from hypoxia before PCO2 increases and stimulates resp. drive (thereby causing drowning)
Drowning : First Aid

- Start mouth to mouth ventilation while patient in water, with Sellick maneuver if possible
- Immobilize neck early if diving
- Clear airway of debris
- ? Heimlich maneuver (may cause emesis & aspiration)
- Do not rely on estimated submersion time
- On beach : position patient parallel to surf line (so head not above or below heart level)
- O2 always, if available
Drowning: Salt Water Vs. Fresh Water: Features Common to Both

- Surfactant loss (washout vs. denatured)
- Persistent hypoxemia due to intrapulmonary shunt
- Pulmonary edema
- Focal lung hemorrhages
- No major change in blood volume
- No major change in serum electrolytes
- No dysrhythmias (unless Vfib due to hypoxia or hypothermia)
Drowning: Patient Classification

- Group A ("Awake")
- Group B ("Blunted"): conscious but obtunded
- Group C ("Comatose"): 
  - C1: Flexion response to pain
  - C2: Extensor response to pain
  - C3: Flaccid
- Prognosis decreases A to C3
### The "ABC" Classification System for Victims of Near-drowning

<table>
<thead>
<tr>
<th>Category</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> Patient awake, alert, and oriented</td>
<td>100 % survival with normal brain function</td>
</tr>
<tr>
<td><strong>B</strong> Patients with blunted consciousness who are lethargic, semicomatose, combative, agitated or disoriented</td>
<td>89 % of adults and 92 % of children survive with normal brain function</td>
</tr>
<tr>
<td><strong>C</strong> Comatose patients</td>
<td>73 % of adults and 44 % of children survive with normal brain function; an additional 17 % of children survive with incapacitating brain damage</td>
</tr>
</tbody>
</table>
Drowning Rx : Group A

- CXR, pulse oximetry for all
- Maybe ABG and CBC
- O2 (usually by nasal prongs)
  - +NG tube ; NPO X 12 hours
  - Admit overnight
- Discharge if stable & no pulmonary symptoms next day
Drowning Rx : Group B

- ABG's, CXR, CBC, Electrolytes
- O2 ; may need intubation
  - NG tube
  - Admit to ICU
  - Serial ABG's and CXR's
  - Restrict fluids to prevent cerebral edema
- Discharge if no later secondary deterioration ; usually need at least a 2 day admission
Drowning Rx : Group C *

- ABG's, CXR, CBC, Electrolytes
- O2, intubation, hyperventilation, + PEEP
- Admit to ICU
- Fluid restriction + diuretics
- Temperature control
- + paralytic agents
  - + barbiturates
  - + antibiotics

* Generally similar to management of closed head injury
Drowning: Direct Complications

Monitor for:

- Atelectasis
- Pneumonia
- Pneumothorax & pneumomediastinum
- Pulmonary edema
- Progressive cerebral edema
Drowning: Non-Pulmonary Complications

Monitor for:
- Metabolic acidosis
- Renal failure
- Bowel mucosal necrosis (GI bleed)
- Disseminated Intravascular Coagulation (DIC)
- Decreased cardiac output
- Liver failure (rare)
Drowning:
Additional X-Rays to Remember

- C-spine series if diving accident
- Skeletal survey (R/O non-accidental trauma) if bathtub drowning
- Head CT scan if normothermic, ? for diving trauma, and persistent decreased mental status
Drowning: Summary Criteria for Hospital Admission

**History**
- Apnea or cyanosis
- LOC
- Required CPR (even if brief)

**Exam**
- Hypoxemia
- Acidosis
- Abnormal CXR
- Abnormal physical exam

**Consider ICU Admission if:**
- Prolonged resuscitation, or needs assisted ventilation, or persistent decrease in mental status
Drowning: Glasgow Coma Scale in Relation to Prognosis

<table>
<thead>
<tr>
<th>GCS</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>&gt; 90 % normal</td>
</tr>
<tr>
<td>4 to 5</td>
<td>25 to 50 % normal</td>
</tr>
<tr>
<td>*3</td>
<td>0 to 39 % normal</td>
</tr>
<tr>
<td>3 &amp; arrest</td>
<td>0 to 8 % normal</td>
</tr>
<tr>
<td>(*flaccid coma)</td>
<td></td>
</tr>
</tbody>
</table>

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Near-Drowning Prognosis: Time to First Spontaneous Gasp Post-Rescue

- If within 15 to 30 minutes post-rescue:
  - Less than 10% have mental retardation or spastic quadriplegia
- If not until 60 to 120 minutes post-rescue:
  - 50 to 80% have serious neurologic sequelae
# Prognostic Signs in Near-drowning Victims

<table>
<thead>
<tr>
<th>GOOD</th>
<th>BAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert on admission</td>
<td>Age &lt; 3 years</td>
</tr>
<tr>
<td>Hypothermic</td>
<td>Fixed, dilated pupils in ED</td>
</tr>
<tr>
<td>Older child or adult</td>
<td>Submerged &gt; 5 minutes</td>
</tr>
<tr>
<td>Brief submersion time</td>
<td>No resuscitation attempts for more than 10 minutes</td>
</tr>
<tr>
<td>On-scene basic and/or advanced life support (probably most important)</td>
<td>Preexisting chronic disease</td>
</tr>
<tr>
<td>Good response to initial resuscitation measures</td>
<td>Arterial pH $\leq 7.10$</td>
</tr>
<tr>
<td></td>
<td>Coma on admission to ED</td>
</tr>
</tbody>
</table>
Near-Drowning Prognosis: Orlowski Scale

Consider these 5 factors:

- Age < 3 years
- Submersion > 5 minutes
- No resuscitation during first 10 minutes after rescue
- Coma on admission
- pH < 7.1 on admission

If only one or two of above: 90% chance of recovery

If 3 or more: only 5% recovery
Near-Drowning: Problems in Some Long-Term Survivors

- Fine motor coordination
- Chronic lung disease:
  - Large airway dysfunction
  - Small airway dysfunction
- Fear of water environments
Drowning Prevention

- Home swimming pools
  - Fully fenced & locked
  - Maintain water level up to edge of pool
  - Floats and pole available
  - Splash alarms

- General
  - Swimming training
  - Wear life jackets
  - Avoid alcohol or drugs
  - Avoid for epileptics or patients with recurrent syncope (at least they should never swim alone)
  - Utilize lifeguards
Hypothermia and Drowning

- Rapid core cooling from aspiration and swallowing cold water
- BMR decreases to 50% at 28°C
- Children (large surface to weight ratio) cool rapidly
- Enhanced cooling from exercise or alcohol (such as struggling or swimming)
- ? action of diving reflex ( ? more minute ventilation with less breath holding ability ; ? less breath holding ability in children)