Drowning:
Resuscitation & Management

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No Relevant Issues to Disclosure

- Paid by Saint Louis University & SLUCare
- Practice Cardinal Glennon Childrens Medical Center
- Have never drowned myself
- Have treated Pediatric Drowning Victims from 9 states submerged in water from pools, buckets, bathtubs, rivers, reservoirs, lakes, floods & Pacific Ocean
- Seen miraculous recovery
- Sent many to Rehab
- Pronounced Brain Death far too frequently
- My son is a Lifeguard
2002, Drowning World Congress; Amsterdam
“Respiratory embarrassment from submersion / immersion in a liquid medium”
Previously Died----Drowning
Alive > 24hr near drowning
How big is the problem?

- 2005-2009 average of 3,533/yr fatal unintentional drownings (non-boating related)
- About 10 people die every day
- Of these, 2 are children <14yr
  2 are 15-19
How big is the problem?

• For every 1 death
  – 4 others hospitalized
  – 14 seen in the ER

• Incidence: holidays, weekends and warm weather

• Fatality: 35%
  33% with neurological impairment;
  11% severe neurologic sequelae
Who is most at risk?

- **Minors**: Children ages 1 to 4 have the highest drowning rates.
- **Minorities**: African Americans 5-14 yo drowning rate 3x Caucasians.
- **Males**: Nearly 80% of Deaths are male.
Who is most at risk?

- **Minorities:**

![Bar graph showing rates per 100,000 population for different age groups and ethnicities.]
Who is most at risk?

- **Males:**

![Bar chart showing age-specific risk rates per 100,000 population for males and females across different age groups. The chart highlights the highest risk for males in the 20-24 age group.]
Where Does Drowning Occur?

- Children <5
  - Pools
- Older kids + Adults
  - Open water
## Where Does Drowning Occur?

*More specific breakdown for kids*

<table>
<thead>
<tr>
<th>Salt Water</th>
<th>1-2%</th>
<th>98%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fresh water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>swimming pools: public</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>swimming pools: private</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>lakes, rivers, streams, storm drains</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>bathtubs</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>buckets of water</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>fish tanks or pools</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>toilets</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>washing machines</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>
When Does Drowning Occur?

Australia ---- Down Under

Drowning Deaths, Month of Incident, 2010/11

- July: 26
- August: 19
- September: 15
- October: 32
- November: 23
- December: 32
- January: 71
- February: 26
- March: 22
- April: 14
- May: 14
- June: 19
What Causes Drowning?

• **Toddlers:**
  – Lapse of supervision----”Gone for <5min”
  – Afternoon/early evening-meal time
  – 84% with responsible supervising adults
  – Only 18% of cases actually witnessed

• **Older Kids & Adolescents**
  – Diving accident - 1st Dive
  – Drinking alcohol
  – Using drugs
What Happens with Drowning?

Most children aspirate < 4 mL/kg of fluid as a result of capillary leak from asphyxia.
Pathophysiology

- Voluntary breath-holding
- Aspiration of small amounts into larynx
- Involuntary laryngospasm
- Swallow large amounts
- Decrease in sats
- Laryngospasm abates (due to hypoxia)
- Aspiration into lungs
- Decrease in cardiac output
- Intense peripheral vasoconstriction
- Hypothermia
- Bradycardia
- Circulatory arrest; Asystole, VF rare
Key Features

- Drowning usually occurs silently and rapidly.
- Treatment remains essentially supportive care.
- Prevention is key for reducing M & M from drowning.
- Multisystem organ failure may ensue.
- Neurologic & Cardiac complications are most severe.
Symptoms (no Arrest)

- 70% develops sx within 7 hrs
- Alertness → agitation → coma
- Cyanosis, cough & pink frothy sputum (pulmonary edema)
- Low grade fever
- Tachypnea, tachycardia
- Rales, rhonchi & less often wheezes
- Poss Signs of Trauma to Head & Neck
Sequelae (Arrest)

Primary Insult is Multisystem Organ Failure from Asphyxia

- Lungs 1-3 ml/kg -- pulmonary vasoconstriction and hypertension
  - Postobstructive pulmonary edema - following laryngeal spasm
  - Neurogenic pulmonary edema
  - Pulmonary edema from acute volume overload – swallowed water
  - ARDS - altered surfactant & other factors
  - Chemical Pneumonitis – chlorinated water….
  - Aspiration Pneumonia

- CNS <2min vs >10 min - hypoxic neuronal injury
  - Hypoxia----Ischemia-----Acidosis----Hypotension
  - Cerebral edema, Seizures,
  - Intracranial Hypertension----ICP monitoring & tx of no value (unless traumatic)

- CV Myocardial Depression/Dysrhythmia/Capillary Leak
- Heme- DIC
- Renal- ATN -ARF
- Muscle- Rhabdo
- Gastrointestinal Emesis, mucosal sloughing – ischemic hepatitis
AAP: 4 Phases after Submersion Injury

- Initial lay person rescue at the scene
- Emergency medical team or paramedic response
- Stabilization in the ED--
- Care in the PICU
Initial Rescue

**Chain of Drowning Survival**

A person who is drowning has the greatest chance of survival if these steps are followed:

1. **Recognize the signs of someone in trouble and shout for help.**
2. **Rescue and remove the person from the water (without putting yourself in danger).**
3. **Call emergency medical services (EMS).**
4. **Begin rescue breathing and CPR.**
5. **Use an AED if available and transfer care to advanced life support.**

American Red Cross
At Scene, Resuscitate Child to Restore Cardiac Output, Oxygenation, & Acid-base status

Ignore Down time that child may have had during initial resuscitative phase

Airway Patency is Critical, Clear airway debris before attempting to ventilate in the field

Try to protect:
- Airway from Aspiration of Stomach Contents
- Lungs from aggressive positive pressure ventilation;
  - Overdistention & Barotrauma

Once HR Established & Adequate Chest Rise Observed, Transport Child to Closest ED that deals with Kids
In the ED, many interventions required:

- Careful examination
- Further stabilization
- Vascular access
- Gastric decompression
- Bladder catheterization
- Appropriate respiratory support

Monitor Cardiorespiratory Status

- Vital signs; including Temperature
- Continuous ECG
- Oximetry
- BP monitoring
PICU Treatment - CNS

• ICP monitoring - **not indicated**; *irreversible cytotoxic injury*
• Brain CT – **not indicated**, unless TBI suspected
• Mild hyperventilation – **not indicated**
• Osmotherapy – **not indicated**
• Corticosteroids (dexamethasone) - **no proven benefit**
• **Seizures - treat aggressively**
• Shivering or random, purposeless movements can increase ICP
• Hypothermia and barbiturate coma - **unlikely to benefit**

(31 comatose kids, J Modell, NEJM 1993)
Predictors of Death or Severe Neurological Impairment

At site of submersion
- Immersion duration > 10min
- Delay in CPR provision

In the ED
- Asystole on ED arrival or CPR duration > 25min
- Fixed and dilated pupils and GCS < 5
- Fixed and dilated pupils and arterial pH < 7

In the PICU
- No spontaneous purposeful movements &
- abnormal brainstem function
  12-24h after immersion
Prolonged resuscitation may increase the success of resuscitation without normal neurologic recovery.

After 25 min of full but unsuccessful resuscitation, thin “PROGNOSIS”
Importance
It is unclear whether advanced airway management such as endotracheal intubation or use of supraglottic airway devices in the prehospital setting improves outcomes following out-of-hospital cardiac arrest (OHCA) compared with conventional bag-valve-mask ventilation.

Objective
To test the hypothesis that prehospital advanced airway management is associated with favorable outcome after adult OHCA.

Design, Setting, and Participants
Prospective, nationwide, population-based study (All-Japan Utstein Registry) involving 649,654 consecutive adult patients in Japan who had an OHCA and in whom resuscitation was attempted by emergency responders with subsequent transport to medical institutions from January 2005 through December 2010.

Main Outcome Measures
Favorable neurological outcome 1 month after an OHCA, defined as cerebral performance category 1 or 2.

Results
Of the eligible 649,359 patients with OHCA, 367,837 (57%) underwent bag-valve-mask ventilation and 281,522 (43%) advanced airway management, including 41,972 (6%) with endotracheal intubation and 239,550 (37%) with use of supraglottic airways. In the full cohort, the advanced airway group incurred a lower rate of favorable neurological outcome compared with the bag-valve-mask group (1.1% vs 2.9%; odds ratio [OR], 0.38; 95% CI, 0.36-0.39). In multivariable logistic regression, advanced airway management had an OR for favorable neurological outcome of 0.38 (95% CI, 0.37-0.40) after adjusting for age, sex, etiology of arrest, first documented rhythm, witnessed status, type of bystander cardiopulmonary resuscitation, use of public access automated external defibrillator, epinephrine administration, and time intervals. Similarly, the odds of neurologically favorable survival were significantly lower both for endotracheal intubation (adjusted OR, 0.41; 95% CI, 0.37-0.45) and for supraglottic airways (adjusted OR, 0.38; 95% CI, 0.36-0.40). In a propensity score-matched cohort (357,228 patients), the adjusted odds of neurologically favorable survival were significantly lower both for endotracheal intubation (adjusted OR, 0.45; 95% CI, 0.37-0.55) and for use of supraglottic airways (adjusted OR, 0.36; 95% CI, 0.33-0.39). Both endotracheal intubation and use of supraglottic airways were similarly associated with decreased odds of neurologically favorable survival.

Conclusion and Relevance
Among adult patients with OHCA, any type of advanced airway management was independently associated with decreased odds of neurologically favorable survival compared with conventional bag-valve-mask ventilation.
Impact of Dispatcher-Assisted Bystander Cardiopulmonary Resuscitation on Neurological Outcomes in Children With Out-of-Hospital Cardiac Arrests: A Prospective, Nationwide, Population-Based Cohort Study

Yoshikazu Goto, MD, PhD; Tetsuo Maeda, MD; Yumiko Goto, MD, PhD

Background—The impact of dispatcher-assisted bystander cardiopulmonary resuscitation (CPR) on neurological outcomes in children is unclear. We investigated whether dispatcher-assisted bystander CPR shows favorable neurological outcomes (Cerebral Performance Category scale 1 or 2) in children with out-of-hospital cardiac arrest (OHCA).

Methods and Results—Children (n=5009, age<18 years) with OHCA were selected from a nationwide Utstein-style Japanese database (2008–2010) and divided into 3 groups: no bystander CPR (n=2287); bystander CPR with dispatcher instruction (n=2019); and bystander CPR without dispatcher instruction (n=703) groups. The primary endpoint was favorable neurological outcome at 1 month post-OHCA. Dispatcher CPR instruction was offered to 53.9% of patients, significantly increasing bystander CPR provision rate (adjusted odds ratio [aOR], 7.51; 95% confidence interval [CI], 6.60 to 8.57). Bystander CPR with and without dispatcher instruction were significantly associated with improved 1-month favorable neurological outcomes (aOR, 1.81 and 1.68; 95% CI, 1.24 to 2.67 and 1.07 to 2.62, respectively), compared to no bystander CPR. Conventional CPR was associated with increased odds of 1-month favorable neurological outcomes irrespective of etiology of cardiac arrest (aOR, 2.30; 95% CI, 1.56 to 3.41). However, chest-compression-only CPR was not associated with 1-month meaningful outcomes (aOR, 1.05; 95% CI, 0.67 to 1.64).

Conclusions—in children with OHCA, dispatcher-assisted bystander CPR increased bystander CPR provision rate and was associated with improved 1-month favorable neurological outcomes, compared to no bystander CPR. Conventional bystander CPR was associated with greater likelihood of neurologically intact survival, compared to chest-compression-only CPR, irrespective of cardiac arrest etiology. (J Am Heart Assoc. 2014;3:e000499 doi: 10.1161/JAHA.113.000499)
Study profile.

5659 children (aged < 18 years) experienced out-of-hospital cardiac arrest

- 280 did not receive resuscitation
- 5379 received resuscitation
- 370 experienced arrest after EMS arrival

5009 were eligible for analysis

- 703 received immediate bystander CPR
- 2698 bystanders were offered dispatcher CPR instruction
- 1608 bystanders were not offered dispatcher CPR instruction

- 679 bystanders did not perform CPR despite dispatcher offer of CPR instruction

2019 received bystander CPR with dispatcher instruction
- 2287 did not receive bystander CPR
- 703 received bystander CPR without dispatcher instruction

74 OR 1.8
57 OR 1 (ref)
44 OR 1.7
Parents should never leave children alone in or near the pool, even for a moment. A fence should be erected to separate house & play area from pool. The fence should be ≥ 4 feet high around all 4 sides of the pool. Gates should auto-close and auto-latch, with latches higher than children's reach. A power safety cover that meets ASTM standards adds protection but should not replace a fence between house & pool. Even fencing & safety cover will not prevent all drownings. Keep rescue equipment (e.g., a shepherd's hook, life preserver) and a telephone by the pool. Remove all toys from the pool after use so children are not tempted to reach for them. After children are done swimming, the pool should be secured so kids cannot get back in. Do not let children use air-filled swimming aids; they can be dangerous. Use life vests. Know CPR. Anyone watching children around a pool should learn CPR and be able to rescue. Parents should stay within an arm’s length of child. Teaching a child how to swim does not mean that he/she is safe in water. Key is Prevention.

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- Begin rescue breathing and CPR
- Use an AED if available and transfer care to advanced life support

American Red Cross