EMS Concepts and Challenges in Trauma: Airway and Ventilation

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- Dan Davis MD
- Ray Moreno MD
- Henry Wang MD
- Many others
Airway

• Endotracheal Intubation (ETI) remains the gold standard for definitive airway management in the prehospital setting

• Procedure that “defines” paramedic level care
Airway Indications - Trauma

• Control & Protection against aspiration
  • Altered mental status (GCS < 8)
• Facilitation of therapeutic ventilation
  • Traumatic brain injury (TBI)
• Combativeness/safety (helicopter)
• Patients at risk for airway compromise
  • Thermal injury, facial trauma, snake bite
TBI

• 1.4 million cases per year USA
• 235,000 hospitalized
• 50,000 deaths
• Lifetime costs $60 billion (2000)

• Risk groups
  • Males 2:1
  • 0-4
  • 15-19
  • >75 highest rates of hospitalization and death
  • African Americans – highest death rate
TBI – Management Goals

• Primary Injury

• Prevention of Secondary Injury
  • Prevent hypoxia and hypoxemia
  • Avoid hypotension
  • Control ICP
Hypoxia and TBI

Chesnut et al. J Trauma 1993
Prehospital ETI

- >20 studies of prehospital intubation and outcome (survival)

  Recurrent theme:
  - Prehospital intubation associated with increased risk of death
  - Prehospital intubation associated with poorer neurological outcome
Intubation of TBI

- Pennsylvania Statewide Data, 2000-2002
- N=4,000 Severe TBI
- Compared EMS vs. ED Intubation

- Prehospital ETI ➔ 4x higher odds of death
- Prehospital ETI ➔ 1.6x higher odds of poor neurological outcome”
ROC Trauma Epistry: GCS < 8

Focus on Trauma

The relationship between out-of-hospital airway management and outcome among trauma patients with Glasgow Coma Scale scores of 8 or less

Daniel P. Davis, MD, Kent M. Koprowicz, MS, Craig D. Newgard, MD, MPH, Mohamud Daya, MD, MS, Eileen M. Bulger, MD, Ian Stiell, MD, Graham Nichol, MD, Shannon Stephens, EMT-P, Jonathan Dreyer, MD, Joseph Minei, MD, Jeffrey D. Kerby, and the ROC Investigators
GCS 8, Intubate?

- Field ETI
  - GCS 3-8: 0.74 (0.57, 0.86)
  - Head AIS 4+: 0.72 (0.61, 0.84)
  - GCS 3-8 & Head AIS 4+: 0.78 (0.66, 0.92)

- Field vs. ED Intubation
  - GCS 3-8: 0.47 (0.40, 0.55)

- Field ETI
  - GCS 3-8: 0.70 (0.57, 0.83)
  - Head AIS 4+: 0.69 (0.63, 0.84)
  - GCS 3-8 & Head AIS 4+: 0.74 (0.63, 0.87)

- RSI - Mortality
  - 0.50 (0.50, 0.50)

- RSI - Good
  - 0.50 (0.50, 0.50)
Association of out-of-hospital advanced airway management with outcomes after traumatic brain injury and hemorrhagic shock in the ROC hypertonic saline trial

Henry E Wang, Siobhan P Brown, Russell D MacDonald, Shawn K Dowling, Steve Lin, Daniel Davis, Martin A Schreiber, Judy Powell, Rardi van Heest, Mohamud Daya
ROC-HS: Airway Outcomes

- TBI 28-Day Death: 1.57 (0.93, 2.64)
- TBI 6-month GOSE ≤4: 1.80 (1.09, 2.96)
- TBI 6-month DRS ≥4: 1.63 (1.00, 2.68)
- Shock 28-Day Death: 5.14 (2.42, 10.90)

Favor Out-of-Hospital AAM
Favor ED AAM

Adjusted Odds Ratio (95% CI)
RSI for TBI
Davis DP et al. J Trauma 2003

- Prehospital Rapid Sequence Intubation
- 209 patients compared with 627 historical controls
- 84% RSI success rate
- RSI associated with increased death
  - OR: 1.6 [1.1-2.2]
RSI for TBI

- Australian RCT of prehospital RSI vs. Supportive Airway
- No differences in primary endpoint (eGOS at 6 months)
  - Subgroup with improved 6-mos outcome
  - “Good” (eGOS 5-8) vs. “Poor” (eGOS 1-4)
    Relative Risk 1.28; 1.00-1.64

- 16 hours RSI training (OR)
  - 97% RSI success rate
Why might this be?

- Selection bias
  - Sicker patients get intubated
- Intubation causes harm
- Skills levels and success rates
Intubation and potential harm

- Misplaced tubes
- Desaturations
- ICP rise with laryngoscopy
- Hyperventilation
Endotracheal Tube Misplacement

- N=108 Prehospital intubations
- Systematic reconfirmation in ED
- 25% tube misplacement rate
- 2/3 esophageal
- 1/3 above vocal cords
Capnography
ET Confirmation

Total patients 153

Continuous ETCO₂ monitoring
93 (61%)

No continuous ETCO₂ monitoring
60 (39%)

ED ETT confirmation

Unrecognized misplaced intubation
0 (0%)

Unrecognized misplaced intubation
14 (23%)

Eosophageal
13 (93%)

Hypopharyngeal
1 (7%)

Silvestri, Ann Emerg Med 2005
Dunford, Ann Emerg Med 2004

- San Diego RSI Trial
- Subset of 152 RSI patients
  - Out of 462 from total trial
- Continuously recorded waveforms:
  - Heart Rate
  - Oxygen Saturation
  - End-Tidal Capnography
Desaturation and Bradycardia

  - San Diego RSI Trial, n=152
- Oxygen desaturation: 31 (57%)
  - Median duration: 160 seconds (IQR 48 to 272)
  - Median desaturation (SpO2): 22%
- Bradycardia: 6 (19%)
  - Pulse rate <50 beats/min
- Paramedics described intubation as "easy" in 84%
Hyperventilation

Davis et al. Crit Care Med 2006
Hyperventilation and Survival

Arrival pCO2 (mmHg)

<20 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55+

Odds Ratio

Davis (2006) *Crit Care Med*
Pepe et al. J Trauma 2003

- Swine study
- Controlled hemorrhage model
- Bled till SBP fell below 65 mm Hg
- Ventilated animals at different settings (TV = 12 ml/kg)

- RR = 12 (5 min)
- RR = 6 (10 min)
- RR = 20 (10 min)
- RR = 30 (10 min)
- RR = 6 (10 min)
# Results

Table 1  Mean Values (n = 8) for Cardiopulmonary Variables Using Various Rates of PPV in a Swine Model of Moderate, Controlled Hemorrhage

<table>
<thead>
<tr>
<th>Variable</th>
<th>RR (breaths/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td>RA (mm Hg)*</td>
<td>1 ± 1</td>
</tr>
<tr>
<td>ITP (mm Hg)</td>
<td>15 ± 2</td>
</tr>
<tr>
<td>Ao Syst (mm Hg)*</td>
<td>65 ± 2</td>
</tr>
<tr>
<td>Ao Diast (mm Hg)</td>
<td>51 ± 2</td>
</tr>
<tr>
<td>Pao₂ (mm Hg)</td>
<td>68 ± 4</td>
</tr>
<tr>
<td>Paco₂ (mm Hg)</td>
<td>35 ± 1</td>
</tr>
<tr>
<td>pH (arterial)</td>
<td>7.46 ± 0.02</td>
</tr>
<tr>
<td>CPP (mm Hg)</td>
<td>50 ± 2</td>
</tr>
<tr>
<td>Qr (L/min)</td>
<td>2.4</td>
</tr>
</tbody>
</table>

RA, right atrial diastolic pressure; ITP, mean intrathoracic airway pressure; Ao Syst, aortic systolic pressure; Ao Diast, aortic diastolic pressure; Pao₂, arterial oxygen tension; Paco₂, arterial carbon dioxide tension; CPP, coronary perfusion pressure (averaged over 10 min); Qr, Cardiac output.

* Measured at end-expiration.
Hyperventilation

Pepe (2004) J Trauma
Brain and Hypocapneic Vasoconstriction
Mean Arterial Pressures

![Graph showing mean arterial pressures for RR6, RR12, and ETCO2 with NS indicated at each level.]}
ETCO$_2$ During Shock

![Graph showing ETCO$_2$ levels during shock with statistical significance]

- RR6: $P = 0.0009$ vs 12
- RR12: $P = 0.0006$ vs 12
- ETCO2: $P = 0.0006$ vs 12
Cerebral Perfusion During Shock

![Bar chart showing cerebral perfusion rates at different times.](chart.png)

**mL/100 gm/min**

- **RR6**: P = .004 v 12
- **RR12**: P = .004 v 12
- **ETCO2**: P = .004 v 12
Brain Oxygenation During Shock

P = .0016 vs 12

P = .0046 vs 12

mm Hg
Hypocarbia and Cell Injury

- Ca++ influx into cells $\rightarrow$ depolarization $\rightarrow$ release of glutamate $\rightarrow$ initiation of apoptosis

- Mitochondrial Injury
  - CO$_2$ or $\uparrow$ pH
  - increase cell membrane permeability $\rightarrow$ protein shifts $\rightarrow$ loss of membrane potential, mitochondrial rupture
Neurochemical Effects

[Graph showing changes in calcium concentration ([Ca^{2+}]_i) with normal and hyperventilation.

Ou-Yang (1994) Brain Res
Ventilation Patterns

- Good
- Too Fast
- Too Long
- Too Much

or

Graphs illustrating different ventilation patterns.
Hyperventilation

Figure. Mechanisms of secondary injury induced during hyperventilation. ETI, Intubation; O₂, oxygen; Hb, hemoglobin; CNS, central nervous system; JVP, jugular venous pressure.
Summary

- Use ETCO2 to confirm tube position and guide ventilation when possible.
  - Most useful in isolated TBI (torso trauma, correlation of ETCO2 and PaCO2 poor).
  - If ETCO2 not functioning or suspect, ventilate at 6-12 breaths/min. Lower perfusion states require less ventilation.
  - Consider use of mechanical ventilators to control rate and tidal volume.
ETCO2 and TBI: SD Trauma Registry

Arrival pCO2 (mmHg)

Pre-EtCO2  Transition  Post-EtCO2


83.3%  80.6%  78.5%

24  26  28  30  32  34  36  38  40  42  44
Are We as Good as We Think?
Intubation Skills

“Skill” (“Proficiency”)

Baseline Training

Regular Application
Prehospital Intubation Success Rates – Meta Analysis

- Hubble et al. PEC 2010
- Meta analysis of >100 studies
- Intubation Success Rates
  - Pooled: 86.3%
  - Cardiac arrest: 91.2%
  - RSI: 96.1%
Cardiac Arrest Intubation Success: NEMSIS 2008

Wang, et al. Resuscitation 2010
How Many Tubes Do You Need to Graduate in the US?

- EM Residents: 35
- Anesthesia Residents: 20-57
- CRNA Students: 200
- Paramedic Students: 5
Number of Tubes Per Paramedic Pennsylvania 2003

- Median ETI: 1 (IQR 0-3)
- 39% performed no ETI
- 67% performed 2 or fewer ETI

Why do we still intubate?
Can we improve success rates? Are there any other options for ventilation in trauma?
Laryngoscope View
“Grades”
Direct Laryngoscopy (DL)

- Requires Line of Sight
  - between your eyes and the vocal cords
Video Laryngoscopy (VL)

- Camera along a laryngoscope blade
- Transmits airway image to a monitor
- No need for line of sight
- Video magnifies the view
VL Helps You “See” better

- Glidescope: Meta-analysis - 17 trials, 2000 patients

- Likelihood of Grade 1 View with VL:
  - “Normal” Airways: 1.47 X better than DL
  - “Difficult” Airways: 3.52 X
  - All Airways: 1.97 X

All spinal immobilized patients are difficult airways
1\textsuperscript{st} Pass Success
Difficult Airways

- 2,400 ED Intubations

<table>
<thead>
<tr>
<th># of DACs</th>
<th>DL (n=1048)</th>
<th>VL (n=1375)</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>82.0%</td>
<td>90.8%</td>
</tr>
<tr>
<td>1</td>
<td>69.4%</td>
<td>85.1%</td>
</tr>
<tr>
<td>2</td>
<td>65.8%</td>
<td>80.5%</td>
</tr>
<tr>
<td>&gt;=3</td>
<td>54.1%</td>
<td>68.9%</td>
</tr>
</tbody>
</table>

Sakles, Intern Emerg Med 2014
Why is 1\textsuperscript{st} pass success important?

Complications ↑ as attempts ↑

Sakles et al. Acad Emerg Med 2013
There is an Alternative...
Supraglottic Airway Devices

- Easy to learn
- Lower training burden
- Easy to insert in any position
- Ventilate as well as ET tubes
- Improvement with each generation
Take-Home Messages

• Do not stop intubating

• Airway and ventilation management is complex
  • Maximize airway training opportunities
  • Airway and Ventilation QI is mandatory and should be outcomes based
  • Use EtCO2

• Embrace new approaches
Questions?