Practical Emergency Airway Management: An Algorithm for Patient Safety

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ACCME CME disclosure: Dr. Levitan is a principal in Airway Cam Technologies, Inc., Wayne PA, that makes and sells airway education products and distributes airway equipment. He is, or has been, a consultant for Clarus Medical, AMBU, GE Vital Signs, King Systems, and AirTraq, and receives royalties on the Clarus Levitan FPS stylet.
Elective Anesthesia

The concept of prediction comes from the OR...

Need for immediate airway

RISKS ASSOCIATED WITH FAILURE
The limitations of difficult airway prediction are increasingly recognized within anesthesia


“we believe that attempts at prediction are much less important than knowing what to do when difficulty is encountered...the clinical value of these bedside screening tests for predicting difficult intubation remains limited.”
Emergency Airways

Where we practice…

Need for immediate airway

Feasibility of airway assessment

Feasibility of awake techniques

Low

High

Low

High
Acceptable risks of airway approach changes in the same patient depending upon situational assessment.

- Elective
- Predicted difficulty of intubation?
- Awake with sedation
- Standard induction
- RSI

- Necessary
- Urgent
- ER slow
- NOW!
Failed laryngoscopy occurs, rarely... but prediction works poorly—especially in emergency settings

Routinely choosing an awake technique based upon this potential risk will NOT improve patient safety in emergency airways.

What is the simultaneous risk of failed intubation

AND failed mask / SGA ventilation – balanced against risks of awake technique, delayed airway and patient control?
In elective situations it's OK to “not burn your bridge”

In TRUE emergencies... your bridge is already burning!
Muscle relaxants make laryngoscopy and ventilation easier, but are inherently RISKY...

and not compatible with life if neither intubation nor ventilation occurs rapidly...

Safety in RSI and emergency airway management is about managing this inherent risk
What sky diving can teach us about safety in RSI


1. Redundancy of safety
2. Methodical deployment of primary chute
3. Fast, simple, easy to use back-up chute
4. Attention to monitoring
5. Equipment vigilance
Mask ventilation is at the heart of patient safety

- Critical before RSI in many cases to optimize ventilation and pre-oxygenation
- Critical awaiting muscle relaxation (after meds given)
- **YES…bag before laryngoscopy…start DL with the patient well ventilated…maximize safe apneic period**
- Critical between repeat laryngoscopy
- Critical if laryngoscopy fails
  - Very rarely fails with correct technique (~0.035%)
Difficult face mask ventilation?

- **OBSE** (acronym)
- **Beards**
  - Vaseline / Opsite
- **Elderly**
- **Sleep apnea**
- **Edentulous**
- **Distorted midface and mandible anatomy**
- **Neck radiation**
- **Secretions, vomitus, bleeding, etc.**
Prediction and Outcomes of Impossible Mask Ventilation

- 4 years, 53,000+ anesthetic cases
- 77 cases of impossible mask ventilation, 0.15%
- 2.2% "difficult ventilation" - 2 person, inadequate
- Neck radiation (odds ratio 7.1) highest risk
- Male sex (3.3), Sleep apnea (2.4)
- Mallampati 3-4 (2.0), Beard (1.9)
- 19 of 77 (25%) cases also had "difficult intubation"
- Highest risk: 3 or > risk factors; 1 surgical airway
Elevate the head until the ear is at the sternal notch

Universal intubating and ventilation position Independent of age and size
Mask ventilation

Slow squeeze: 1-2 seconds
Small squeeze: 6-7 cc/kg
Easy squeeze

Coordinate to create patent airway, not to forcefully push air in

JAWS: Jaw thrust, Airways, Work together, Slow/Small
Jaw & submandibular lift more important than AO extension!

Courtesy of George Kovacs, MD Dalhousie NS Emergency Medicine
Difficult face mask ventilation?

Bypassing the need for a face seal

- Supraglottic airways
- (LMA + imitators)
- Combitube
- King LT
A Simple Algorithm for emergency airway management we must know COLD

#1. Cardiac Arrest?
#2. Oral route impossible?
#3. Laryngo-tracheal pathology
#4. Difficult Laryngoscopy

Can you intubate? Can you ventilate?
• DO NOT HYPERVENTILATE!
• Especially bad in cardiac arrest, COPD, asthma
• Estimate minute ventilation prior to intubation and approximate same volume, watching peak pressures, BP, oxygenation--HCO3 drip to deal with acidosis
• Deleganis AV, AJR 2000; 174: 1339–1340

pre-intubation  MV 9L – hypotension  MV 6L
Apply 100% oxygen. Mask ventilate as needed...

1. Cardiac arrest or near arrest?
2. Is the oral route impossible?
3. Is there intrinsic laryngo-tracheal pathology?
4. The four D’s of difficult laryngoscopy?

- **Contra-indication:** Oral route impossible

Rapid Sequence Intubation

**Optimal Laryngoscopy**
Pre-planned strategy for first pass success

Mask Ventilation
Rescue Ventilation
LMA / Intubating LMA / Combitube

Rescue Intubation
Alternative Device / Intubating LMA / Surgical Airway

Step 2
Contra-indication:
Oral route impossible

Can you intubate?
Can you ventilate?

Redundancy of safety does NOT exist
Oral pathology.... Can you intubate? Can you ventilate?

Step 3
Contra-indication: Laryngo-tracheal pathology

Can you intubate?
Can you ventilate?
Redundancy of safety does NOT exist
Epiglottitis

Can you intubate?

Can you ventilate?

Pediatric photographs provided by Scott Cook-Sather, MD, Children’s Hospital of Philadelphia
Laryngo-tracheal pathology

Is it safe to come from above?

Laryngeal fracture cases


Can you intubate? Can you ventilate?
Laryngo-tracheal pathology?
Is it safe to come from above?

Can you intubate?  Can you ventilate?
Can you intubate?

Can you ventilate?

Courtesy Bryan Cotton, MD
Step 4
Weigh risks... & odds of success...
Do you have a good awake alternative?

Intubation may be “difficult”
Can you ventilate?
How emergent?
the surgically inevitable airway
Submental gunshot
420 Pounds, combative severe dyspnea, diaphoresis

pulse ox 50%, ripping off mask, pH 6.9, bradycardic
PROBLEMS without muscle relaxation in emergency airways (intact gag)

1) Non-optimal laryngoscopy
   fighting, biting, gagging, vomiting, longer process

2) Non-optimal mask ventilation
   problems timing inhalation, can’t use oral airway

3) Can’t insert rescue ventilation devices
   intact gag prevents supraglottic airway use (LMA, etc.)

4) Non-optimal rescue intubation via oral route
   intact gag impairs device and tube insertion
Airway risk assessment in emergencies

- Spontaneous ventilation
  - is ventilation adequate?
- Intact gag response
  - risk of vomiting

- Optimal laryngoscopy
- Optimal mask ventilation
- Rescue ventilation-LMA, King LT
- Rescue intubation technique

- Intact tone

Risk failed DL plus failed mask ventilation: 3 to 5 in 10,000; LMA works in 95% of failed mask cases!

* risks of failed laryngoscopy (<0.4%) + mask failure (<0.035%)
Apply 100% oxygen. Mask ventilate as needed...

1. Cardiac arrest or near arrest?
2. Is the oral route impossible?
3. Is there intrinsic laryngo-tracheal pathology?
4. The four D’s of difficult laryngoscopy?

A. Laryngoscopy
B. Combitube
C. Laryngeal Mask
D. Mask Ventilation

RAPID SEQUENCE INTUBATION

OPTIMAL LARYNGOSCOPY
Pre-planned strategy for first pass success

MASK VENTILATION
RESCUE VENTILATION
LMA / Intubating LMA / Combitube

RESCUE INTUBATION
Alternative Device / Intubating LMA / Surgical Airway

skill set? ease of use? speed? vs. DL?
With pulse ox saturation in 90's, how close are you to the edge?

Small changes in SaO2 can correlate with major changes in PaO2
Case Example:
EtOH intoxication, level 560! Video Laryngoscopy

- Flat positioning, no O2, sonorous respiration - 70%
- Flat positioning, no O2, nasal trumpet - 70%
- Flat positioning, face mask, nasal trumpet - 73%
- Head up, trumpet, face mask 15 lpm, NC 15 lpm - 90%
- Head up, trumpet, bag mask, NC 15 lpm - 94%
- Head up, trumpet, apnea during VL*, NC 15 lpm - 98%

*Video laryngoscopy with Glidescope x 4
(two operators, lots of secretions)
How apneic diffusion oxygenation works

- Pre-oxygenation with 100% O2 followed by O2 insufflation

- During the apnoeic period, O2 is extracted from the FRC into the blood at a rate of 250 ml/min to maintain metabolic O2 consumption.

  - Due to greater solubility of CO2 in blood, CO2 only added to the alveolar space at a rate of 10 ml/min

  - Net gas flow from the alveoli to the blood at about 240 ml/min

  - Hence, a subatmospheric pressure is established in the alveoli, and the ambient oxygen is drawn ‘en masse’ into the lungs and maintains oxygenation.

How apneic diffusion oxygenation works

- CO2 has 25 times the solubility of O2 in blood (leaks out slowly)
- With apnea CO2 excretion declines; O2 absorption minimal decrease
- O2 absorption continues in apnea, due to partial pressure gradient, 300 million alveoli, 70 sq meters of absorption area

*** Apnea: smaller transfer of CO2 to blood than O2 to blood ***
Creating sub-atmospheric alveolar pressure (-240 ml/min)
The net effect: O2 is PULLED down the airway!

O2 movement
250 ml per min
Oxygen Reservoir
in Lungs (~95%)

CO2 movement
10 ml per min
CO2 Reservoir
in blood and tissues (~90%)
**Pharyngeal Insufflation of Oxygen Prevents Arterial Desaturation During Apnea**


- n=20, nasal airway s/p induction (36 Fr)
- 8 Fr Catheter inserted just beyond nasal trumpet, 3 liters per minute
- Sux, sedation, apnea until pulse ox 92% or, 10 minutes had elapsed
- Each patient served as their own control (with and w/o 3 lpm)

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**TABLE 1. Duration of Apnea (i.e., Time from Cessation of Ventilation Until Either (1) SaO₂ fell to 92%, or (2) 10 Min had Elapsed) and Minimum Observed SaO₂ With and Without Pharyngeal Oxygen Insufflation. Values are Means ± SE**

<table>
<thead>
<tr>
<th></th>
<th>O₂ Insufflation</th>
<th>No O₂ Insufflation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First trial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of apnea (min)</td>
<td>10.0 ± 0</td>
<td>7.1 ± 0.6*</td>
</tr>
<tr>
<td>Minimum SaO₂ (%)</td>
<td>98 ± 1</td>
<td>92 ± 1*</td>
</tr>
<tr>
<td>Pre-apnea SaO₂ (%)</td>
<td>99 ± 1</td>
<td>99 ± 1</td>
</tr>
<tr>
<td>Pre-apnea Fₑ₇O₂ (%)</td>
<td>87 ± 1</td>
<td>88 ± 2</td>
</tr>
<tr>
<td>Pre-apnea Pₑ₇CO₂ (mmHg)</td>
<td>26 ± 2</td>
<td>22 ± 2</td>
</tr>
<tr>
<td>N</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Second trial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of apnea (min)</td>
<td>10.0 ± 0</td>
<td>6.6 ± 0.9*</td>
</tr>
<tr>
<td>Minimum SaO₂ (%)</td>
<td>99 ± 1</td>
<td>91 ± 1*</td>
</tr>
<tr>
<td>Pre-apnea SaO₂ (%)</td>
<td>99 ± 1</td>
<td>99 ± 1</td>
</tr>
<tr>
<td>Pre-apnea Fₑ₇O₂ (%)</td>
<td>90 ± 1</td>
<td>92 ± 1</td>
</tr>
<tr>
<td>Pre-apnea Pₑ₇CO₂ (mmHg)</td>
<td>27 ± 1</td>
<td>28 ± 2</td>
</tr>
<tr>
<td>N</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of apnea (min)</td>
<td>10.0 ± 0</td>
<td>6.8 ± 0.6†</td>
</tr>
<tr>
<td>Minimum SaO₂ (%)</td>
<td>98 ± 1</td>
<td>91 ± 1†</td>
</tr>
<tr>
<td>Pre-apnea SaO₂ (%)</td>
<td>99 ± 1</td>
<td>99 ± 1</td>
</tr>
<tr>
<td>Pre-apnea Fₑ₇O₂ (%)</td>
<td>88 ± 1</td>
<td>90 ± 1</td>
</tr>
<tr>
<td>Pre-apnea Pₑ₇CO₂ (mmHg)</td>
<td>27 ± 1</td>
<td>25 ± 1</td>
</tr>
<tr>
<td>N</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

* P < 0.01 compared with oxygen insufflation (same trial).
† P < 0.001 compared with oxygen insufflation.
Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of nasal oxygen administration.  


- n = 30, BMI ~31       – 5 lpm via NC, 25 degree head up  
- 8 deep breaths pre-oxygenation

<table>
<thead>
<tr>
<th></th>
<th>Onas (n=15)</th>
<th>NOnas (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-induction ETO2</td>
<td>(mmHg) 88.3 (1.9)</td>
<td>88.7 (2.6)</td>
</tr>
<tr>
<td>Pre-induction FIO2</td>
<td>(%) 97.4 (1.7)</td>
<td>97.6 (1.9)</td>
</tr>
<tr>
<td>Initial ETCO2</td>
<td>45.3 (4.6)</td>
<td>43.8 (3.9)</td>
</tr>
<tr>
<td>Lowest SpO2 (%)</td>
<td>94.3 (4.4)</td>
<td>87.7 (9.3)*</td>
</tr>
<tr>
<td>SpO2 ≥95% time</td>
<td>(min) 5.29 (1.02)</td>
<td>3.49 (1.33)*</td>
</tr>
<tr>
<td>Resaturation time (min)</td>
<td>0.69 (0.4)</td>
<td>1.57 (1.49)</td>
</tr>
</tbody>
</table>

Results means (SD). Onas=nasal O2 NOnas= no nasal O2, ETO2=end-tidal O2, FIO2=inspired O2 concentration, ETCO2=end-tidal CO2, SpO2=oxygen saturation as measured by pulse oximetry. Resaturation time=time to regain SpO2 100% after tracheal intubation.  

* Statistically significant difference.
Nasal oxygen flushes nasopharynx, eliminating exhaled gas via mouth, and increasing effective FiO2 for next breath.

Face mask: exhaled gas mixes with inspired oxygen.

Face mask only pushes exhaled gas up and down, lowering effective FiO2.
DELIVERY OF HIGH FIO2
John W. Earl RRT, BS. Abstracts Am Assoc Resp Care 2003

Flow rates 10, 15, 30, 45, 60 lpm comparing a non-rebreather mask (NRB) vs. simple face mask (SM) and simple mask with side ports taped. Healthy subjects, breaths 12-18 per minute, TV 300-500 Each test 5 minutes, nitrogen washout 3 minutes

Results: Expired PO2 measured in pharynx:
- 10 LM SM-51% NRB-50%
- 15 LM SM-51% NRB-56%
- 30 LM SM-55% NRB-77%
- 45 LM SM-73% NRB-78%
- 60 LM SM 86% NRB-89% SM taped-93%

"Current thinking that a NRB mask running at 15 L/m is an acceptable way to deliver high FIO2 is not valid and should be revised."
Ear-to-sternal notch > promotes upper airway patency
Positioning improves pulmonary function
Mask and NC combined flow approach appropriate needs 30 liters/minute
Emergency Tracheal Intubation: Complications Associated with Repeat Laryngoscopy


2833 patients, 1 hospital, 10 years
>2 attempts: 7x greater risk of cardiac arrest!

<table>
<thead>
<tr>
<th>Complication</th>
<th>2 or less attempts</th>
<th>&gt;2 attempts</th>
<th>Relative risk &gt;2 attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxemia</td>
<td>10.5%</td>
<td>70%</td>
<td>9X</td>
</tr>
<tr>
<td>Severe hypoxemia</td>
<td>1.9%</td>
<td>28%</td>
<td>14X</td>
</tr>
<tr>
<td>Esophageal intubation</td>
<td>4.8%</td>
<td>51.4%</td>
<td>6X</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>1.9%</td>
<td>22%</td>
<td>7X</td>
</tr>
<tr>
<td>Aspiration</td>
<td>0.8%</td>
<td>13%</td>
<td>4X</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>1.6%</td>
<td>18.5%</td>
<td>4X</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>0.7%</td>
<td>11%</td>
<td>7X</td>
</tr>
</tbody>
</table>
“Secrets” of Direct Laryngoscopy & Intubation

1. Reliable plan to find landmarks
   “seize the mid-line” > epiglottoscopy

2. Optimize laryngeal exposure
   tongue control
   bimanual laryngoscopy
   head elevation

3. Prevent tube passage problems
   straight-to-cuff < 35 degree bend
   come to target from below line of sight
   hang up? clockwise rotate, remove stylet
Epiglottoscopy...The difference between novices and experts?

Delson NJ, et. al. Anesth Analg 2002; 94; S-123

**Novices:**
- 109 cm tip travel
- 36 sec time
- 3.4 Nm torque
- 63 N max force

**Experts**
- 52 cm tip travel
- 12 sec time
- 2.8 Nm torque
- 66 N max force
Good tongue control counts!

- Improves visualization
- Very important for tube delivery

In practice...epiglottoscopy & tongue control happen together.
1. Epiglottis
2. Interarytenoid notch
3. Glottic opening
4. Vocal cords
Bimanual Laryngoscopy - By Laryngoscopist the most effective difficult airway tool

- External laryngeal manipulation by laryngoscopist: “Bimanual laryngoscopy”
  – Not B.U.R.P. (by an assistant)
  – NOT cricoid pressure (assistant, at cricoid ring)
- Manipulation most effective at thyroid cartilage – where vocal cords attach anteriorly
- Once view optimized by laryngoscopist, an assistant can maintain pressure at the right location if needed, freeing the operator’s right hand to place the tube
Bimanual laryngoscopy

1910

1856
Bimanual Laryngoscopy - By Laryngoscopist

1) Moves tip of blade fully into vallecula

2) Drops larynx into line of sight, improves alignment

Chevalier Jackson’s comparison of various neck and head positions for direct laryngoscopy (1910)

“Overextension of the patient’s neck is a frequent cause of difficulty. If the head is held high enough extension is not necessary, and the less the extension the less muscular tension there is in the anterior cervical muscles.”
Head Elevated Laryngoscopy Position

Laryngoscopy and Morbid Obesity: a Comparison of the “Sniff” and “Ramped” Positions

Jeremy S. Collins, MB, ChB¹; Harry J.M. Lemmens, MD, PhD¹; Jay B. Brodsky MD¹; John G. Brock-Utne, MD, PhD¹; Richard M. Levitan, MD²

Figure 1. In the operating-room, patients in Group 1 were placed supine and had a 7-cm headrest placed underneath their occiput.

Table 2. Comparison of views during laryngoscopy

<table>
<thead>
<tr>
<th>GRADED VIEW*</th>
<th>GROUP 1 (n)</th>
<th>GROUP 2 (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Laryngoscopy 100% success
View better with head elevation
Straight-to-cuff shape has narrower long-axis dimension & better maneuverability

Room to maneuver within hypopharynx;
Straight-to-cuff stylet shape initially inserted into mouth; positioned behind maxilla and below line of sight.

Slight tilting of proximal tube and stylet brings distal tip upward, keeping tip visible as it approaches target. Tube is ALWAYS below line of sight until inserted.
Use the right corner to insert and pivot tube

Place tube behind the maxilla. Advance to target from below the line of sight. Toggle tube up to the target, going above the posterior cartilages and notch.
Even after insertion, tube tip can catch on tracheal rings...

If resistance felt, turn tube CLOCKWISE (right turn)

Turning tube to right lowers leading edge allowing it to advance
Straight to cuff shape should not exceed 35 degrees


• 32 operators, 16 cadavers, 256 tube pass efforts
• STC shape – stylets bent at cuff – 25°, 35°, 45°, 60°
• Each stylet stopped behind Murphy eye (@2 cm from tip)
• Randomly assigned order, operators blinded to tube angle
• Impossible tube / stylet passage in:
  – 6 out of 256 at 25 degrees (2.3%)
  – 9 out of 256 at 35 degrees (3.5%)
  – 29 out of 256 at 45 degrees (11.3%)
  – 138 out of 256 at 60 degrees (53.9%)
• Tip catches on tracheal rings > withdraw stylet, rotate clockwise
dental gap
CONCLUSIONS

- Safety hinges on oxygenation throughout procedure
  [ Not just on plastic in trachea ]
- Positioning is easy, very important, under appreciated
- Pre-oxygenation hinges on patent airway, max FiO2
- Positive pressure ventilation during onset RSI
  [ low volume, low pressure, low rate, slow squeeze ]
- Passive oxygenation via nose during intubation effort
- ONE and DONE approach to intubation (DL, VL, etc)
- Redundancy throughout:
  i.e. at least 2 ways to intubate, 2 ways ventilate ready to deploy at head of bed