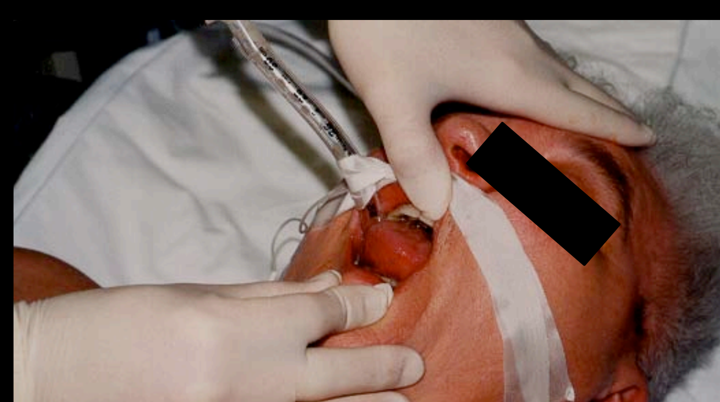
Practical Emergency Airway Management: An Algorithm for Patient Safety

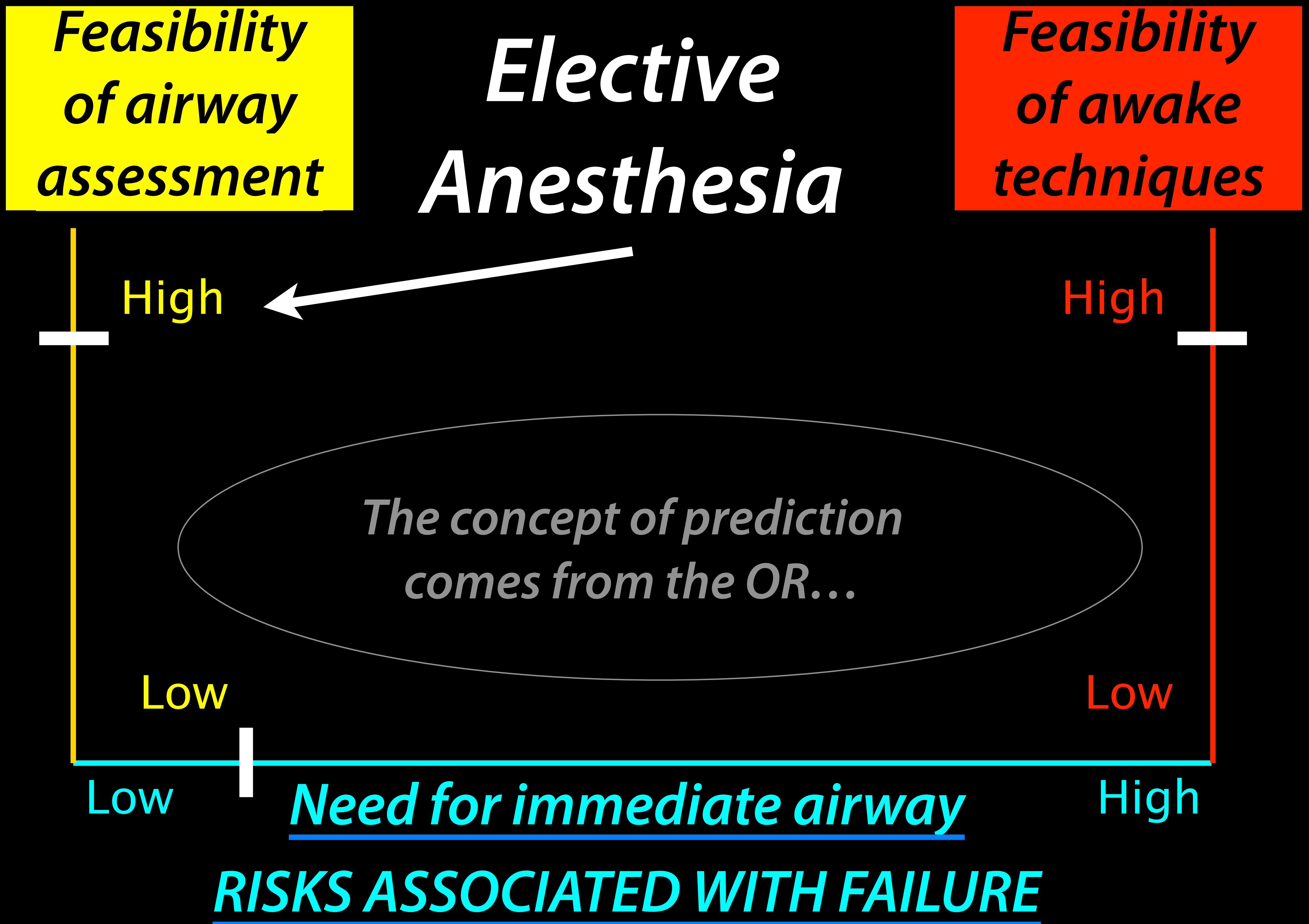
Richard M. Levitan, MD

Jefferson Medical College

Philadelphia PA



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.

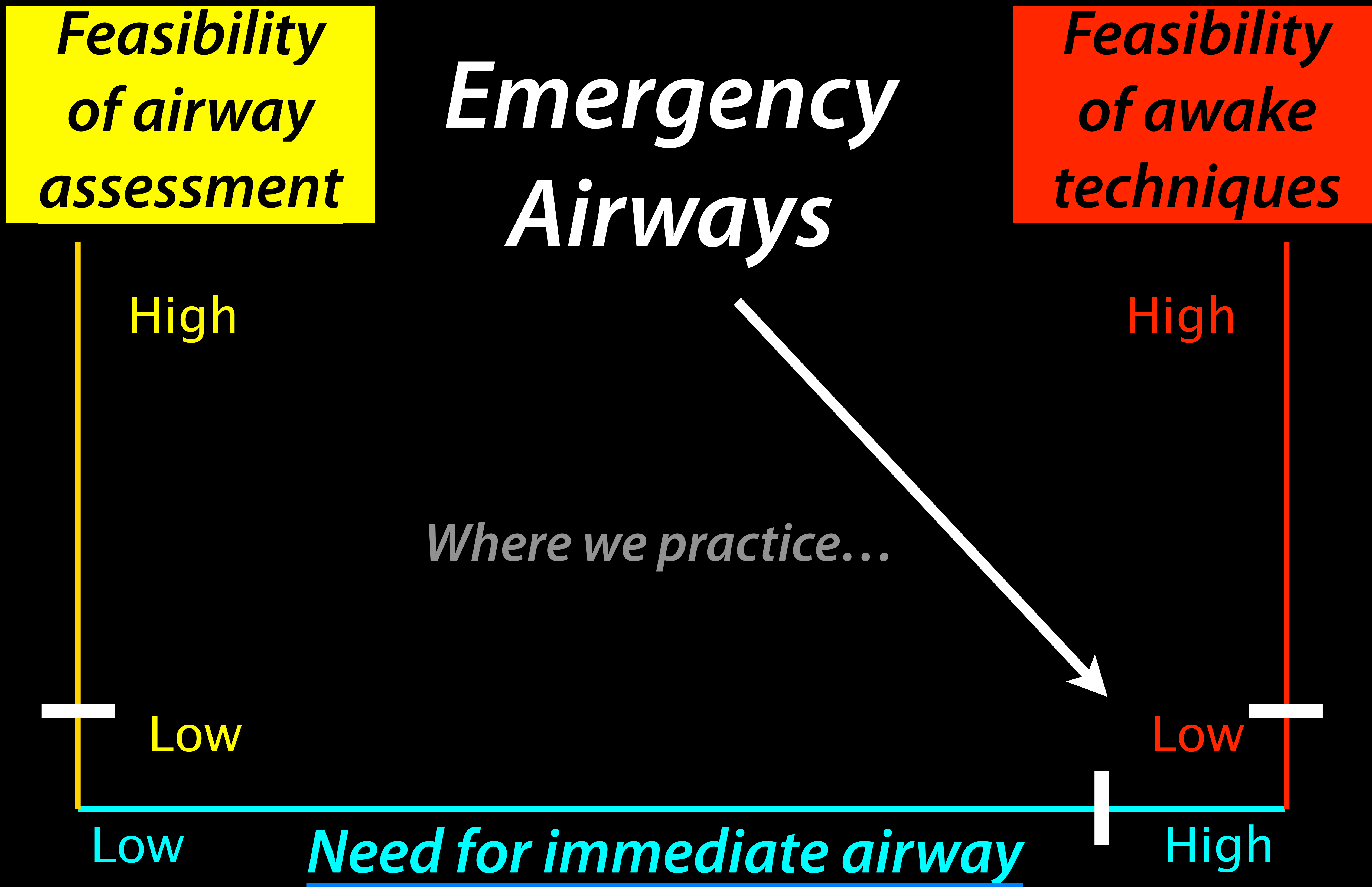

Feasibility of airway assessment
Elective Anesthesia
Feasibility of awake techniques
High
High
The concept of prediction comes from the OR…
Low
Low
Low
Need for immediate airway
High
RISKS ASSOCIATED WITH FAILURE

The limitations of difficult airway prediction are increasingly recognized within anesthesia

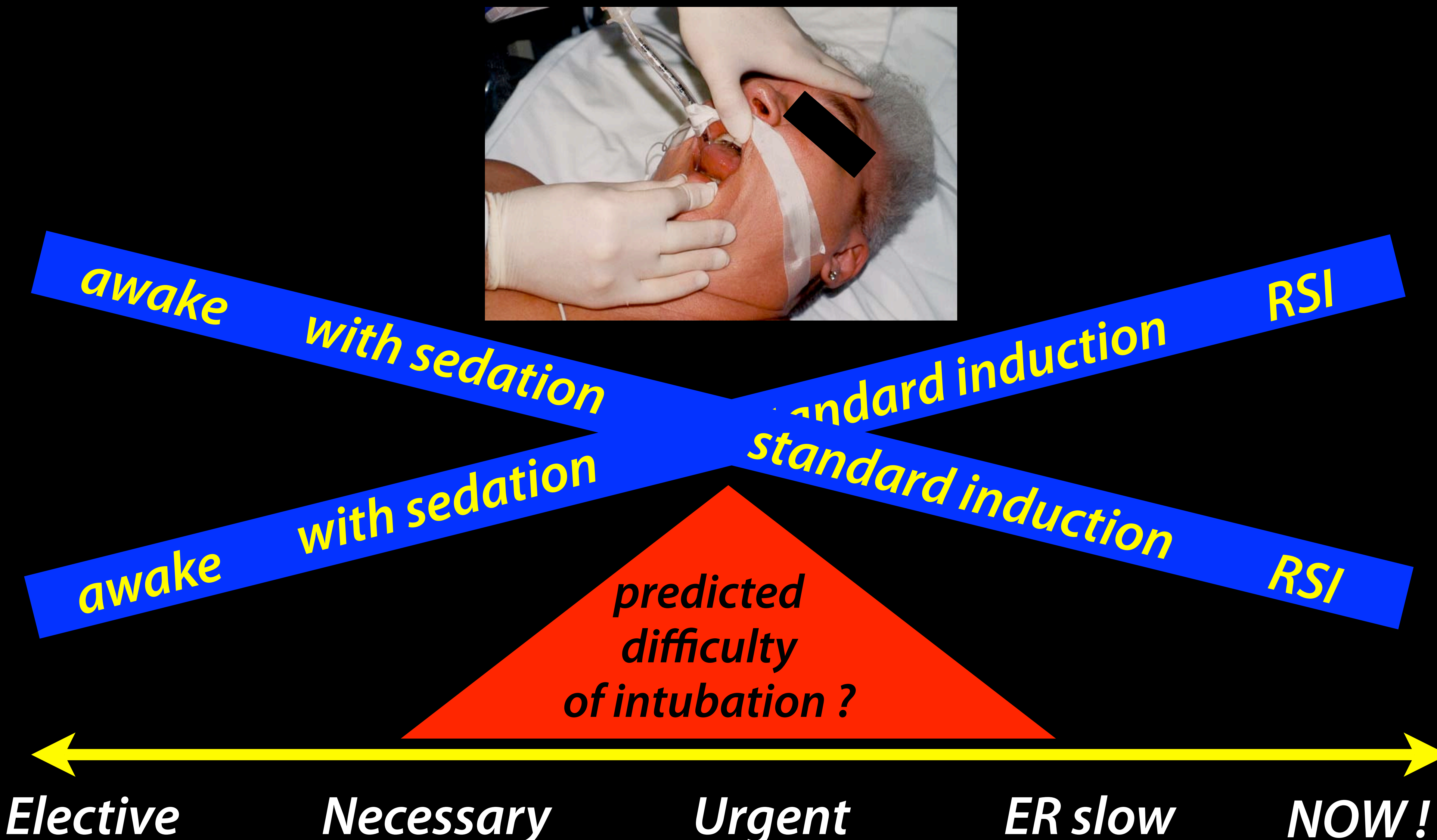
Predicting difficult intubation – worthwhile exercise or pointless ritual? Yentis SM. Anaesthesia 2002, 57: 105-9.

Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. Shiga T, et al. Anesth 2005, 103: 427-37.

"...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."


Feasibility of airway assessment
Emergency Airways
Feasibility of awake techniques
High
High
Where we practice…
Low
Low
Low
Need for immediate airway
High

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



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 <u>AND</u> failed mask / SGA ventilation – balanced against risks of awake technique, delayed airway and patient control?

In elective situations its 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

Levitan RM. Patient safety in emergency airway management and rapid sequence intubation: metaphorical lessons from skydiving. Ann Emerg Med. 2003; 42: 81-7.

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 <u>heart of patient safety</u>

- *Critical before RSI in many cases to optimize ventilation and pre-oxygenation*
- *Critical awaiting muscle relaxation (after meds given)*
- *<u>YES</u>…<u>bag before laryngoscopy</u>…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%)*

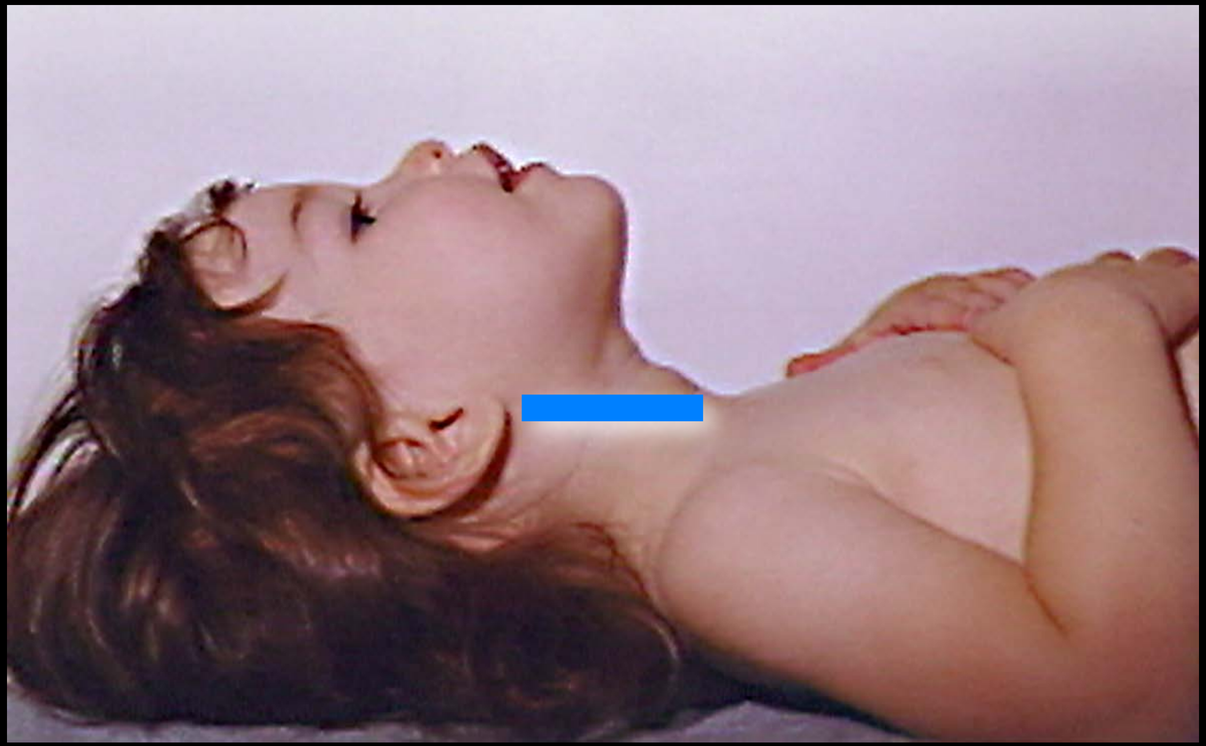
Difficult face mask ventilation?

- *O B E S E (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

Kheterpal, et al. Anesthesiology 2009; 110:891–7

- *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*



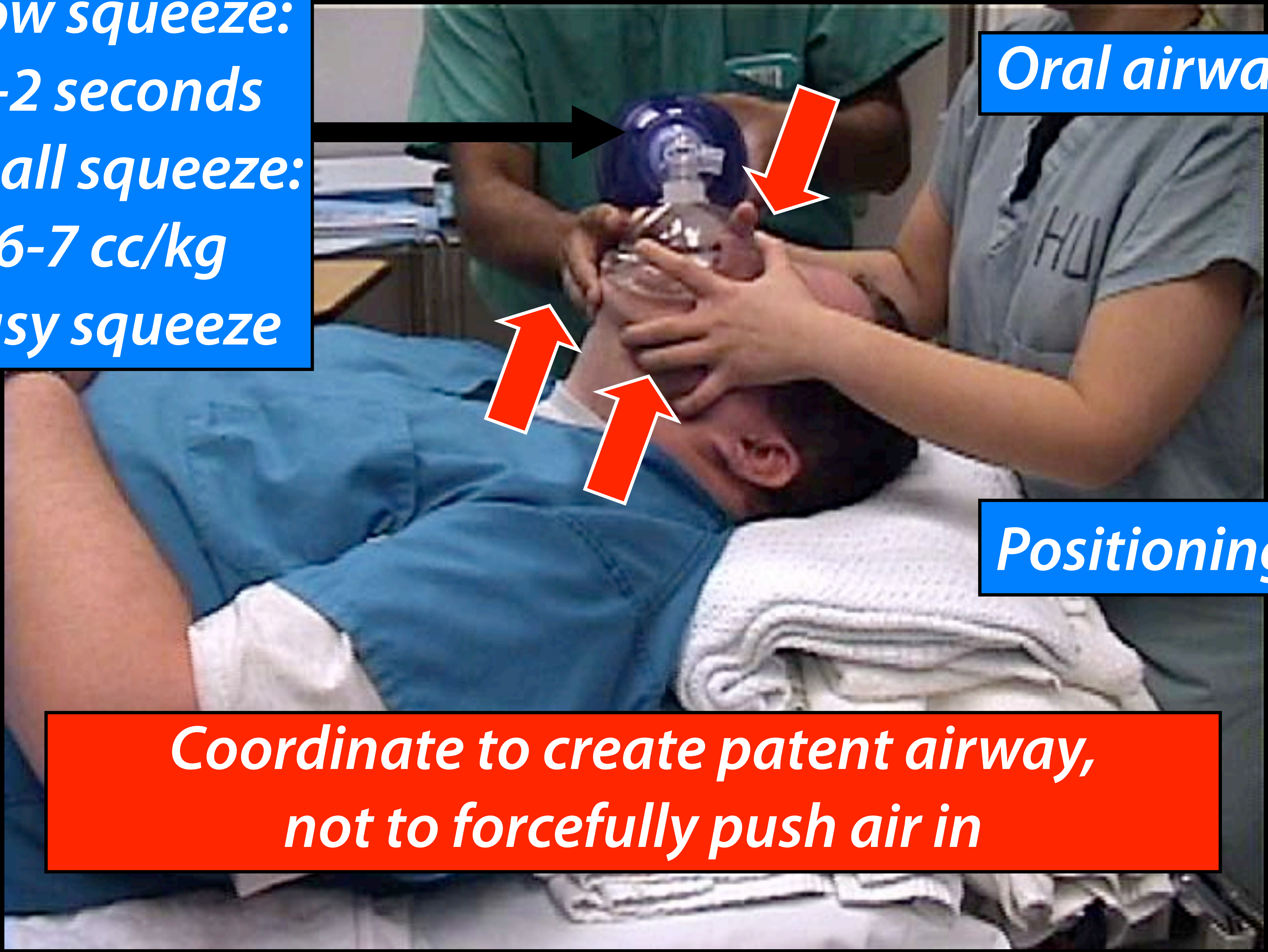
Elevate the head until the ear is at the sternal notch

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

Oral airway!



Positioning!

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

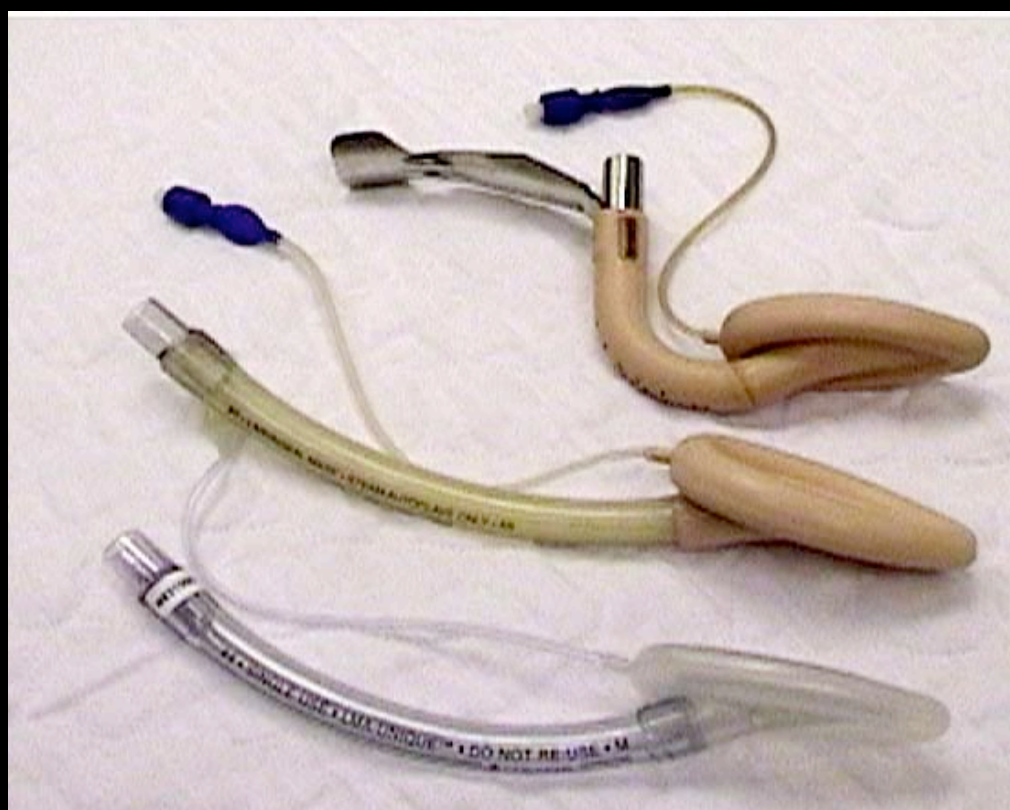
JAWS: Jaw thrust, Airways, Work together, Slow/Small

Jaw & submandibular lift more important than AO extension!

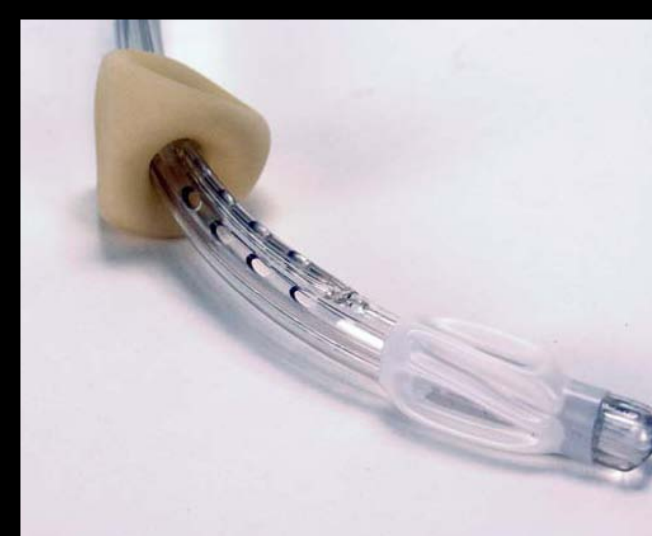
Courtesy of
George Kovacs, MD
Dalhousie NS
Emergency Medicine

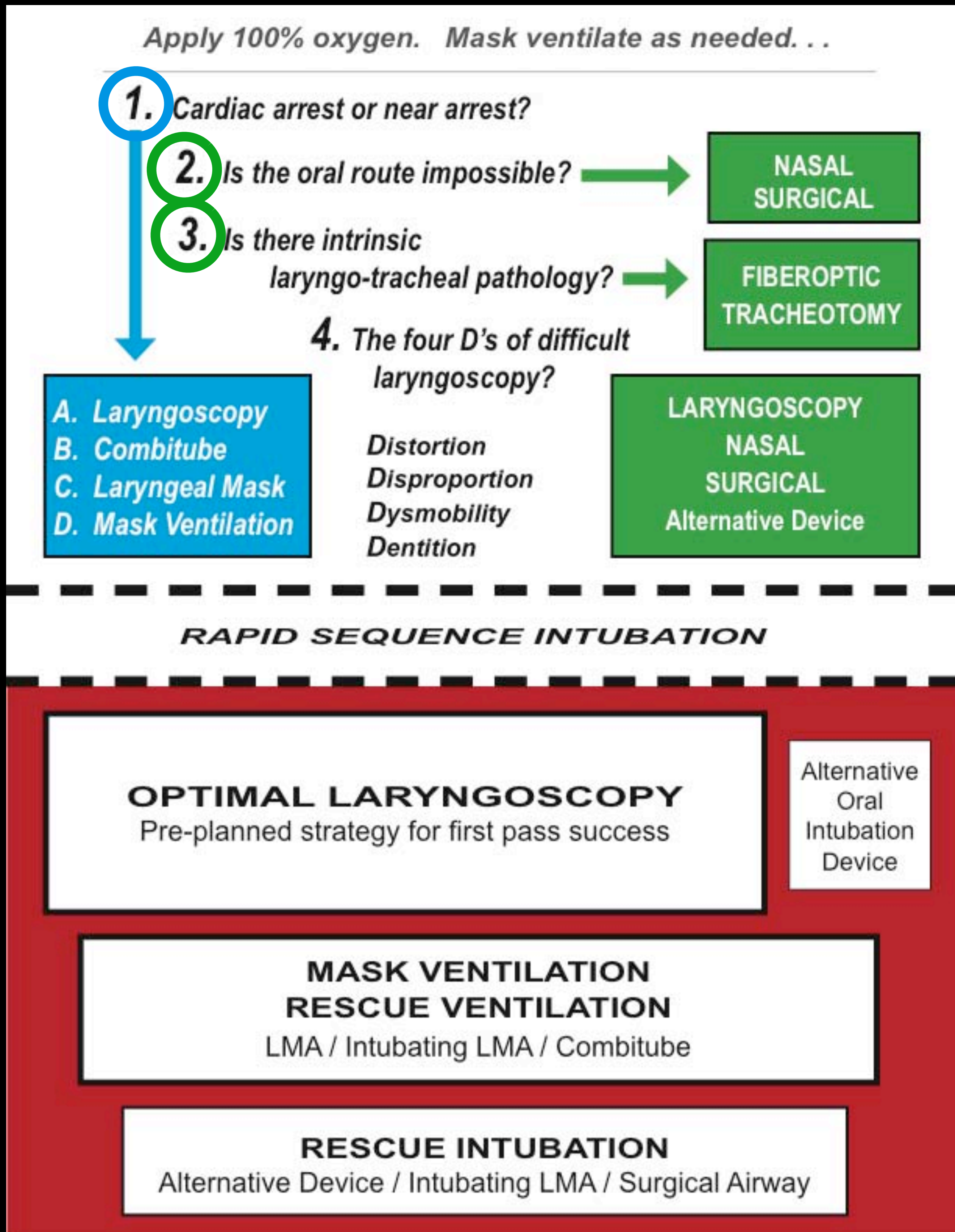
Difficult face mask ventilation?

Bypassing the need for a face seal



- *Supraglottic airways*
- *(LMA + imitators)*
- *Combitube*
- *King LT*





A Simple Algorithm for emergency airway management

we must know C O L D

#1. Cardiac Arrest?

#2: Oral route impossible?

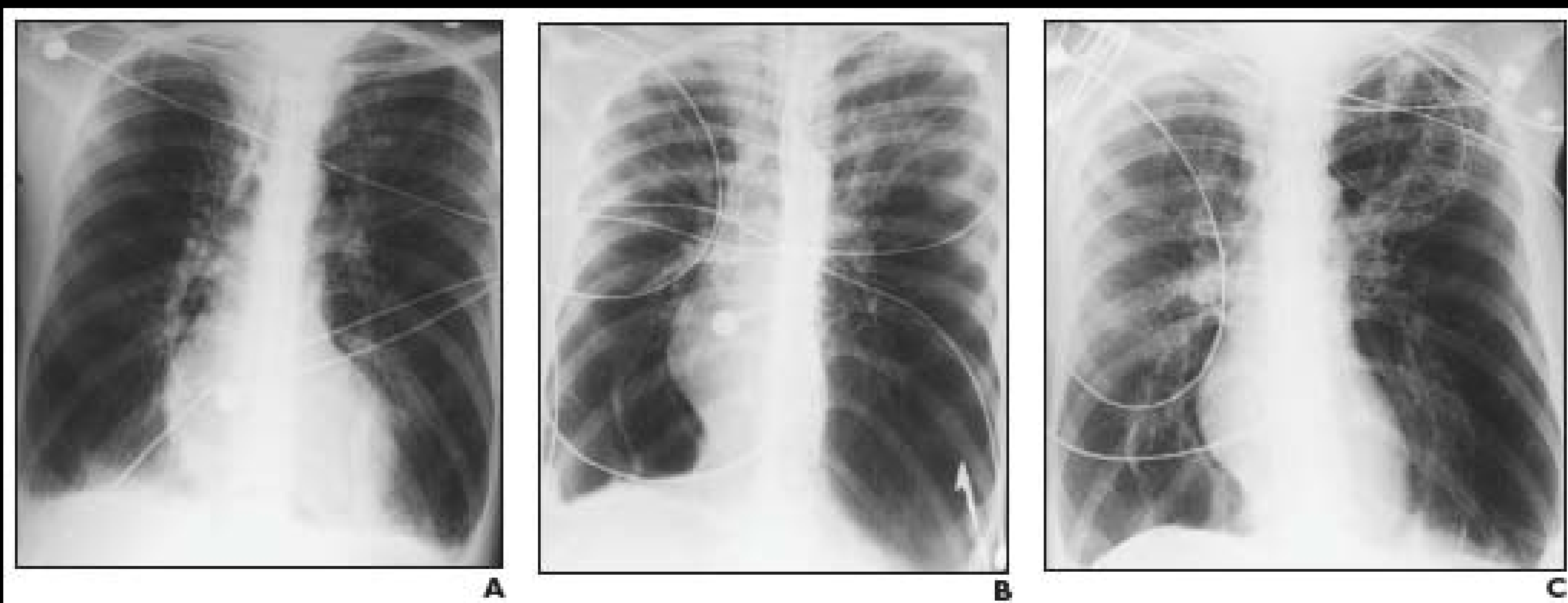
#3: Laryngo-tracheal pathology

#4: Difficult Laryngoscopy

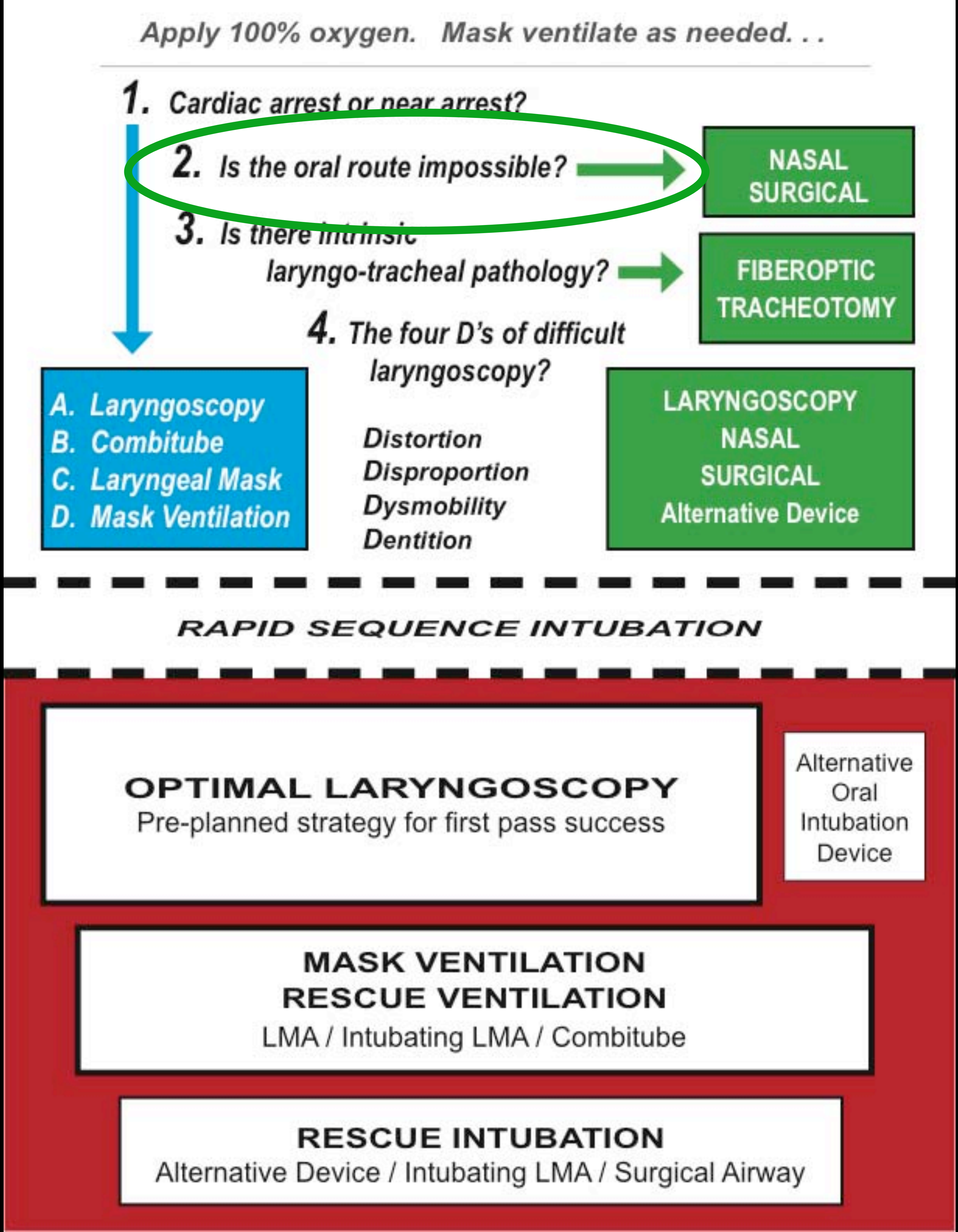
COLORED CIRCLES: RSI IS CONTRA-INDICATED

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*



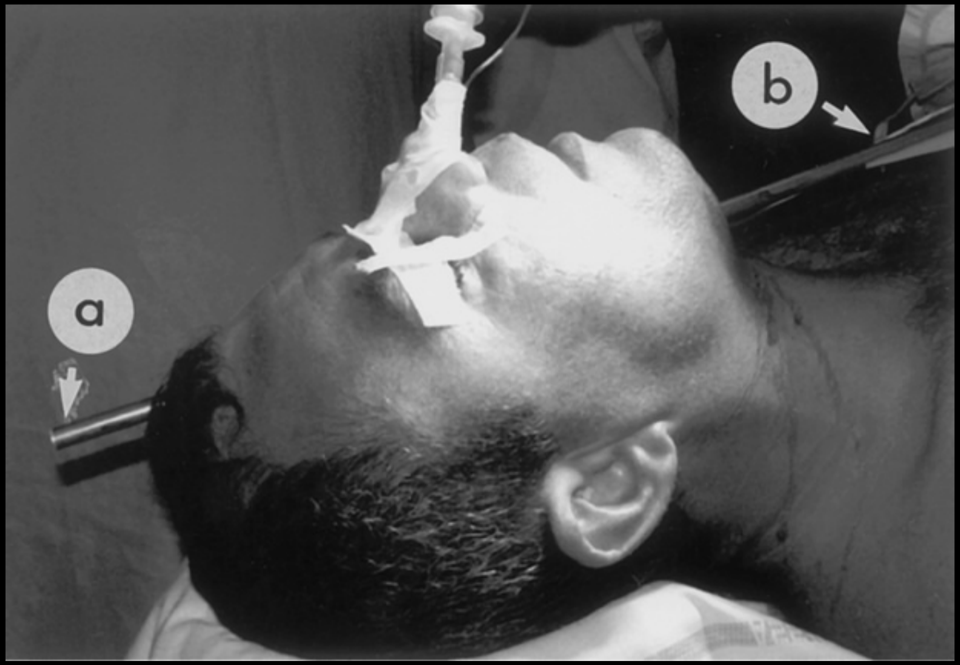
Step 2

Contra-indication: Oral route impossible

Can you intubate?

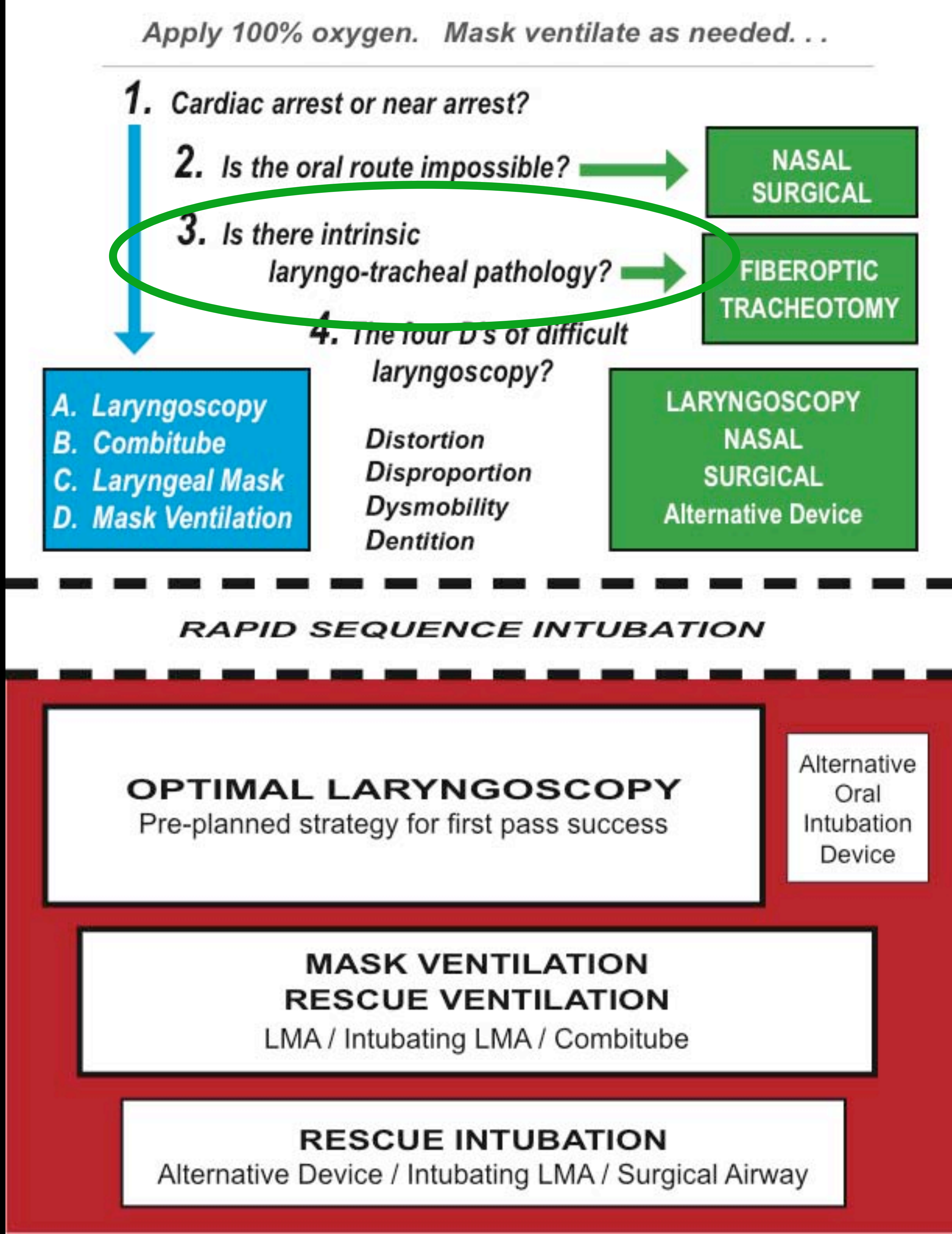
Can you ventilate?

Redundancy of safety does NOT exist



Joly LM. Anesth Analg. 2002; 94: 231-2.

Oral pathology.... Can you intubate? Can you ventilate?



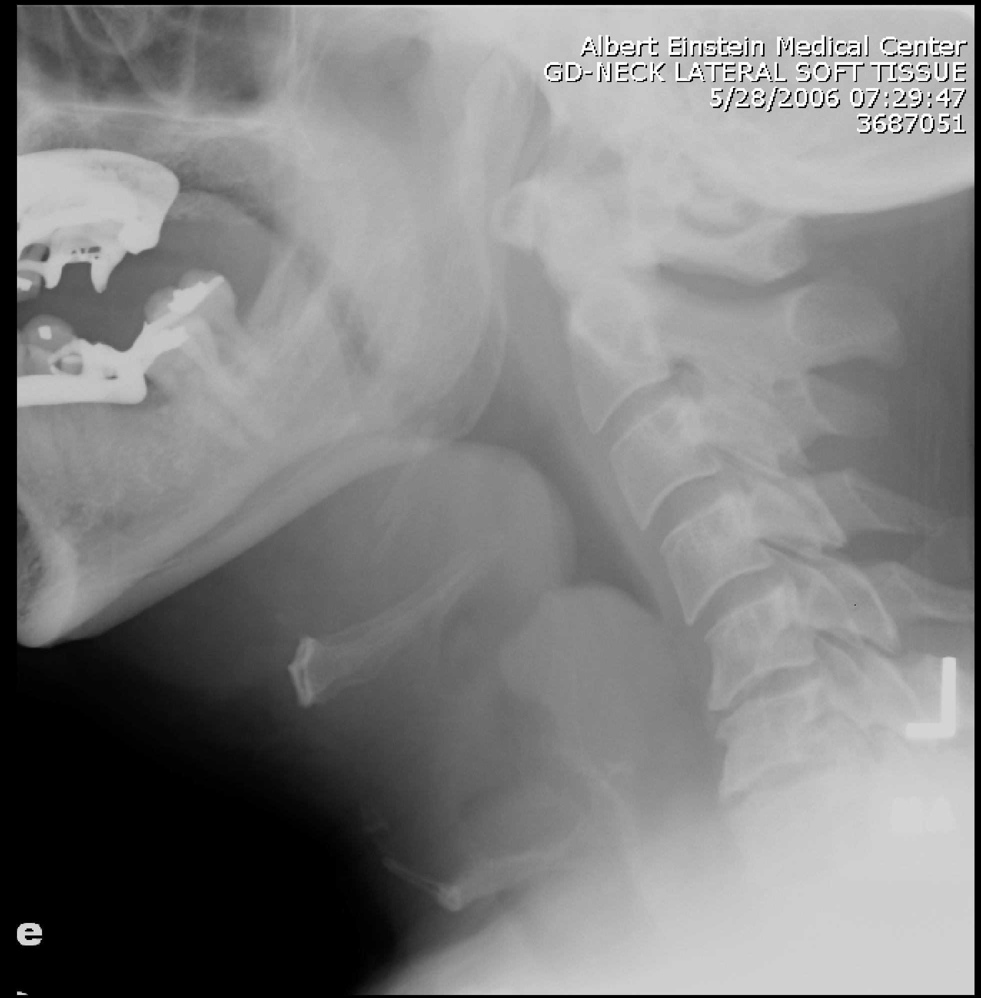
Step 3

Contra-indication: Laryngo-tracheal pathology

Can you intubate?

Can you ventilate?

Redundancy of safety does NOT exist

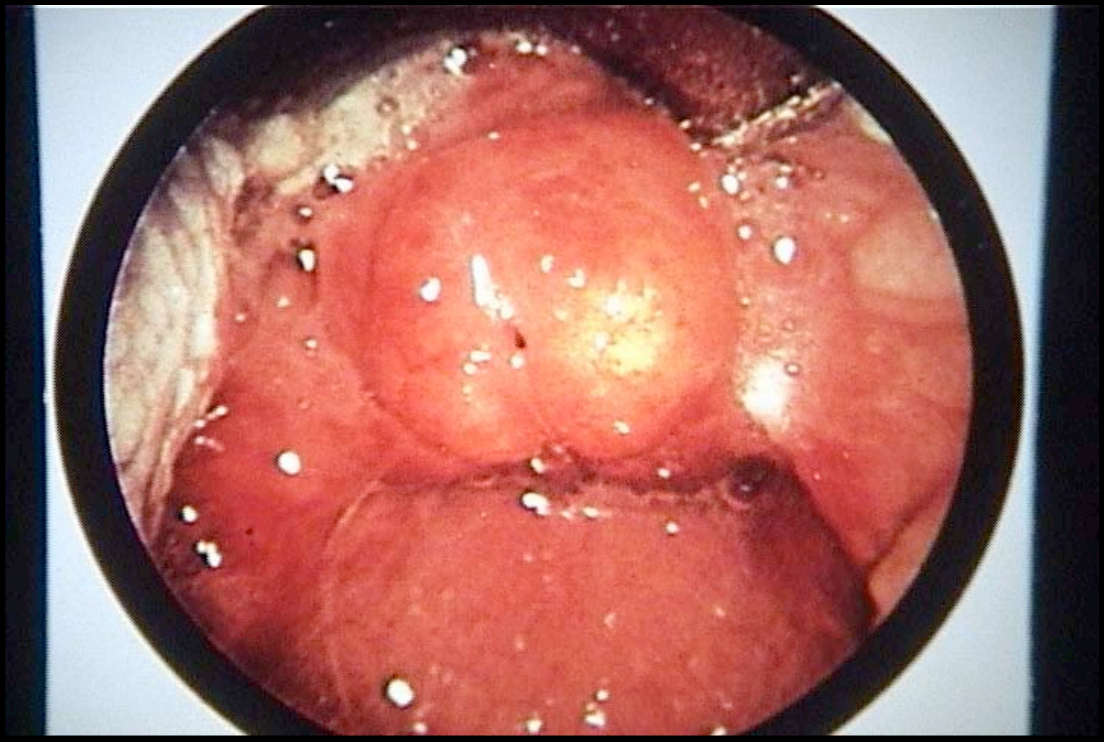


Epiglottitis

Can you intubate?

Can you ventilate?

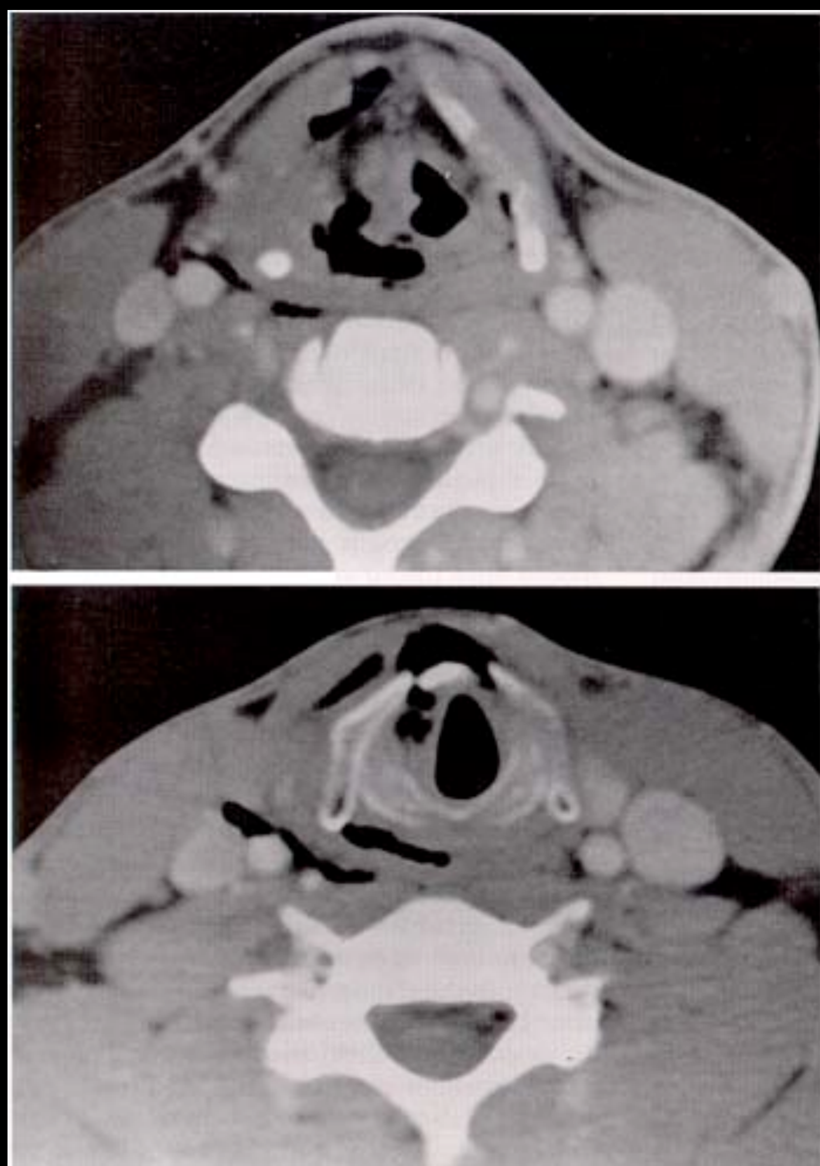
Pediatric photographs provided by Scott Cook-Sather, MD, Children's Hospital of Philadelphia

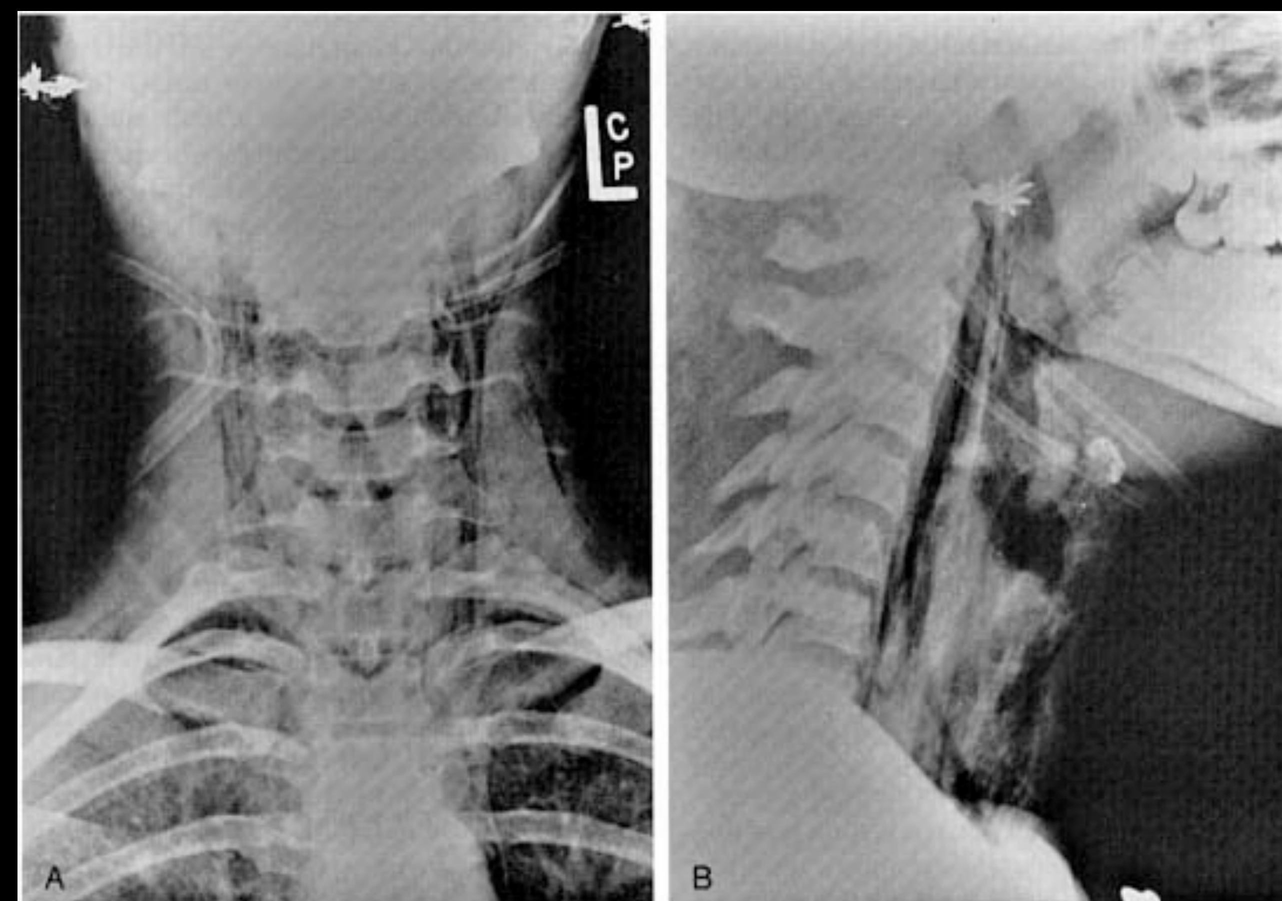


Laryngo-tracheal pathology

Is it safe to come from above?

Laryngeal fracture cases





Eisele and McQuone, Emergencies of Head and Neck, Mosby, 2000.

Can you intubate? Can you ventilate?

Laryngo-tracheal pathology?

Is it safe to come from above?

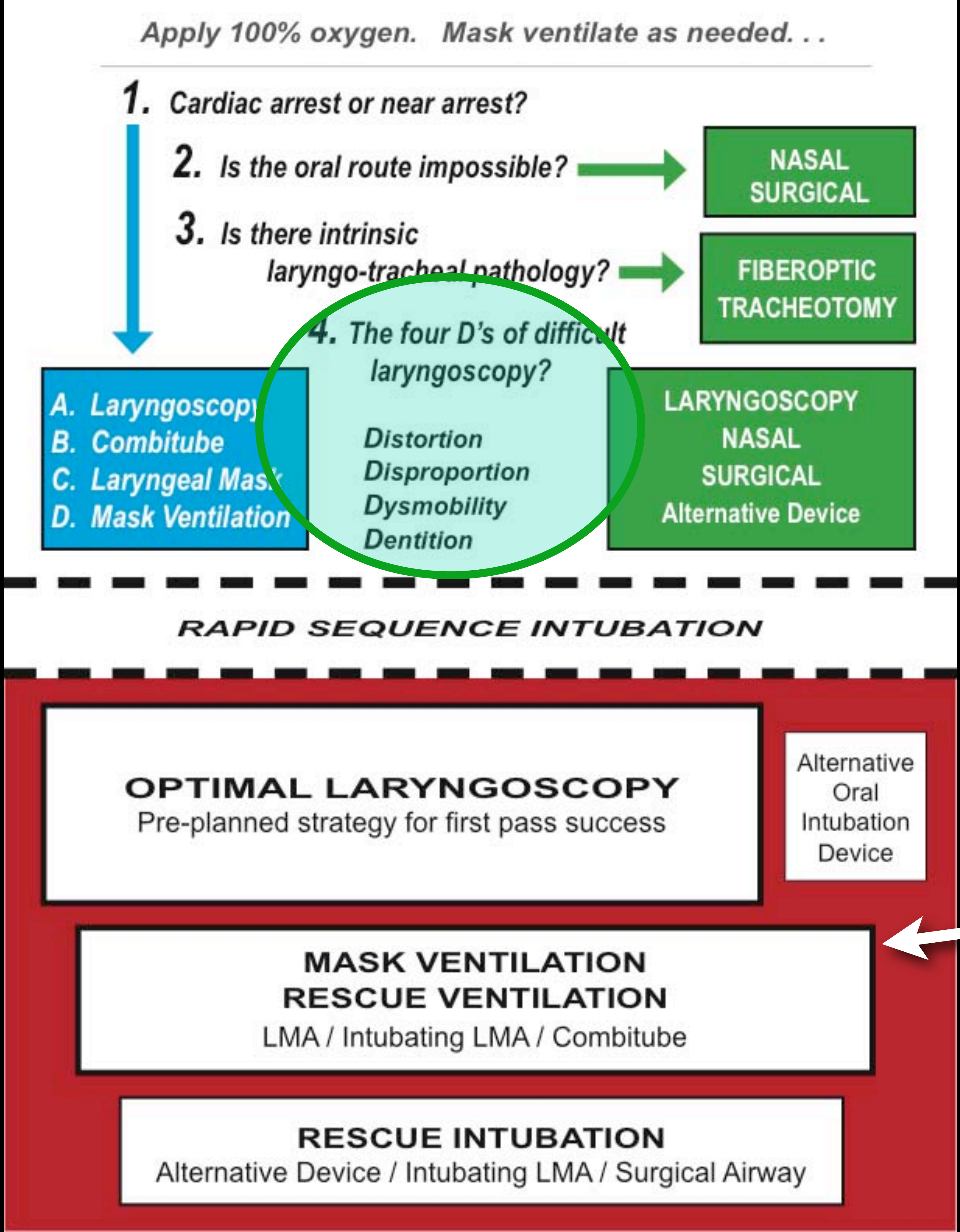
Can you intubate?   Can you ventilate?



Can you intubate?

Can you ventilate?

Courtesy Bryan Cotton, MD



Step 4

Weigh risks…

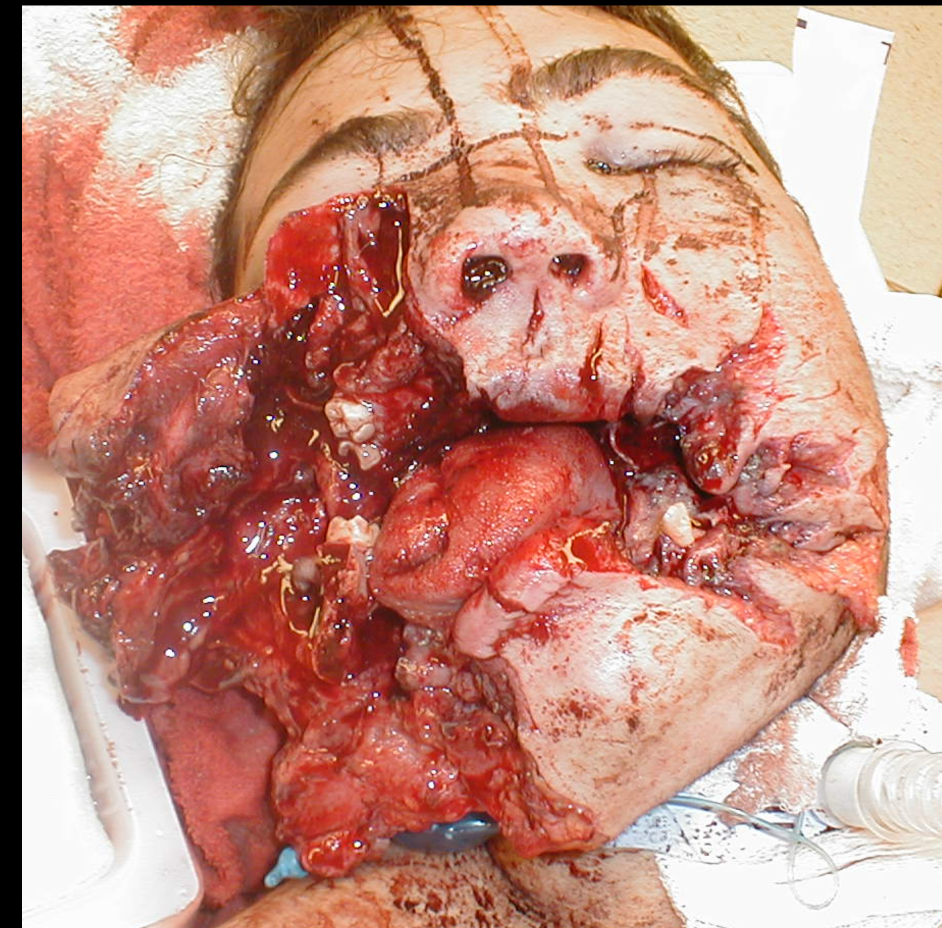
& odds of success…

Do you have a good awake alternative?

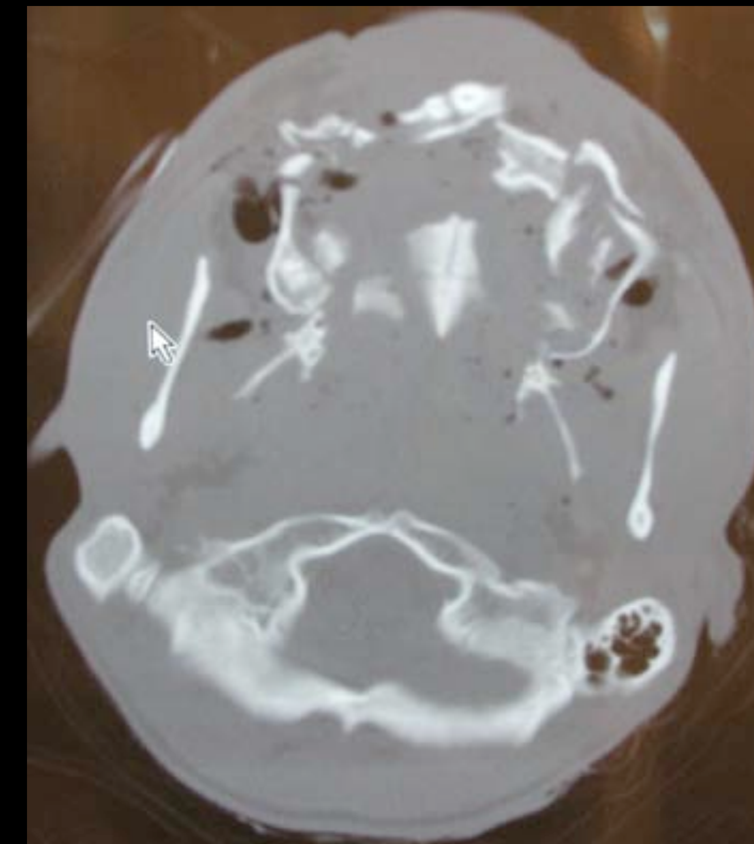
Intubation *may be "difficult"*

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.)

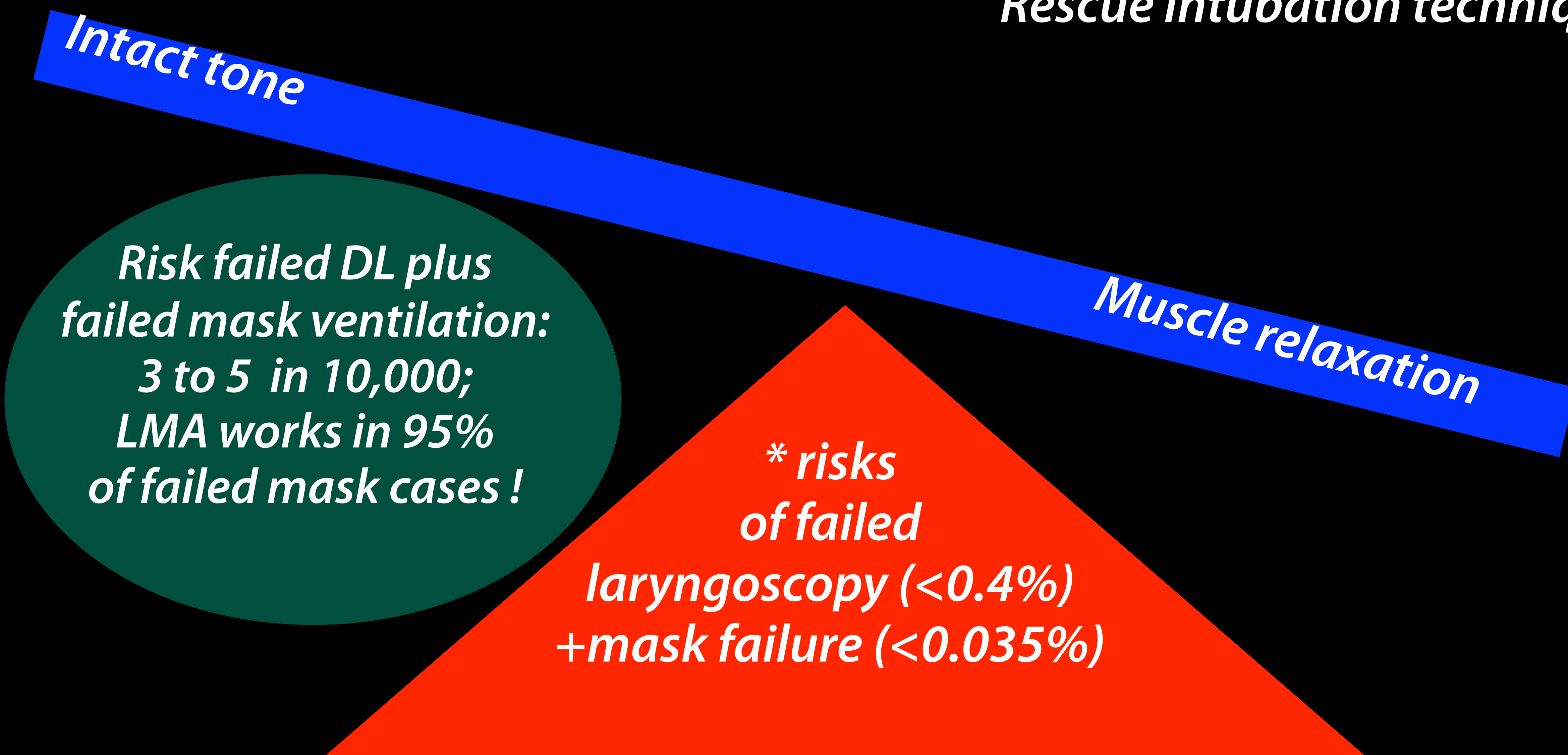
4) Non-optimal rescue intubation via oral route

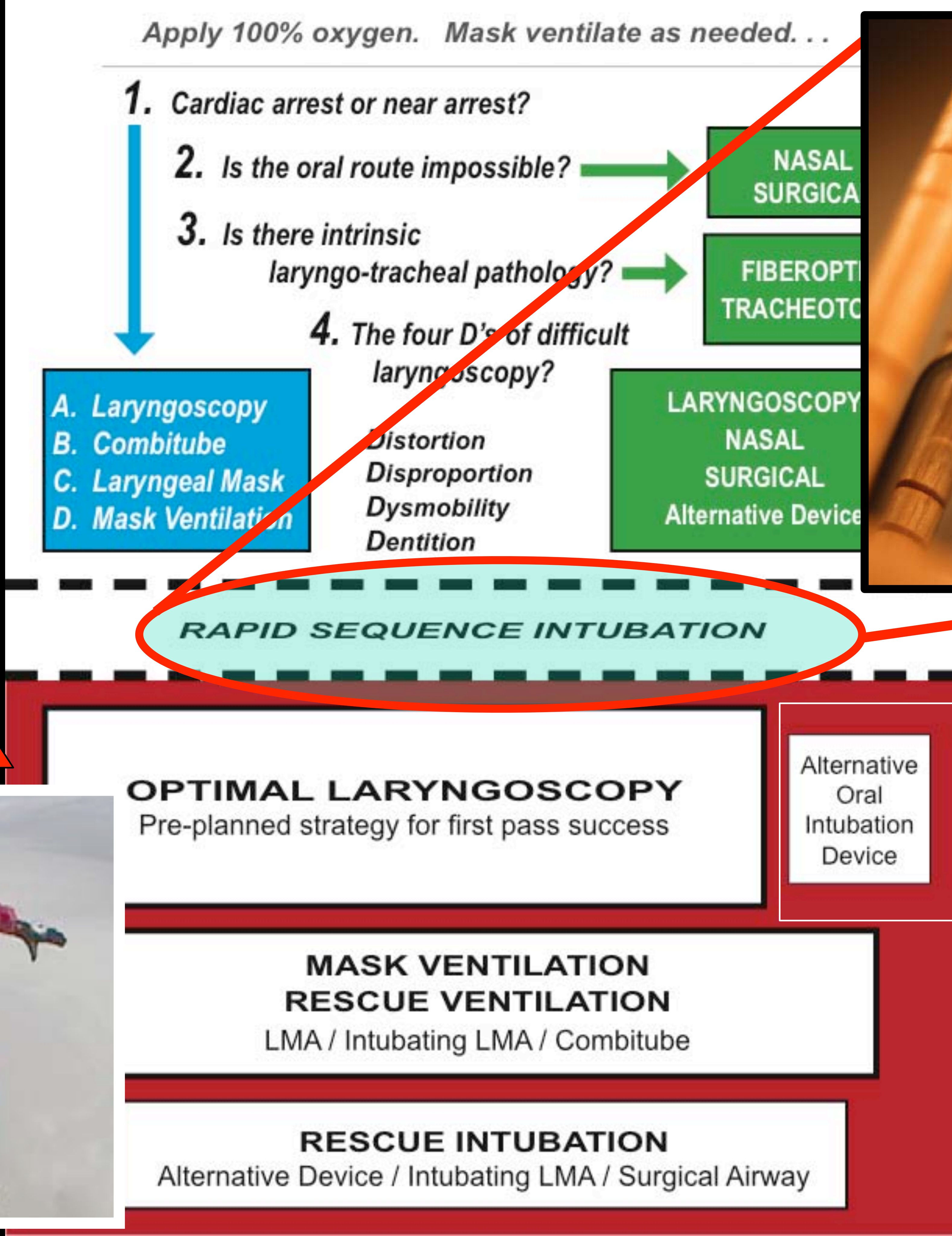
intact gag impairs device and tube insertion

Airway risk assessment in emergencies

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

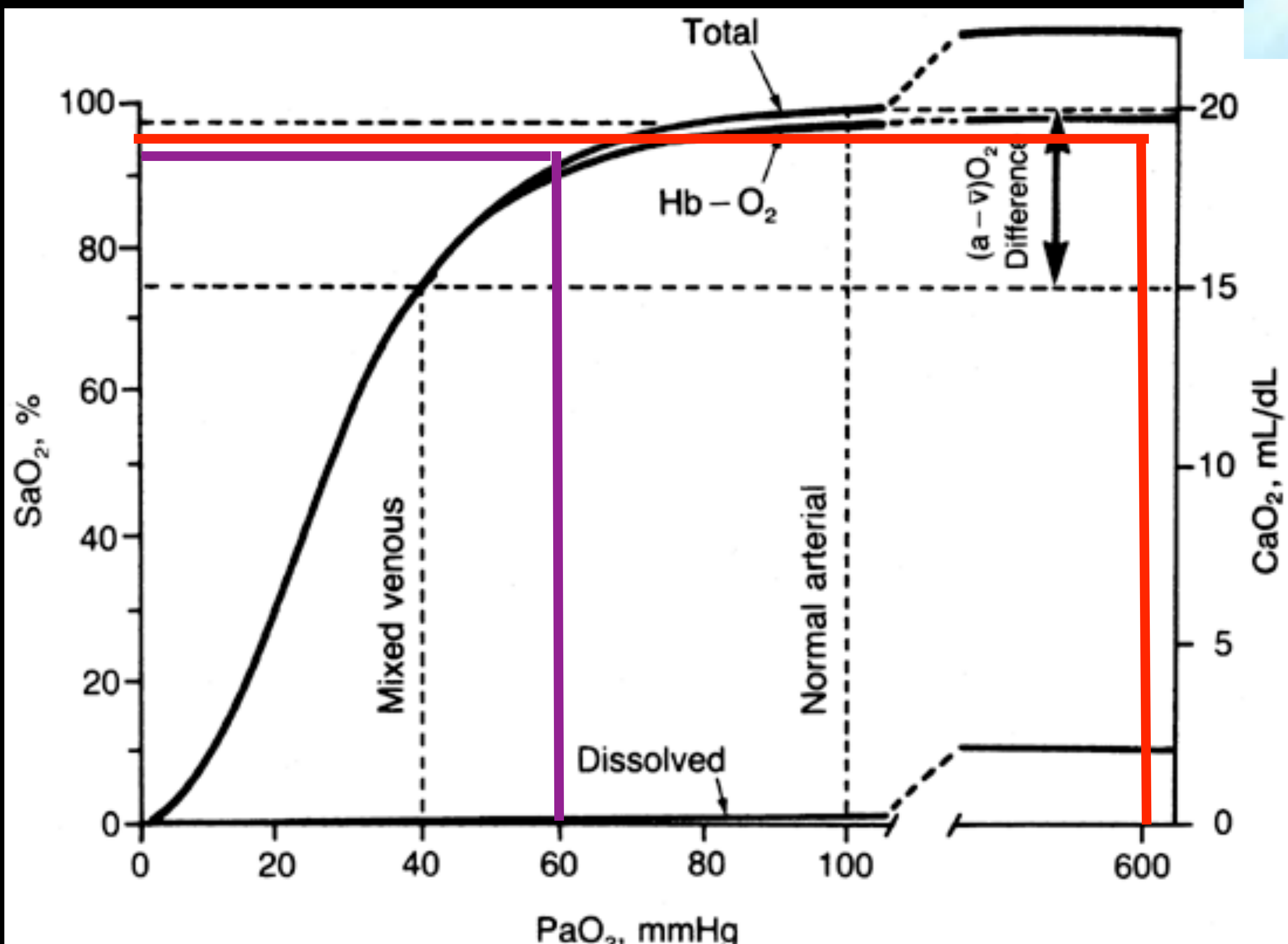
Optimal laryngoscopy
Optimal mask ventilation
Rescue ventilation-LMA, King LT
Rescue intubation technique





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% O_2 followed by O_2 insufflation

- During the apnoeic period, O_2 is extracted from the FRC into the blood at a rate of 250 ml/min to maintain metabolic O_2 consumption.

- Due to greater solubility of CO_2 in blood, CO_2 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.

Pulmonary uptake of oxygen, acid-base metabolism and circulation during prolonged apnea. Apneic diffusion oxygenation. Holmdahl M. Acta Chirurgica Scandinavica 1956; 212 Supplement 1-128 (Suppl.): 1–128.

How apneic diffusion oxygenation works

- CO_2 has 25 times the solubility of O_2 in blood (leaks out slowly)

- With apnea CO_2 excretion declines; O_2 absorption minimal decrease

- O_2 absorption continues in apnea, due to partial pressure gradient, 300 million alveoli, 70 sq meters of absorption area

** * * Apnea: smaller transfer of CO_2 to blood than O_2 to blood * * **

Creating sub-atmospheric alveolar pressure (-240 ml/min)

The net effect: O_2 is PULLED down the airway!

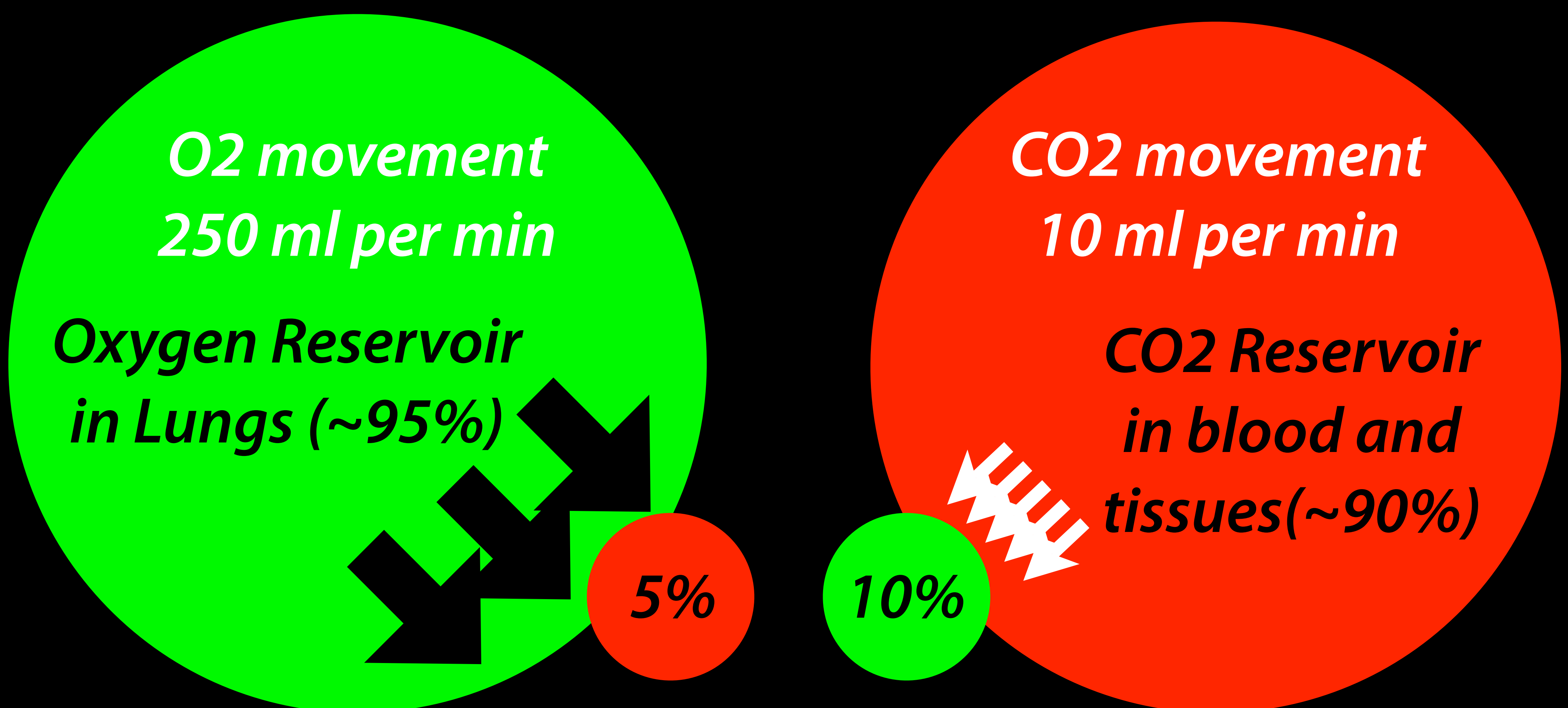


TABLE 1. Duration of Apnea (*i.e.*, Time from Cessation of Ventilation Until Either (1) SaO_2 fell to 92%, or (2) 10 Min had Elapsed) and Minimum Observed SaO_2 With and Without Pharyngeal Oxygen Insufflation. Values are Means ± SE

	O_2 Insufflation	No O_2 Insufflation
First trial		
Duration of apnea (min)	10.0 ± 0	7.1 ± 0.6*
Minimum SaO_2 (%)	98 ± 1	92 ± 1*
Pre-apnea SaO_2 (%)	99 ± 1	99 ± 1
Pre-apnea $F_{ET}O_2$ (%)	87 ± 1	88 ± 2
Pre-apnea $P_{ET}CO_2$ (mmHg)	26 ± 2	22 ± 2
N	6	6
Second trial		
Duration of apnea (min)	10.0 ± 0	6.6 ± 0.9*
Minimum SaO_2 (%)	99 ± 1	91 ± 1*
Pre-apnea SaO_2 (%)	99 ± 1	99 ± 1
Pre-apnea $F_{ET}O_2$ (%)	90 ± 1	92 ± 1
Pre-apnea $P_{ET}CO_2$ (mmHg)	27 ± 1	28 ± 2
N	6	6
Combined		
Duration of apnea (min)	10.0 ± 0	6.8 ± 0.6†
Minimum SaO_2 (%)	98 ± 1	91 ± 1†
Pre-apnea SaO_2 (%)	99 ± 1	99 ± 1
Pre-apnea $F_{ET}O_2$ (%)	88 ± 1	90 ± 1
Pre-apnea $P_{ET}CO_2$ (mmHg)	27 ± 1	25 ± 1
N	12	12

* $P < 0.01$ compared with oxygen insufflation (same trial).
† $P < 0.001$ compared with oxygen insufflation.

Pharyngeal Insufflation of Oxygen Prevents Arterial Desaturation During Apnea

Teller LE, et al. Anesthesiology 1988; 69: 980-982

- *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)*

Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of nasal oxygen administration.

Ramachandran SK, et al. J Clin Anesth. 2010 May;22(3):164-8.

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

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

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 oximetery. Resaturation time=time to regain SpO2 100% after tracheal intubation.

** Statistically significant difference.*

Face mask: exhaled gas mixes with inspired oxygen

Face mask only pushes exhaled gas up and down, lowering effective FiO2

Nasal oxygen flushes nasopharynx, eliminating exhaled gas via mouth, and increasing effective FiO2 for next breath

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."

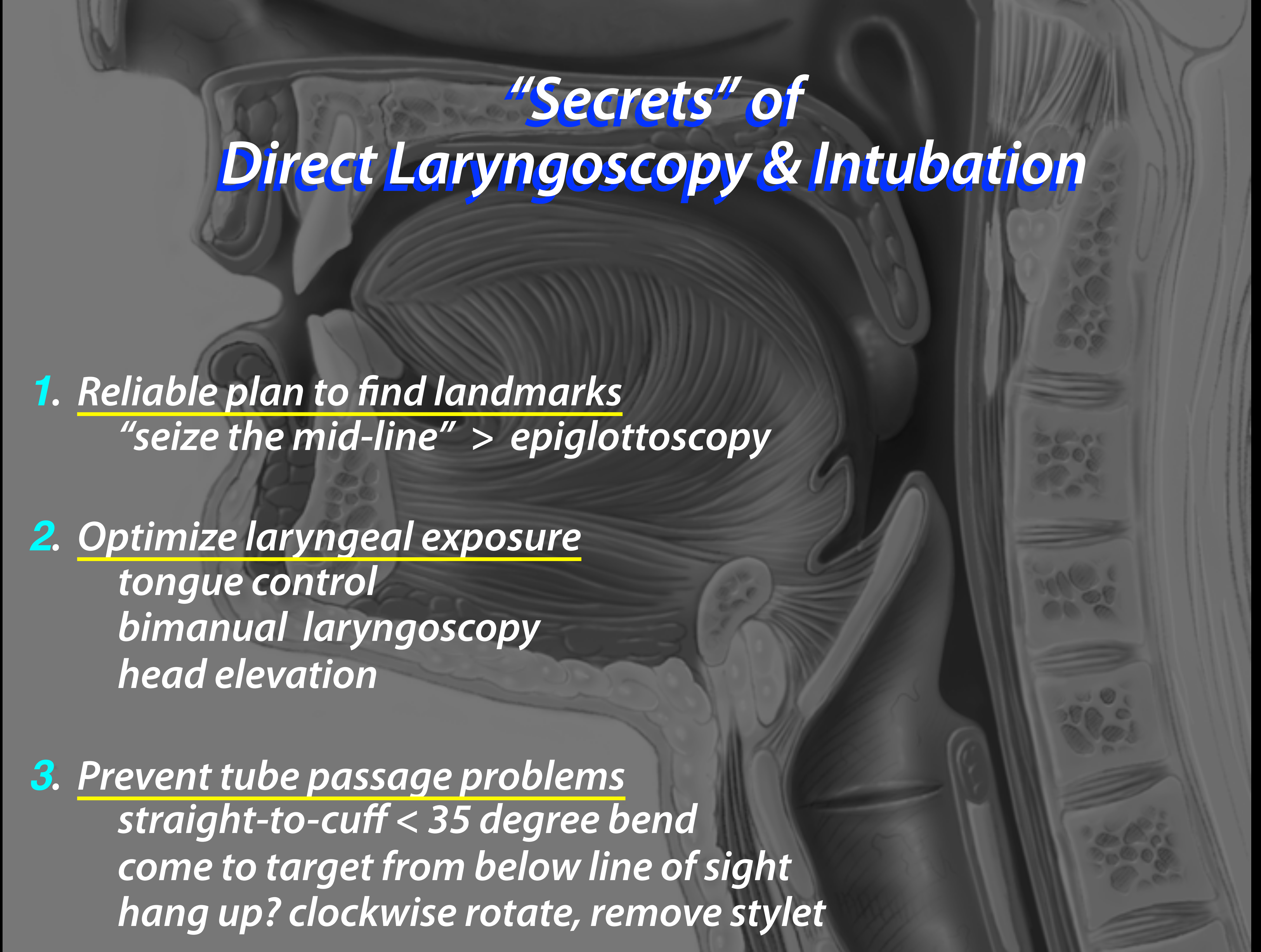
Ear-to-sternal notch > promotes upper airway patency
Positioning improves pulmonary function
Mask and NC combined flow approach appropriate needs 30 liters/minute

Emergency Tracheal Intubation: Complications Associated with Repeat Laryngoscopy

Mort TC. Anesth Analg 2004; 99:607–13

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

Complication	2 or less attempts	>2 attempts	Relative risk >2 attempts
Hypoxemia	10.5%	70%	9X
Severe hypoxemia	1.9%	28%	14X
Esophageal intubation	4.8%	51.4%	6X
Regurgitation	1.9%	22%	7X
Aspiration	0.8%	13%	4X
Bradycardia	1.6%	18.5%	4X
Cardiac arrest	0.7%	11%	7X



"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

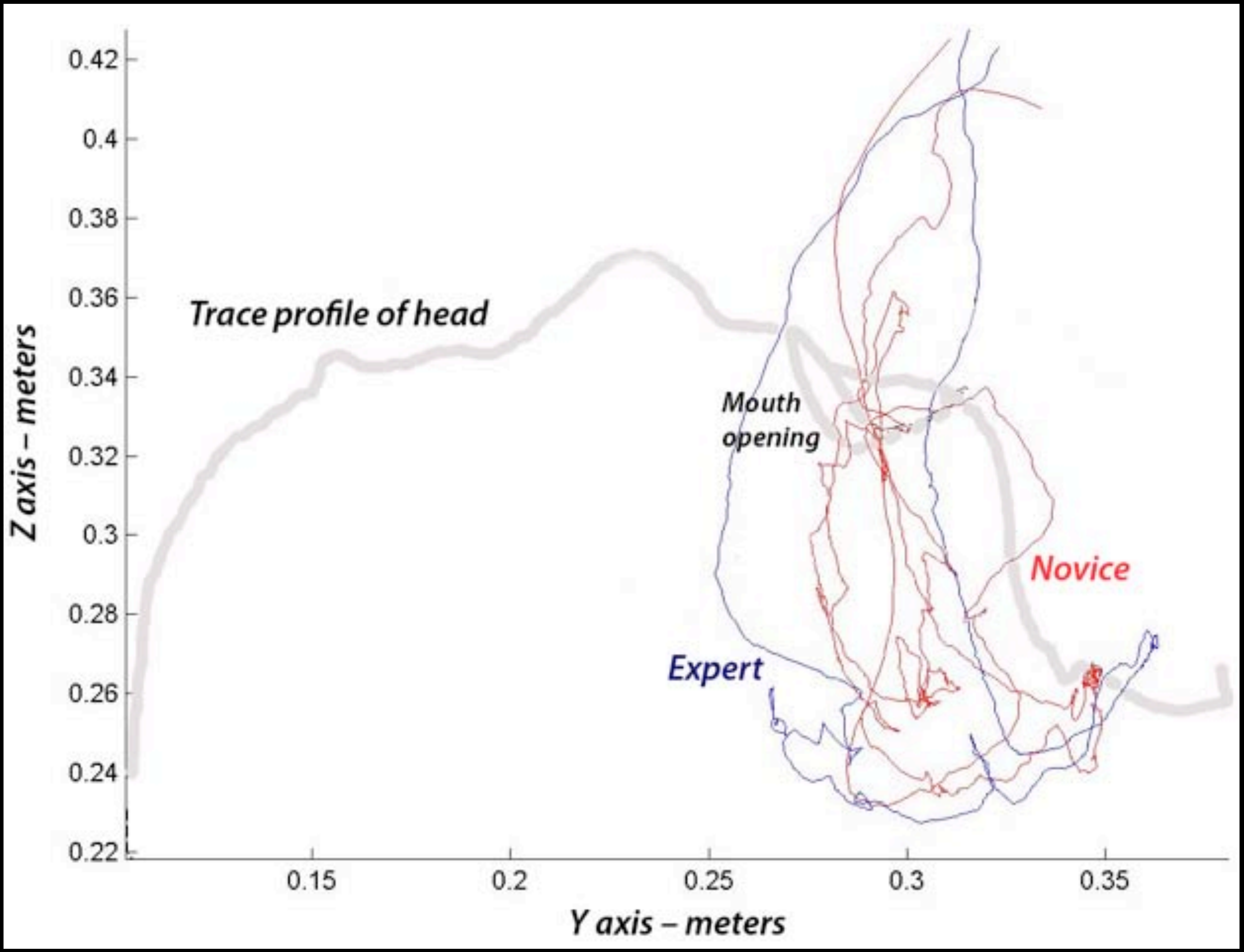
Experts

52 cm tip travel

12 sec time

2.8 Nm torque

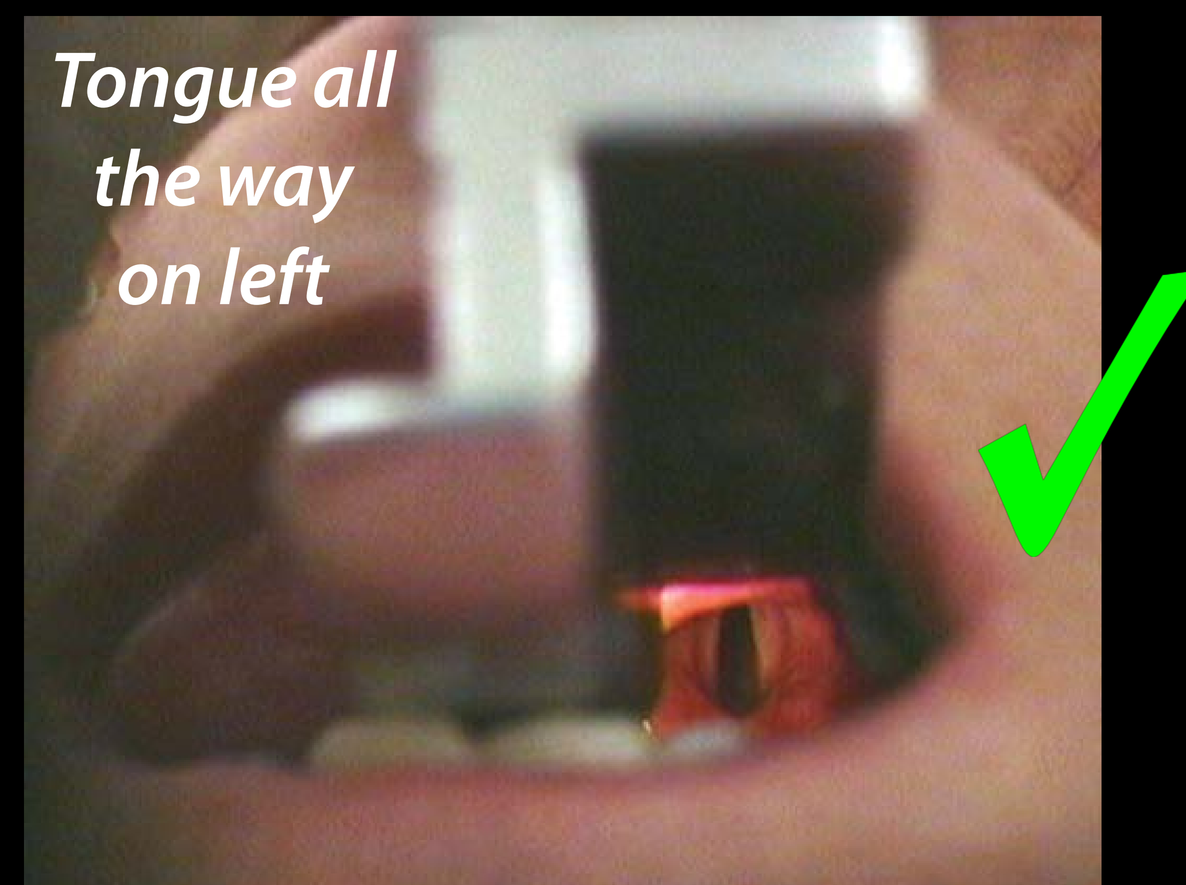
66 N max force



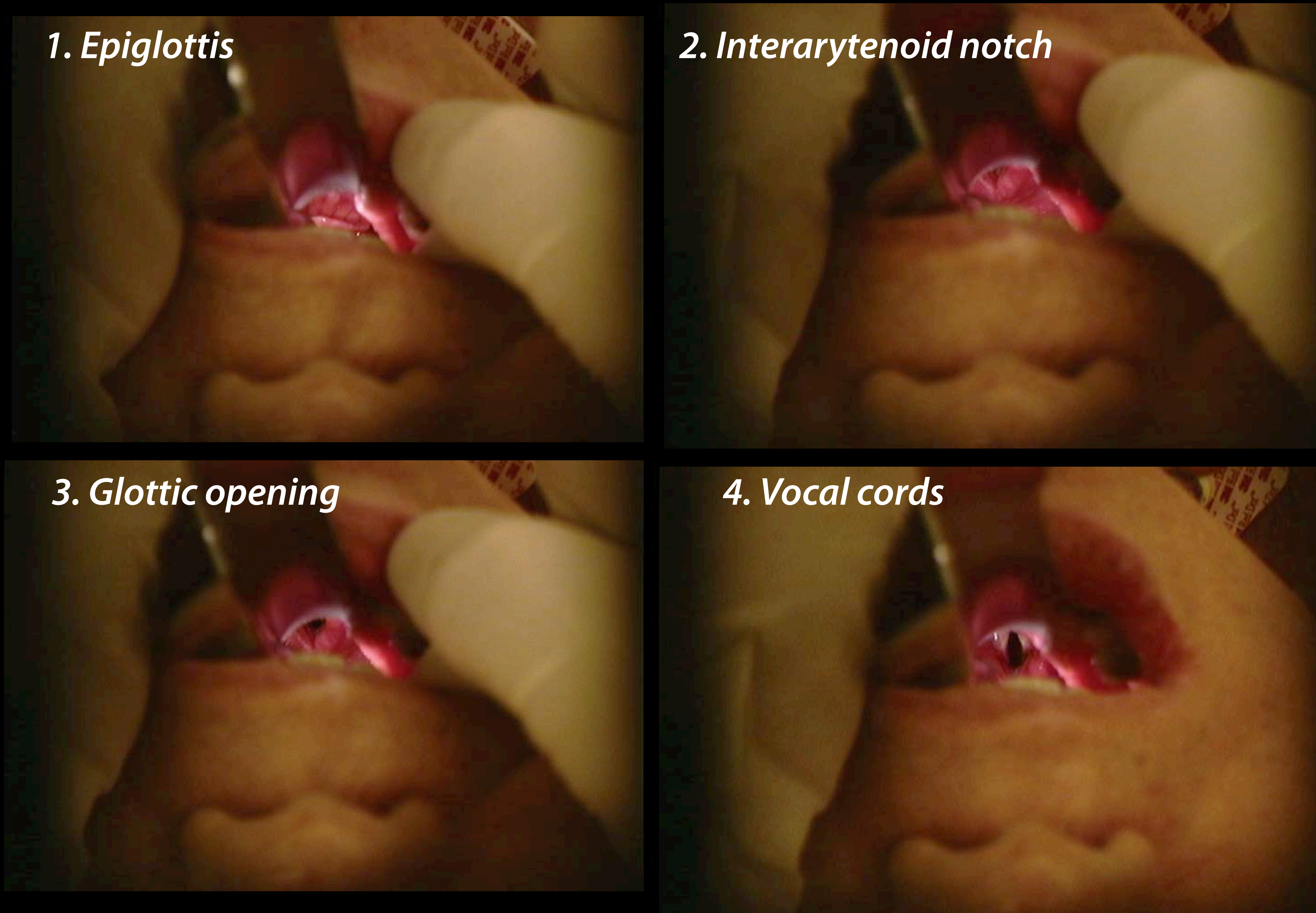
Good tongue control counts !

– *Improves visualization*

– *Very important for tube delivery*



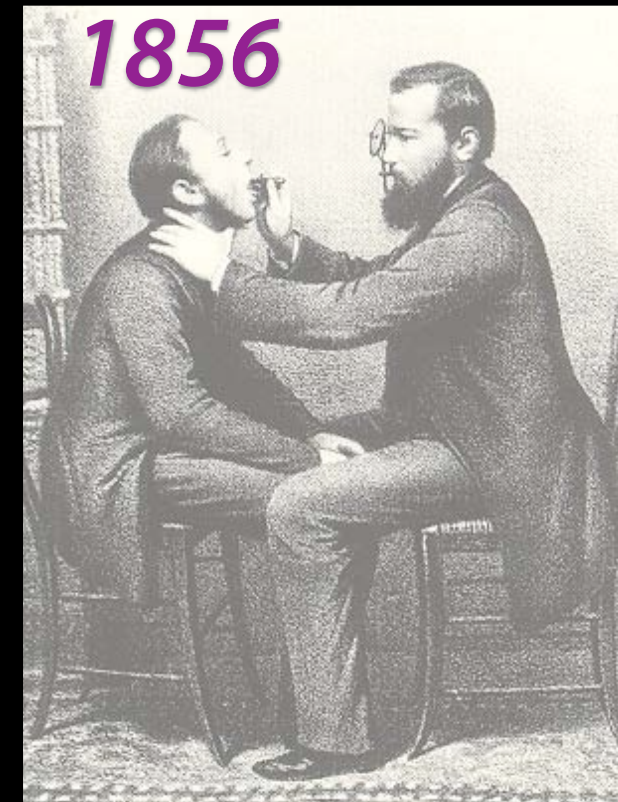
In practice...epiglottoscopy & tongue control happen together.

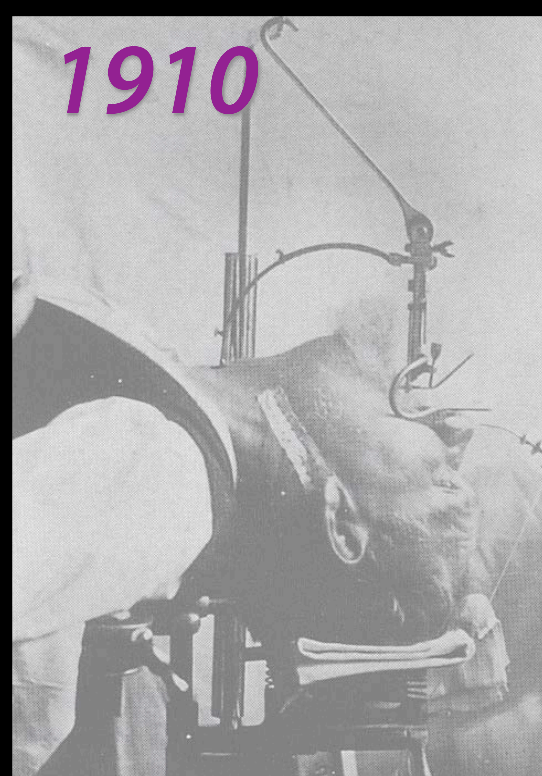

1. Epiglottis
2. Interarytenoid notch
3. Glottic opening
4. Vocal cords

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

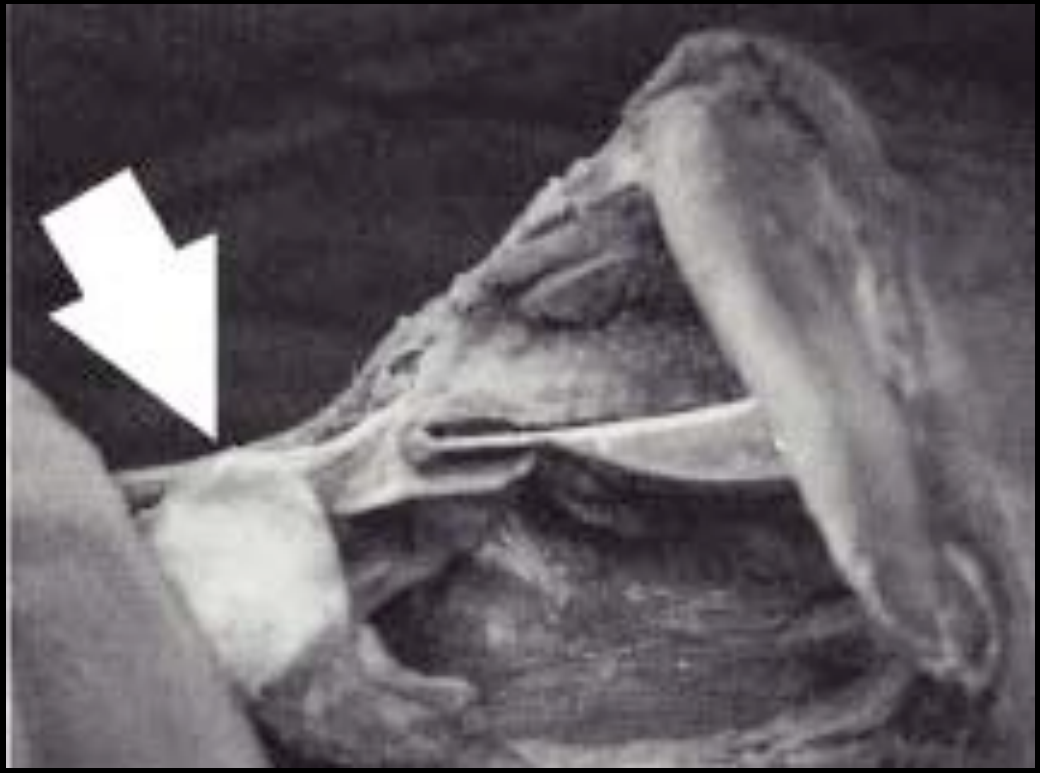

1856


1910

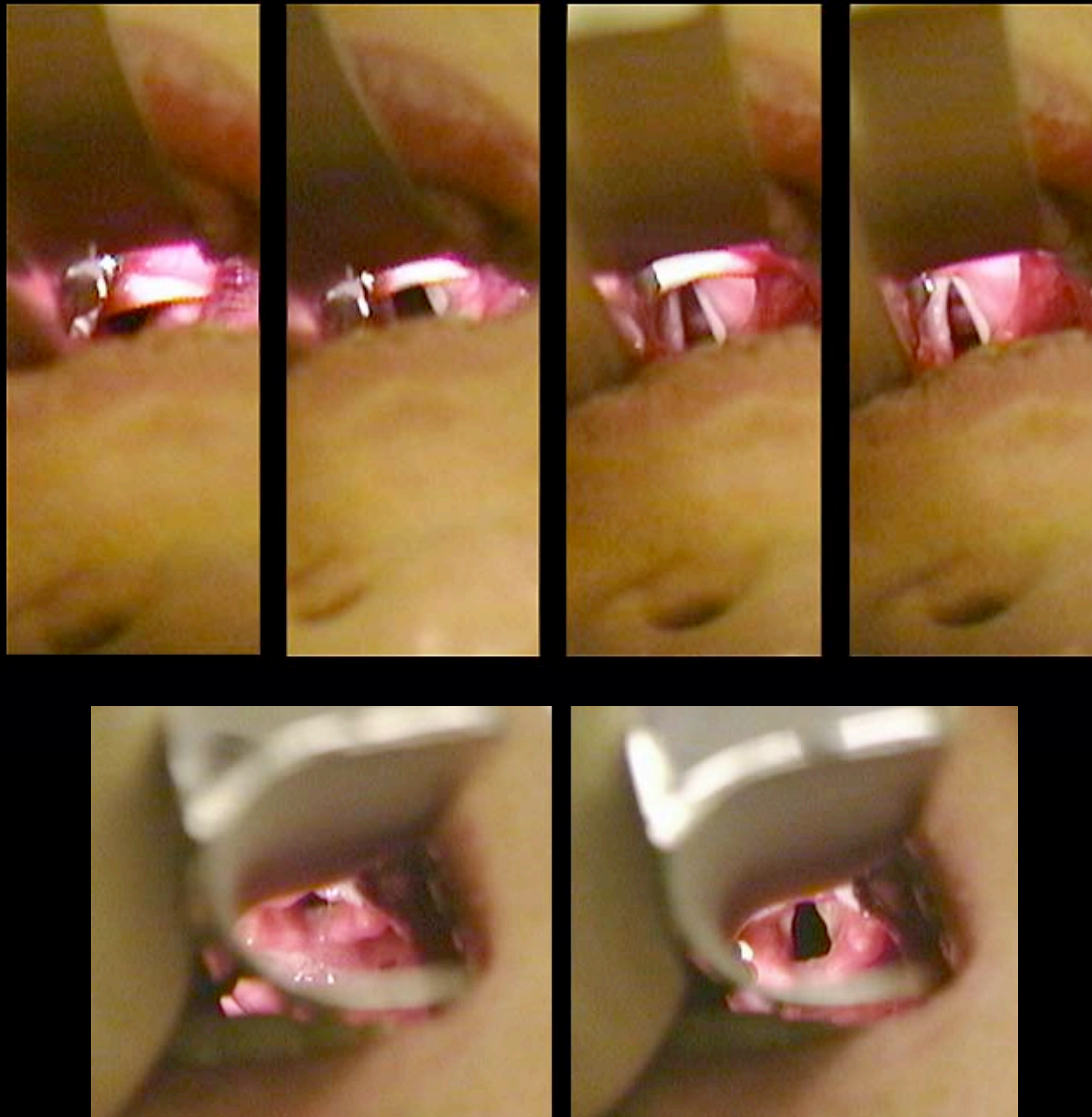
Bimanual Laryngoscopy - By Laryngoscopist

1) Moves tip of blade fully into vallecula

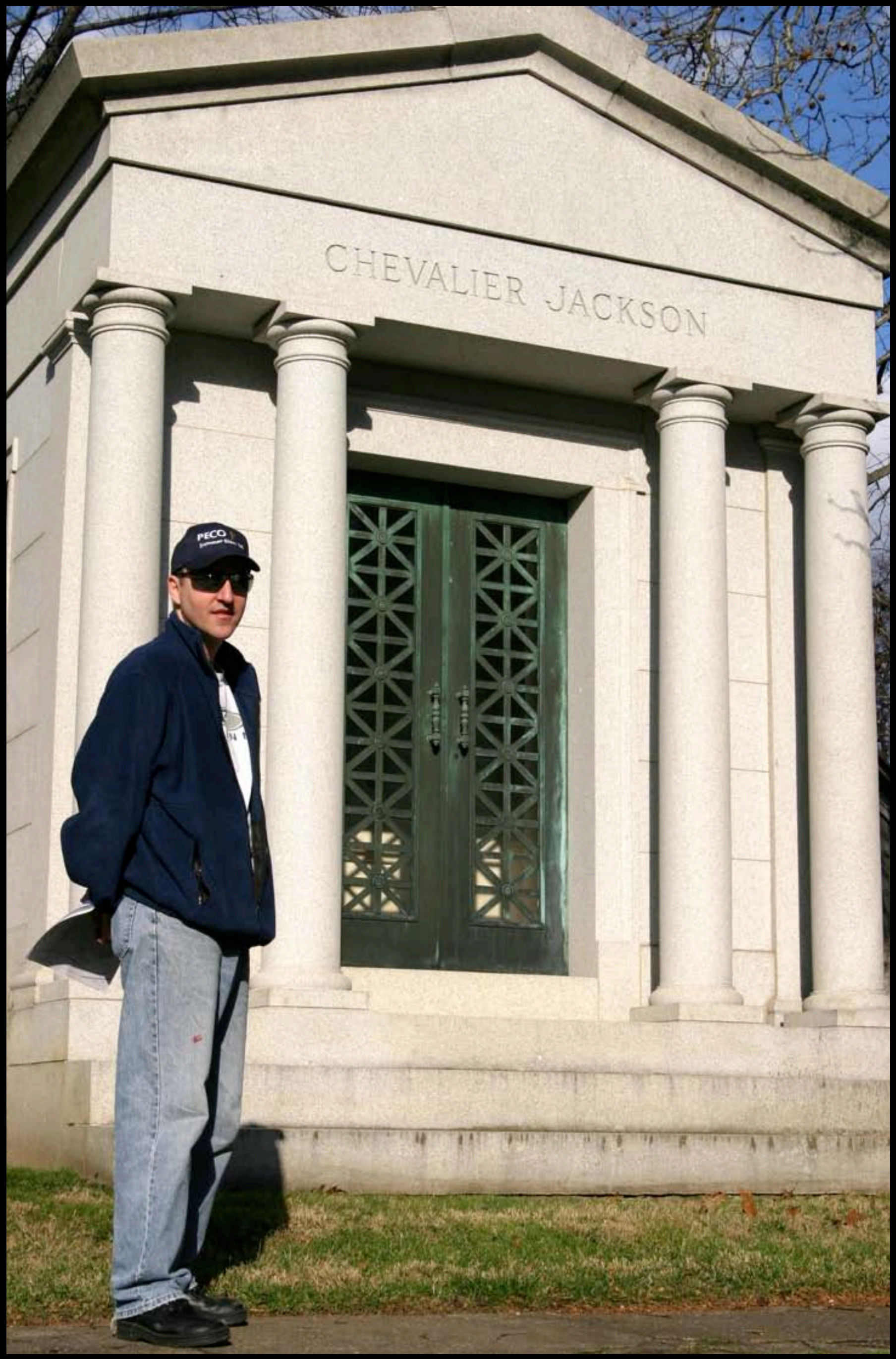
2) Drops larynx into line of sight, improves alignment

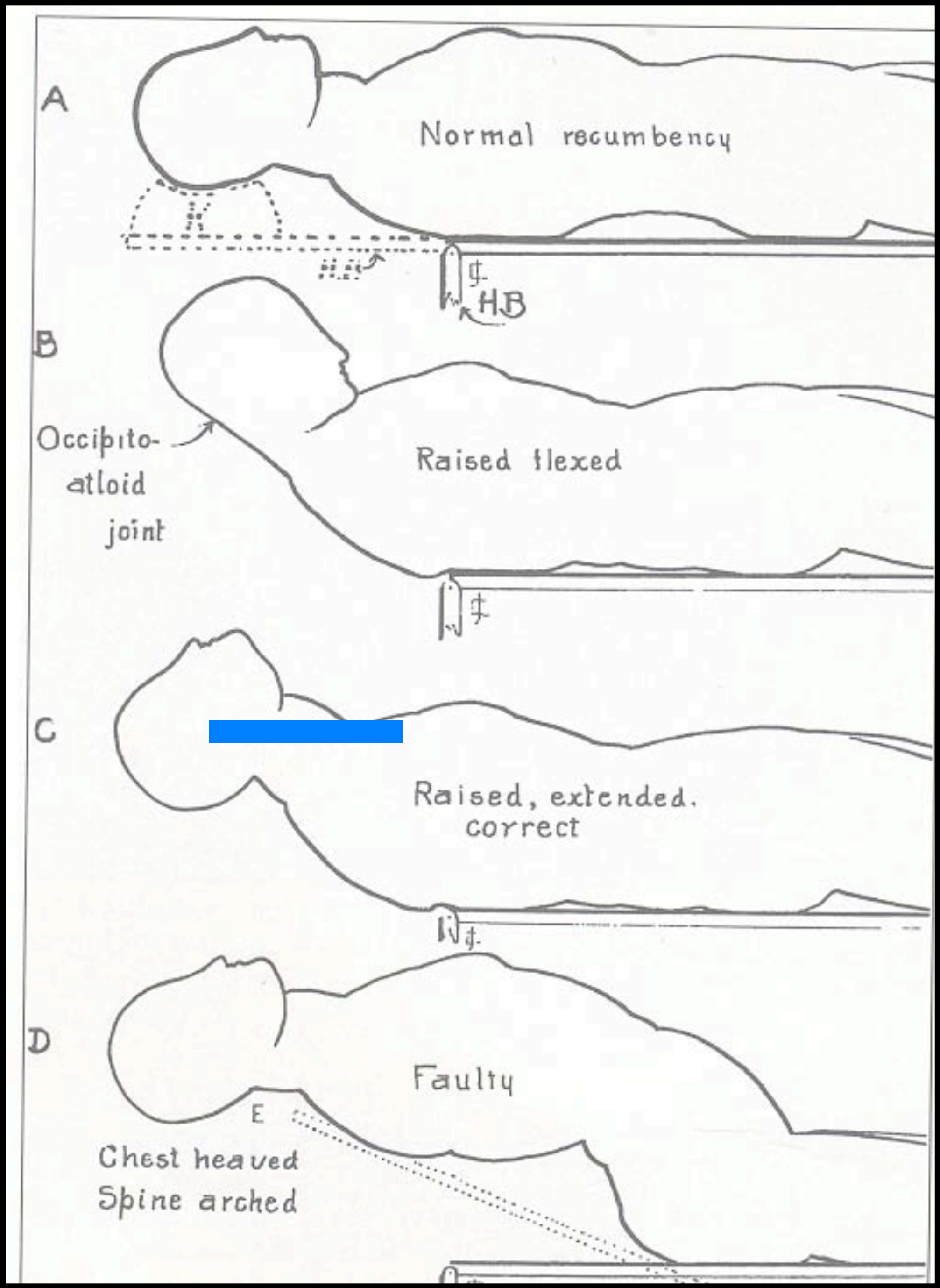


From Gorback MS, Emergency Airway Management, BC Decker, 1990.



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



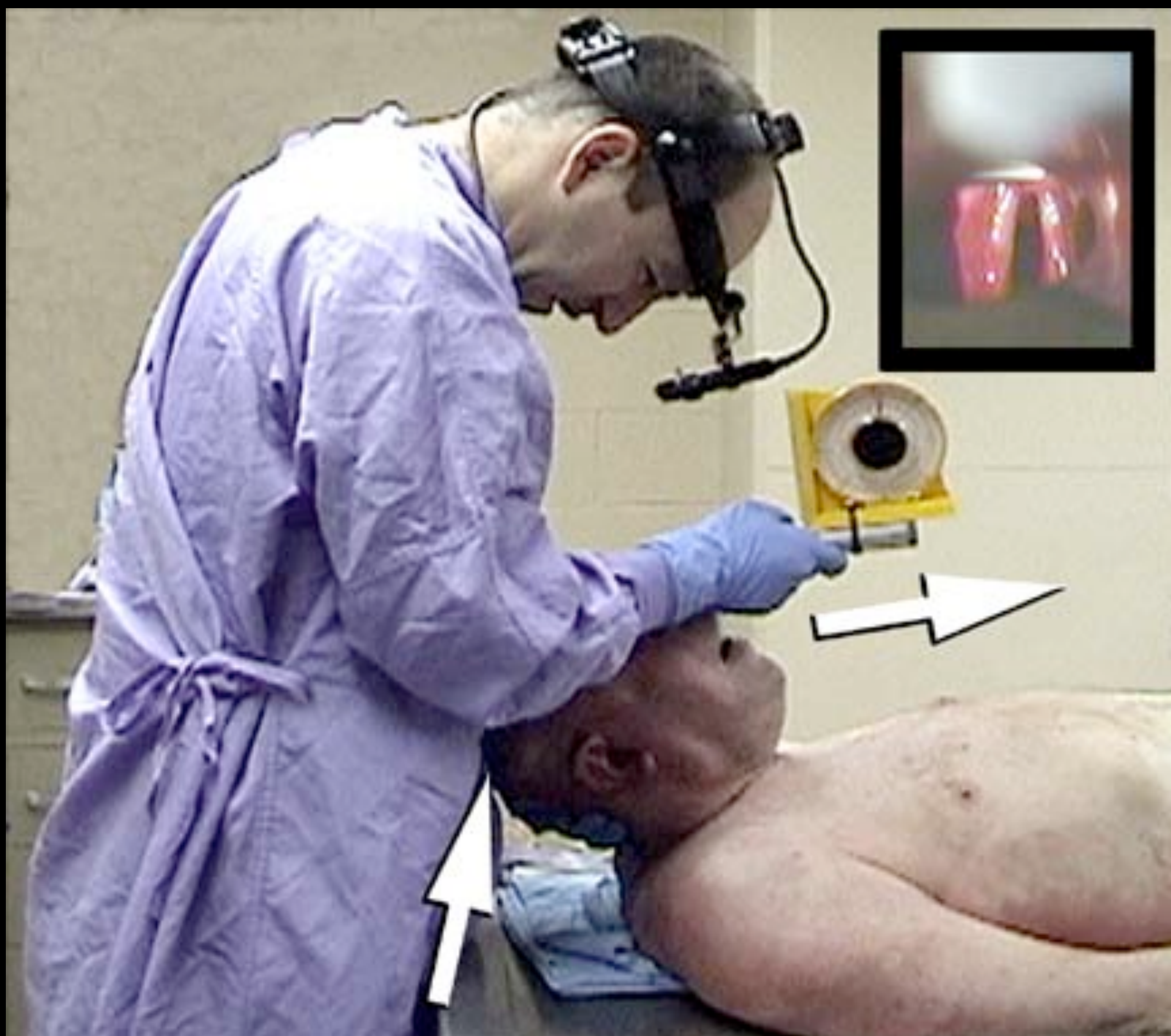


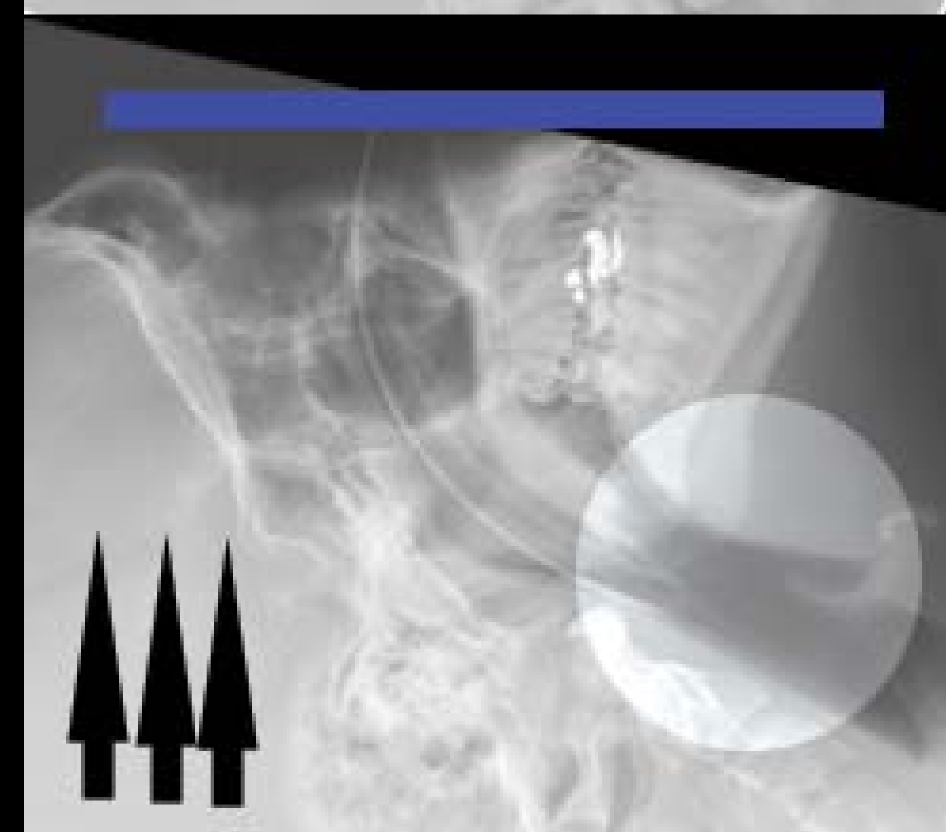
Ear aligned with sternal notch

"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

Levitan RM. Ann Emerg Med 2003; 41: 322-30.





Obesity Surgery, **14**, 1171-1175

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

Jeremy S. Collins, MB, ChB[1]; Harry J.M. Lemmens, MD, PhD[1]; Jay B. Brodsky MD[1]; John G. Brock-Utne, MD, PhD[1]; Richard M. Levitan, MD[2]

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

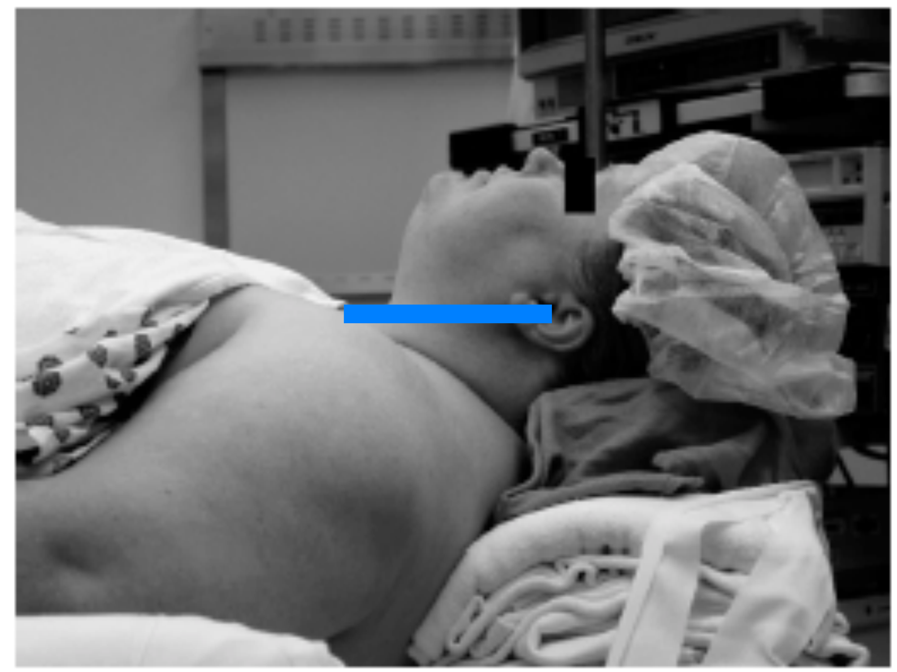


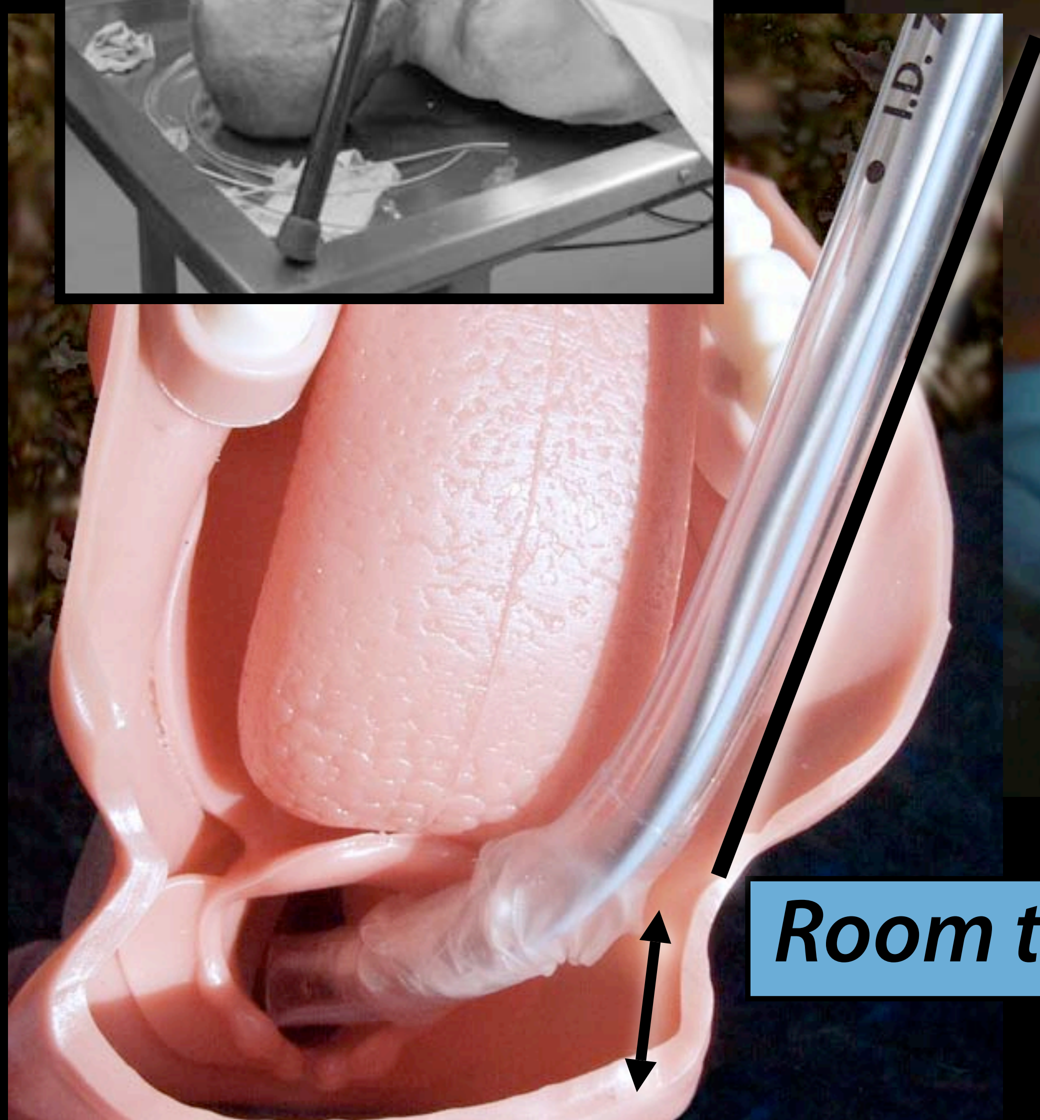
Figure 2. Patients in Group 2 had folded blankets placed under their upper body, head and neck until horizontal alignment between the sternal notch space and the external auditory meatus was achieved.

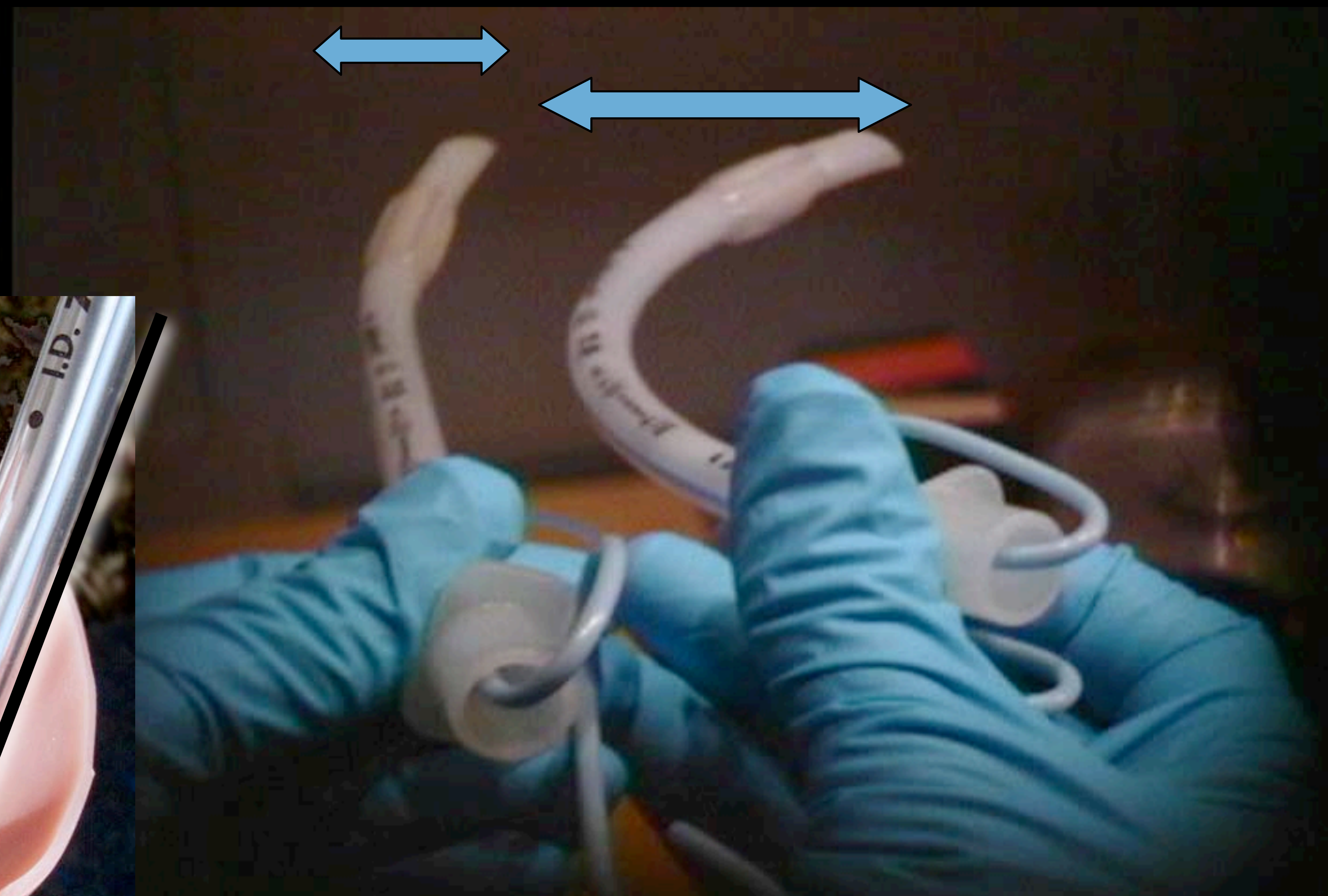
Laryngoscopy 100% success
View better with head elevation

Table 2. Comparison of views during laryngoscopy

GRADED VIEW*	GROUP 1 (n)	GROUP 2 (n)
1	18	29
2	9	3
3	0	1
4	0	0

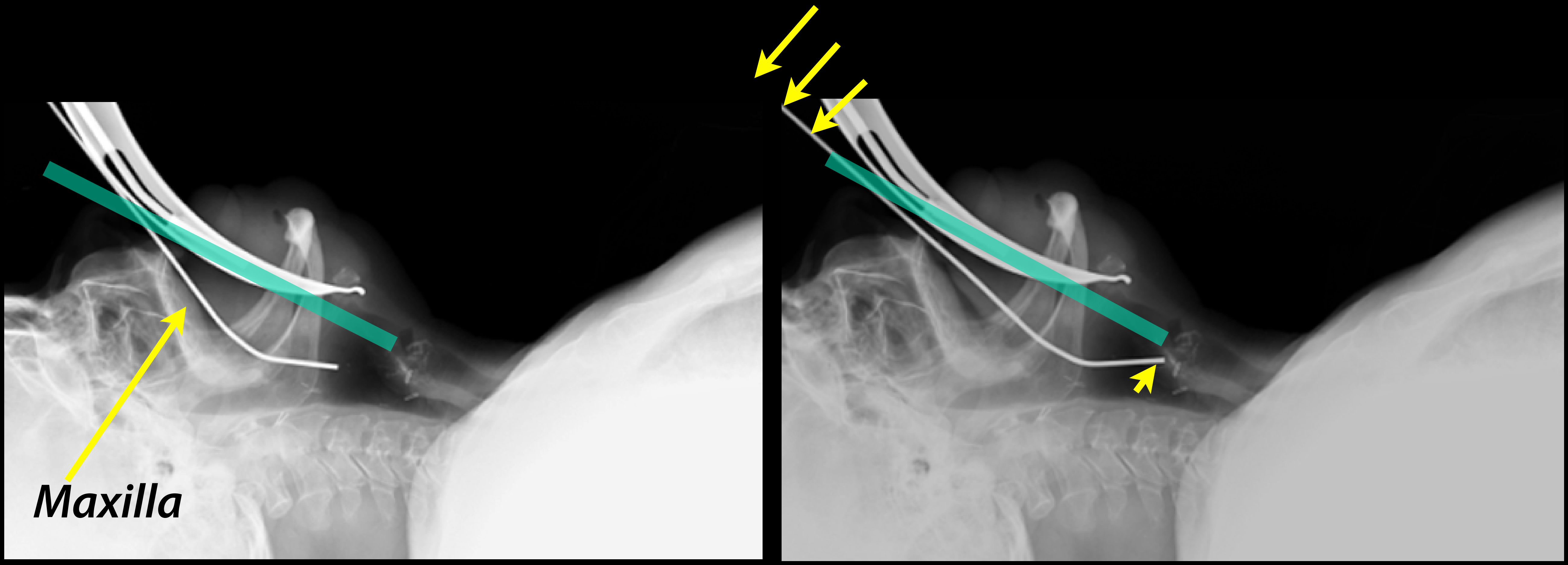
Straight-to-cuff shape has narrower long-axis dimension & better maneuverability





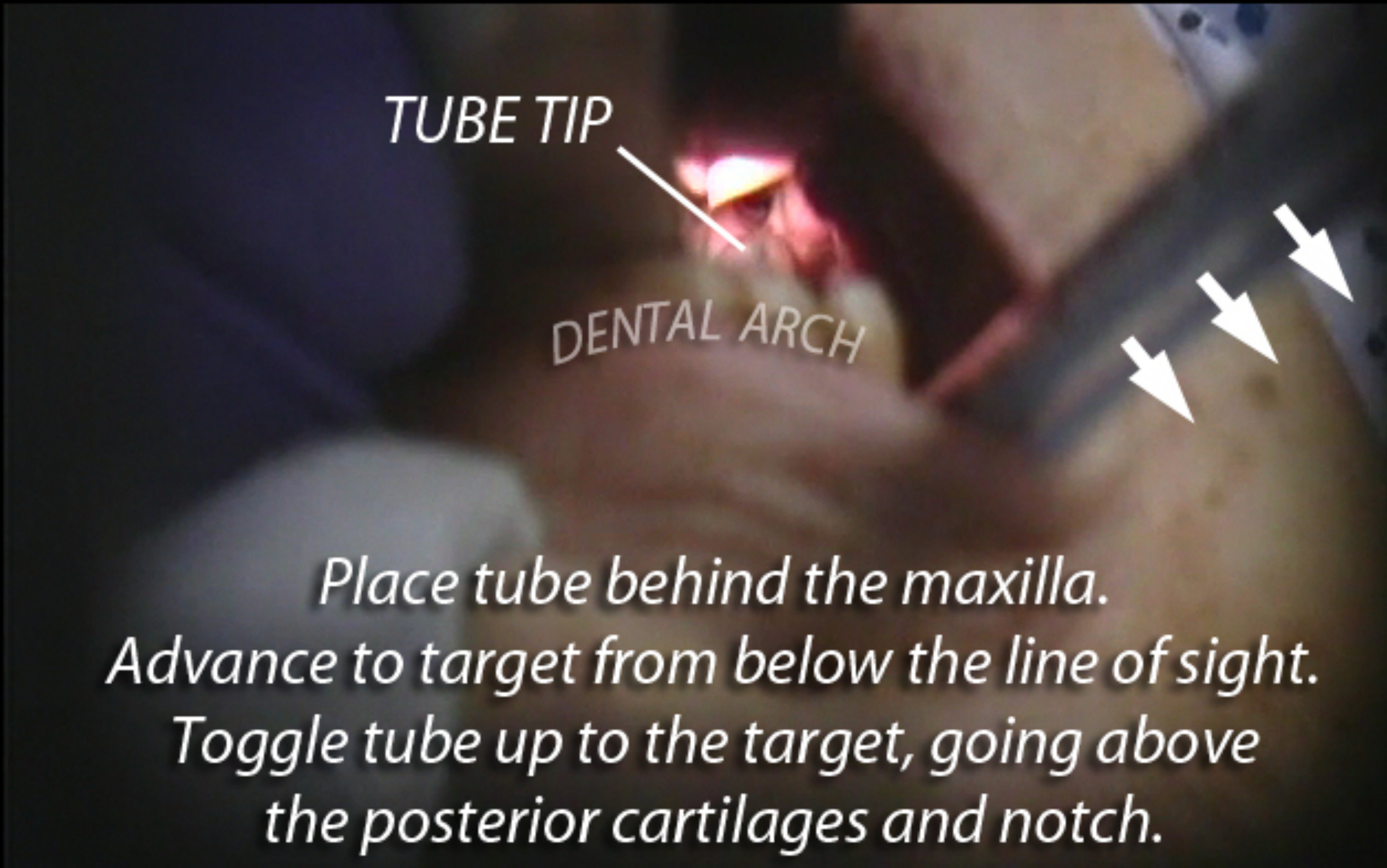
Room to maneuver within hypopharynx;

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.

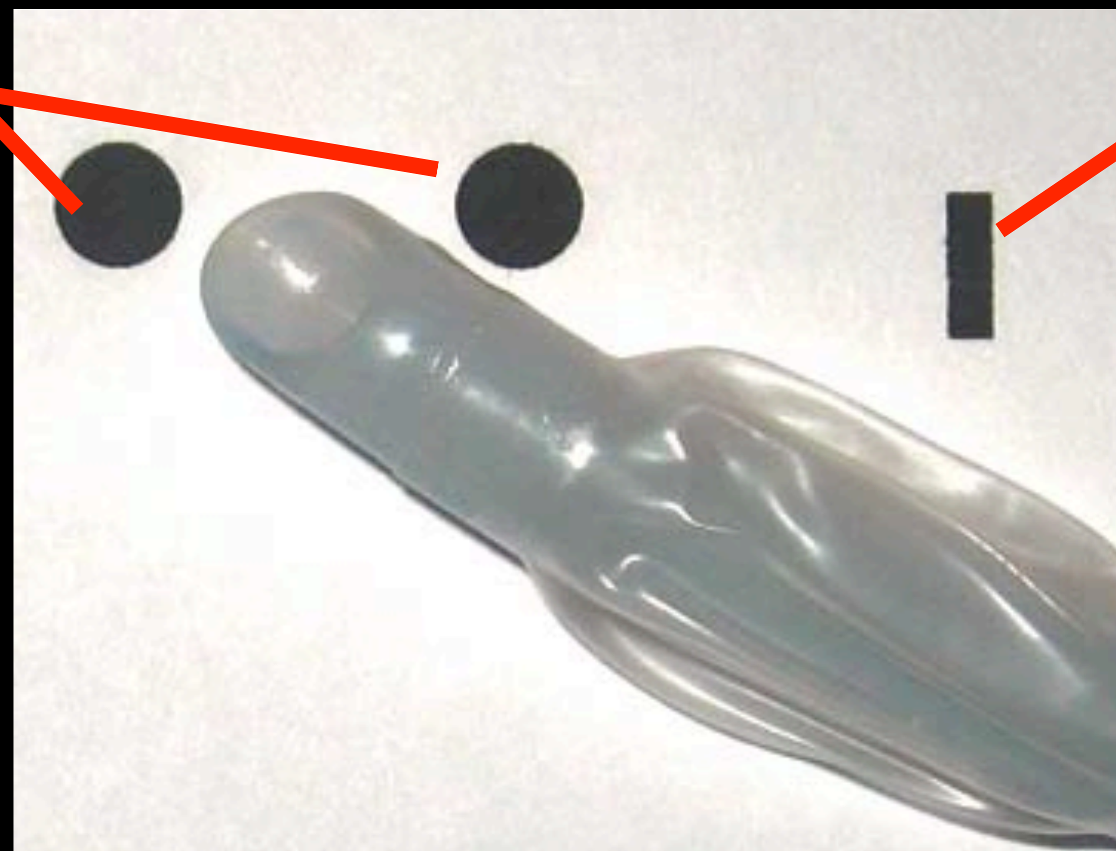
Use the right corner to insert and pivot tube



Even after insertion, tube tip can catch on tracheal rings...

Rings

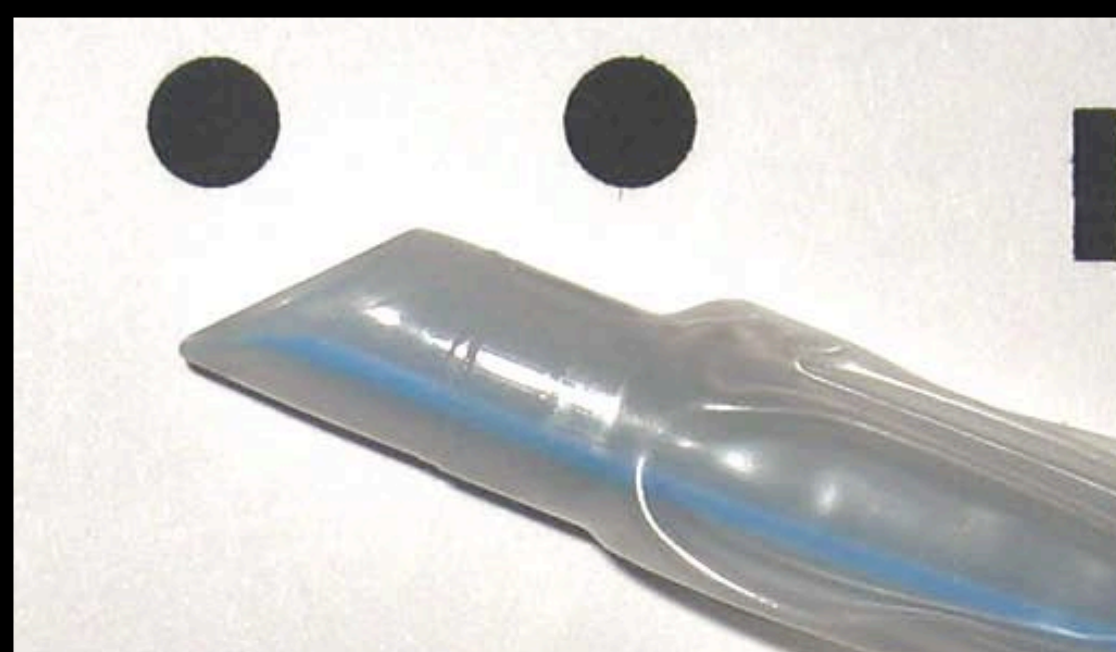
Vocal cords



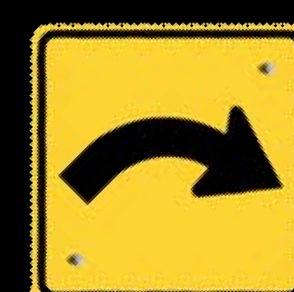
Standard tracheal tubes have a left-facing bevel

If resistance felt, turn tube CLOCKWISE (right turn)

Turning tube to right lowers leading edge allowing it to advance



Rings
RIGHT



Straight to cuff shape should not exceed 35 degrees

Levitan RM, et al. Acad Emerg Med 2006

- *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 256 at 45 degrees (11.3%)*
  - *138 out of 256 at 60 degrees (53.9%)*
- *Tip catches on tracheal rings > withdraw stylet, rotate clockwise*


AIRWAY CAM

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