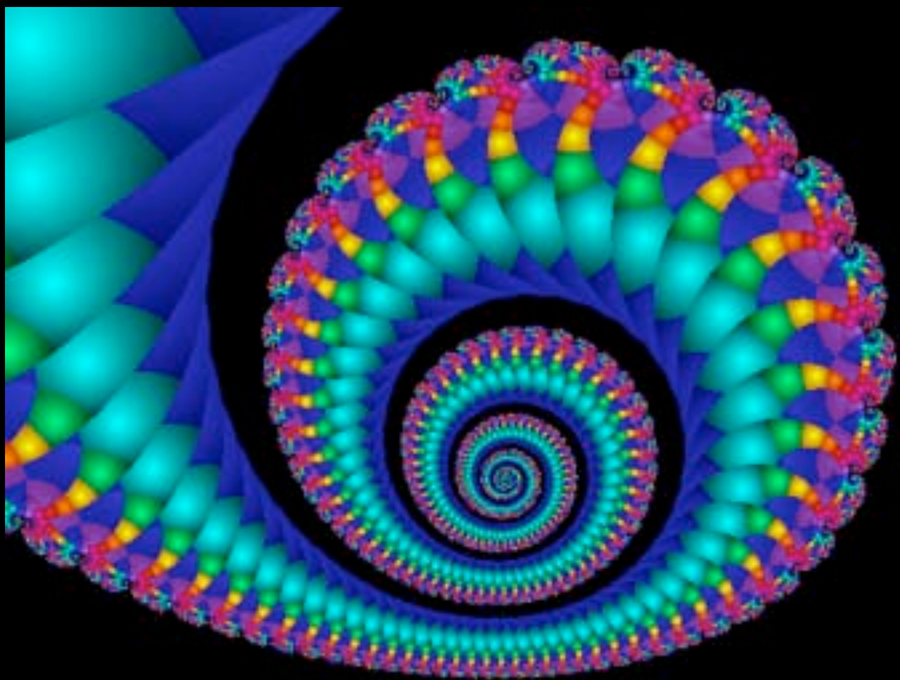
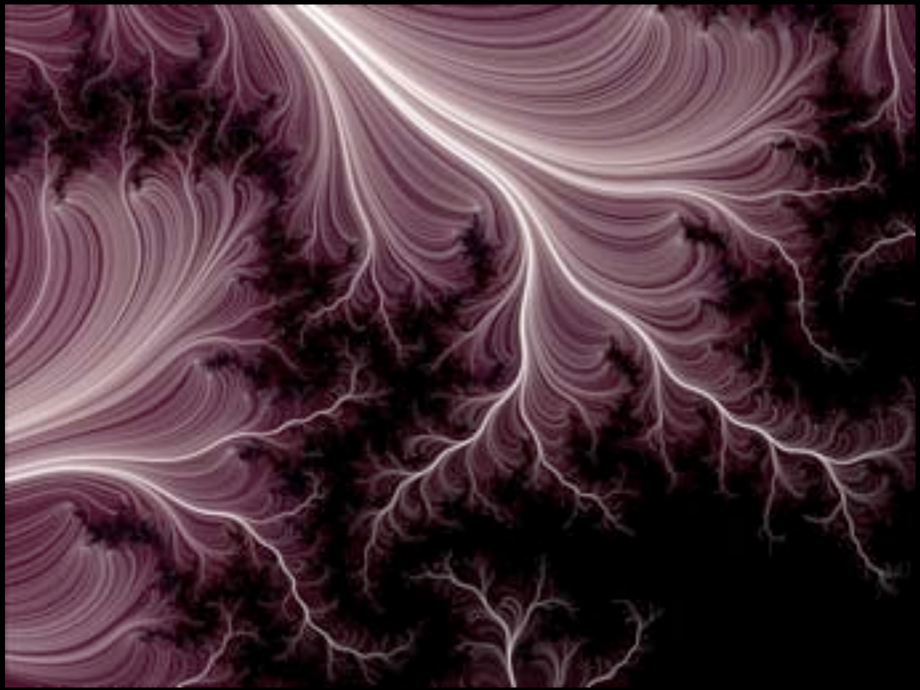
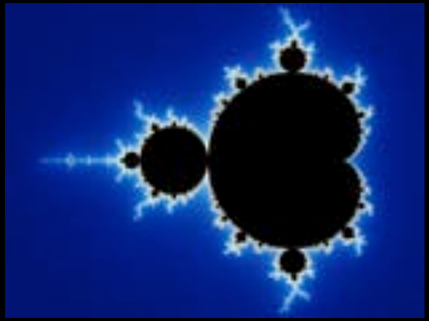
Anatomic Insights and Practice Changing Concepts

Richard M. Levitan, MD   Jefferson Medical College

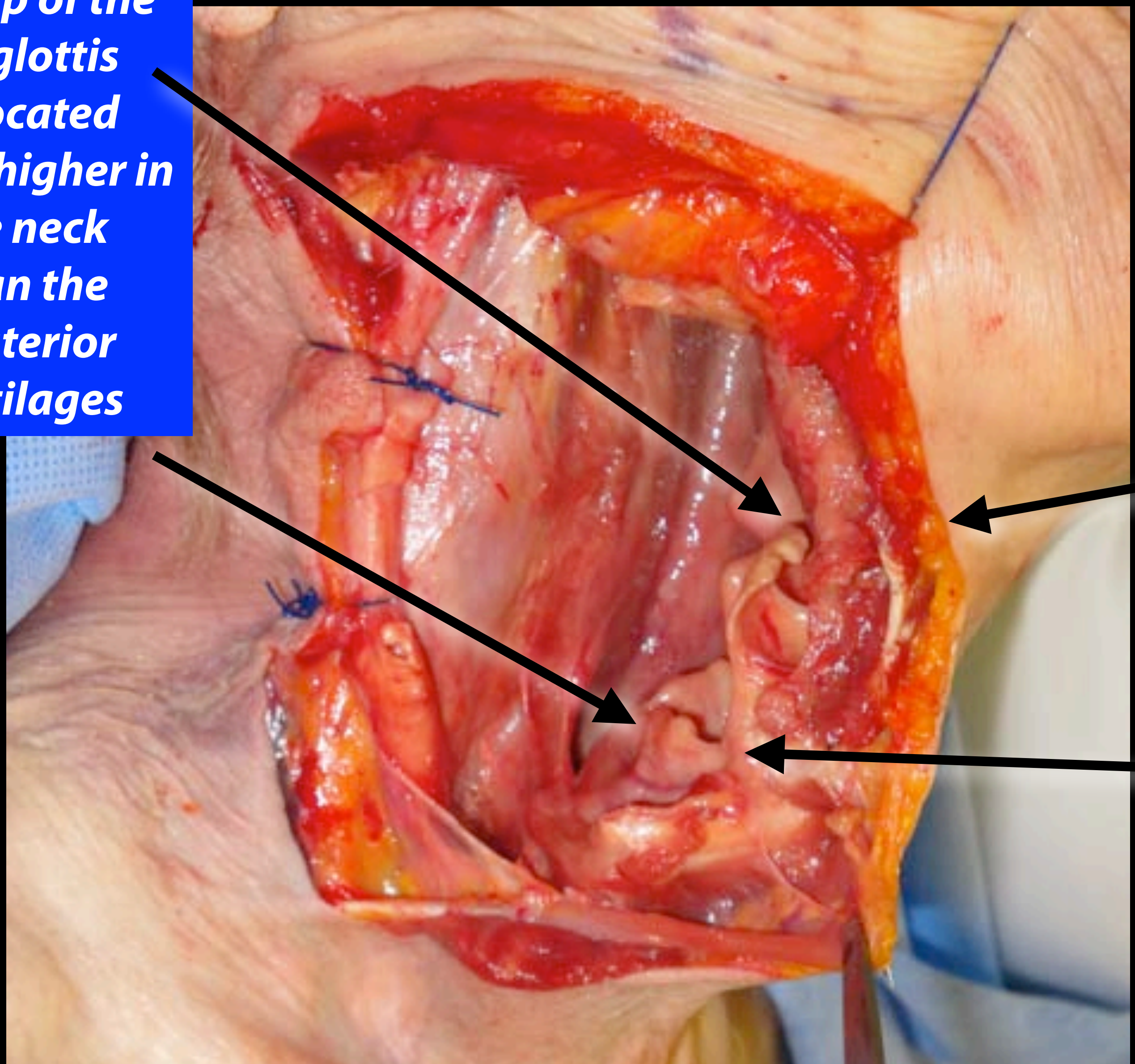




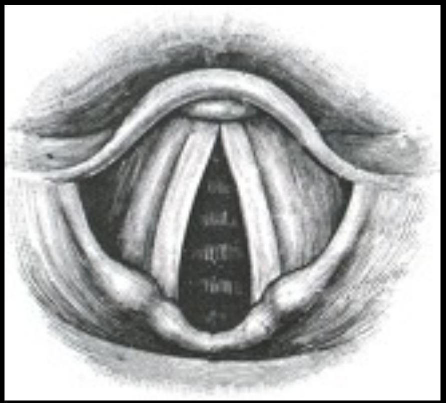


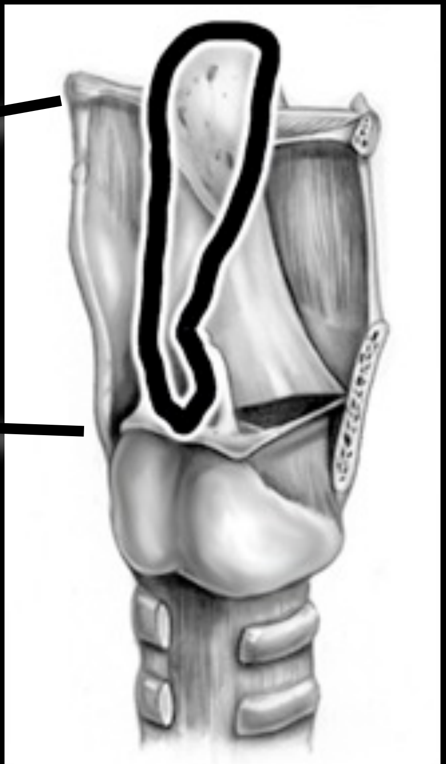
Key Points

- ★ *Epiglottoscopy*
- ★ *Positioning and head elevation*
- ★ *Bimanual laryngoscopy*
- ★ *Apneic Oxygenation*
- ★ *Videographic case review: direct and video*

The tip of the epiglottis is located much higher in the neck than the posterior cartilages







The larynx is a 3 -dimensional structure.
The epiglottis is at the top of the laryngeal inlet.

Epiglottoscopy:

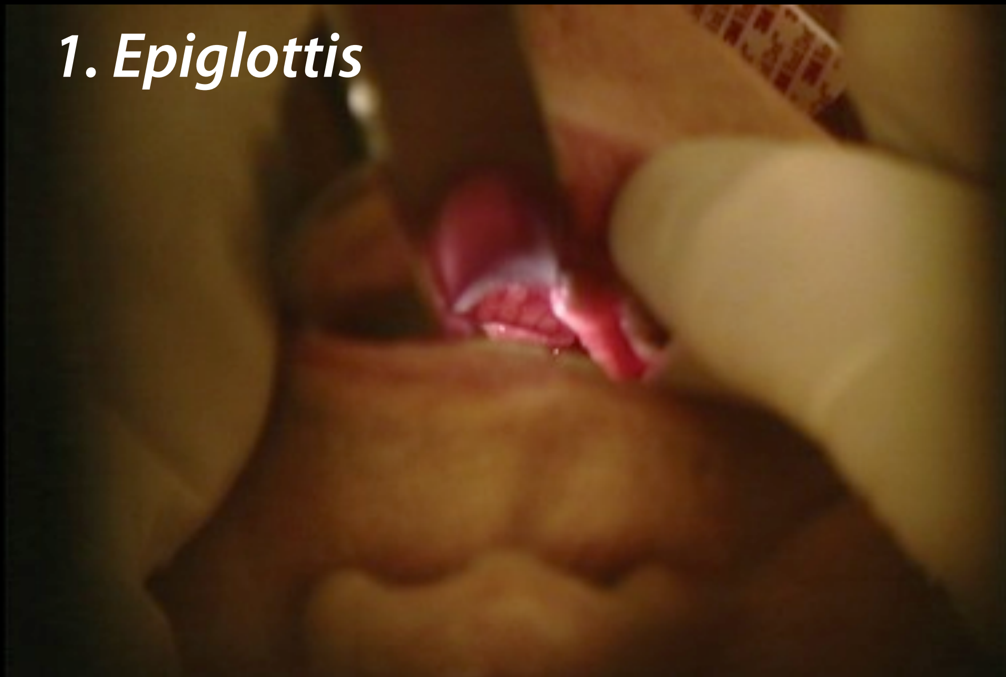
Visualize the epiglottis before exposing the larynx

1895 Kirstein: *"The spatula is introduced in such a manner that its tip catches in the groove between the tongue and the epiglottis...the beginner is liable to hook it behind the epiglottis"*

1912 Brunnings: *"This process may be divided into three stages in the case of all direct examinations of the air-passages. First movement : Bringing into view the lingual surface of the epiglottis..."*

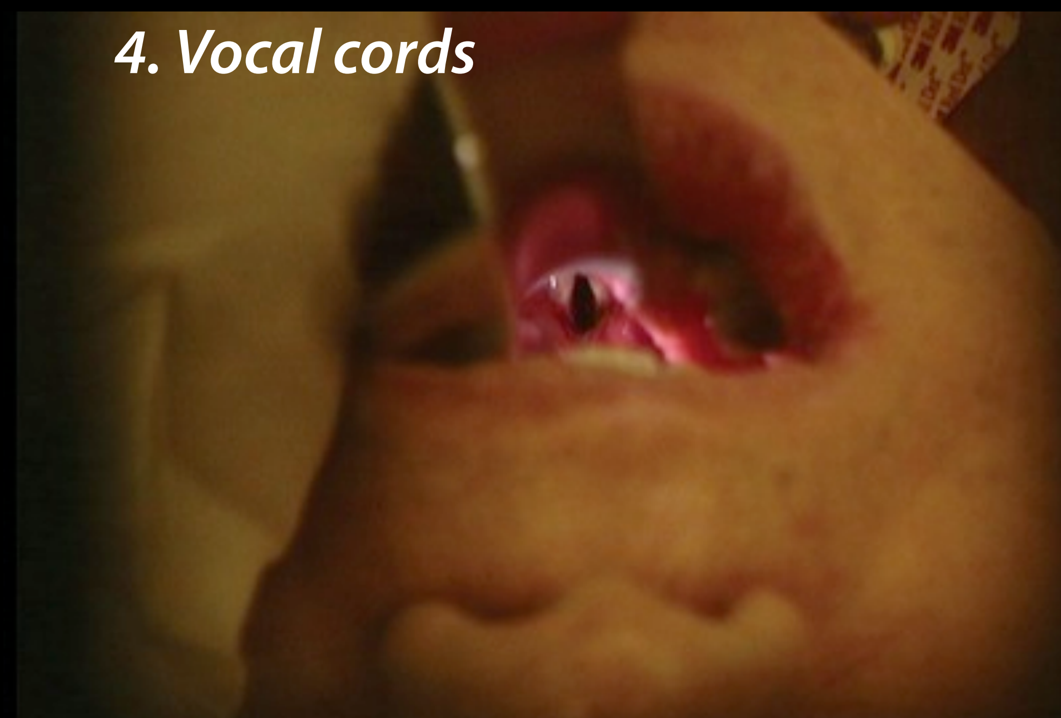
1914 Jackson: *"The introduction of the instrument should be considered in three stages: 1) exposure and identification of the epiglottis..."*

"The epiglottis must always be identified before any attempt is made to expose the larynx"

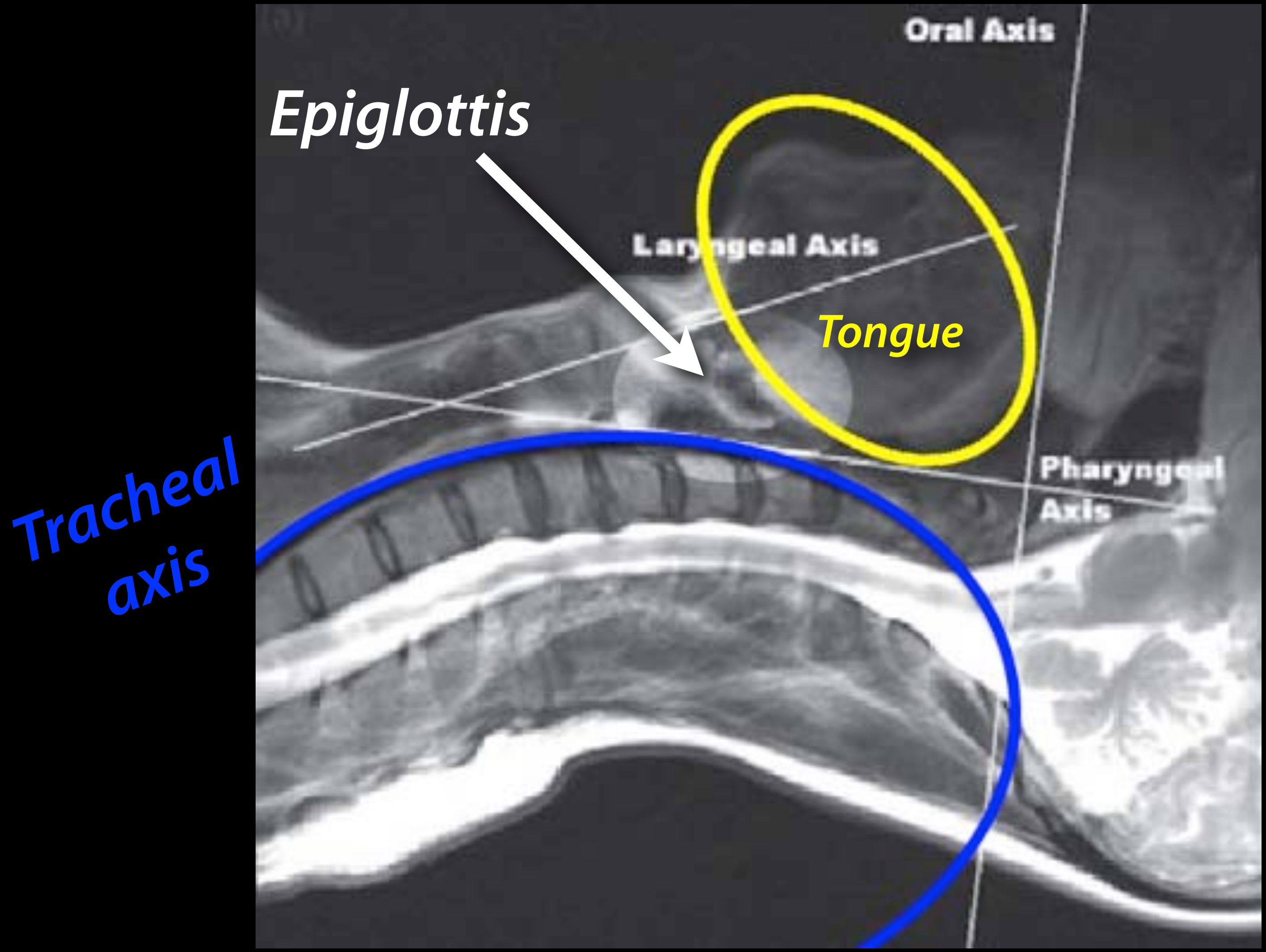

1. Epiglottis


2. Interarytenoid notch


3. Glottic opening


4. Vocal cords

The "SECRET" of laryngoscopy, video laryngoscopy, fiberoptics, any intubation device --- is the EPIGLOTTIS



Epiglottis positioned at intersection of two critical curves.
It is midway from mouth to larynx, and centered between right and left.

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

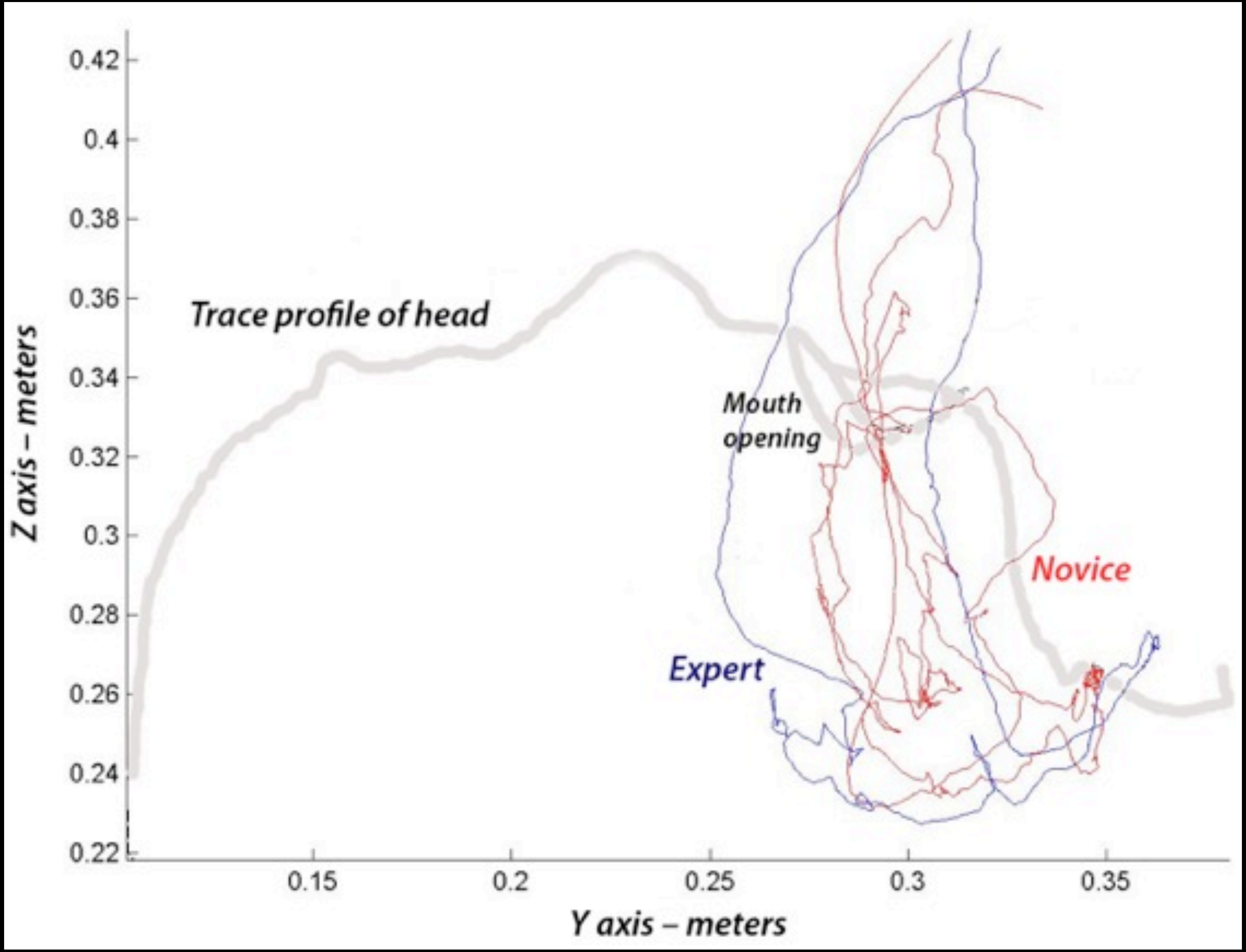
Experts

52 cm tip travel

12 sec time

2.8 Nm torque

66 N max force

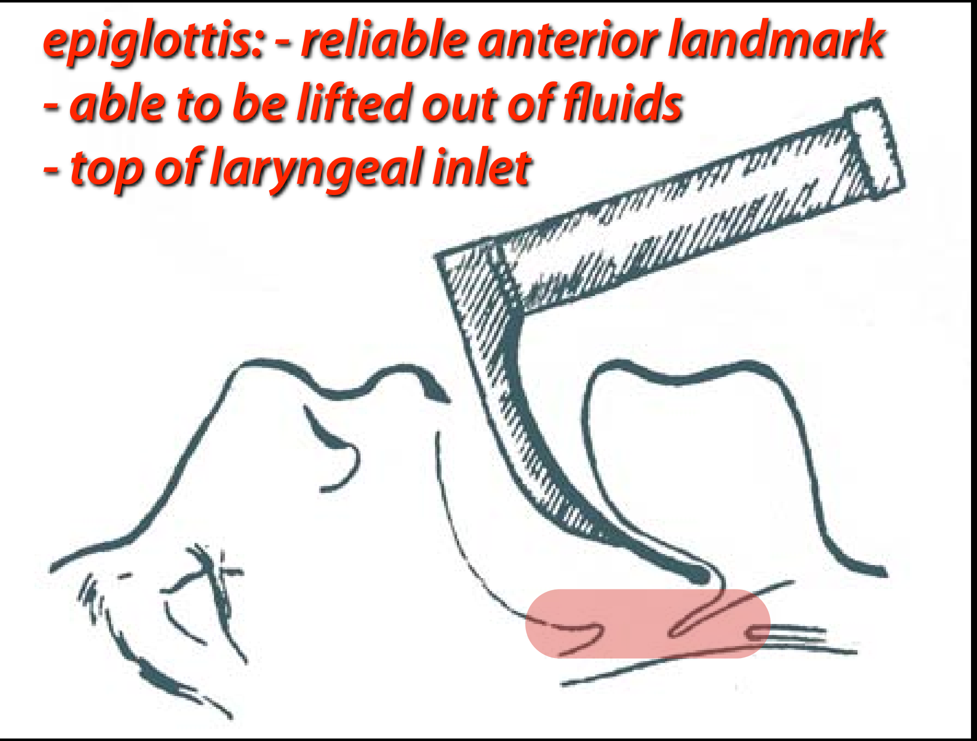


Keys to Epiglottoscopy

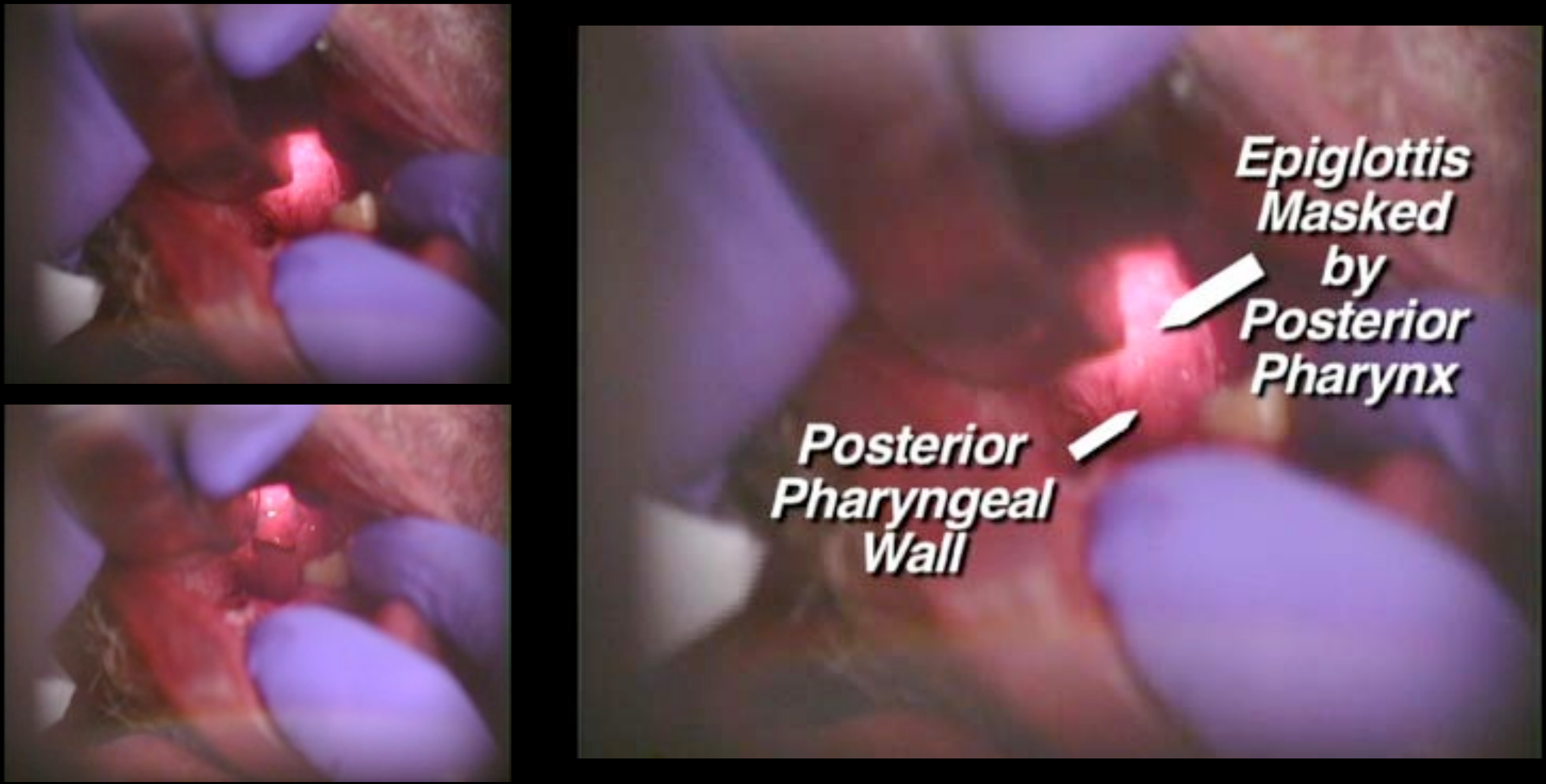
- ★ *Proceed slowly, methodically down tongue*
- ★ *Distract tongue and jaw forward, and lift epiglottis edge off the posterior pharynx*
- ★ *If epiglottis is not seen, march down the tongue midline and then control the tongue*

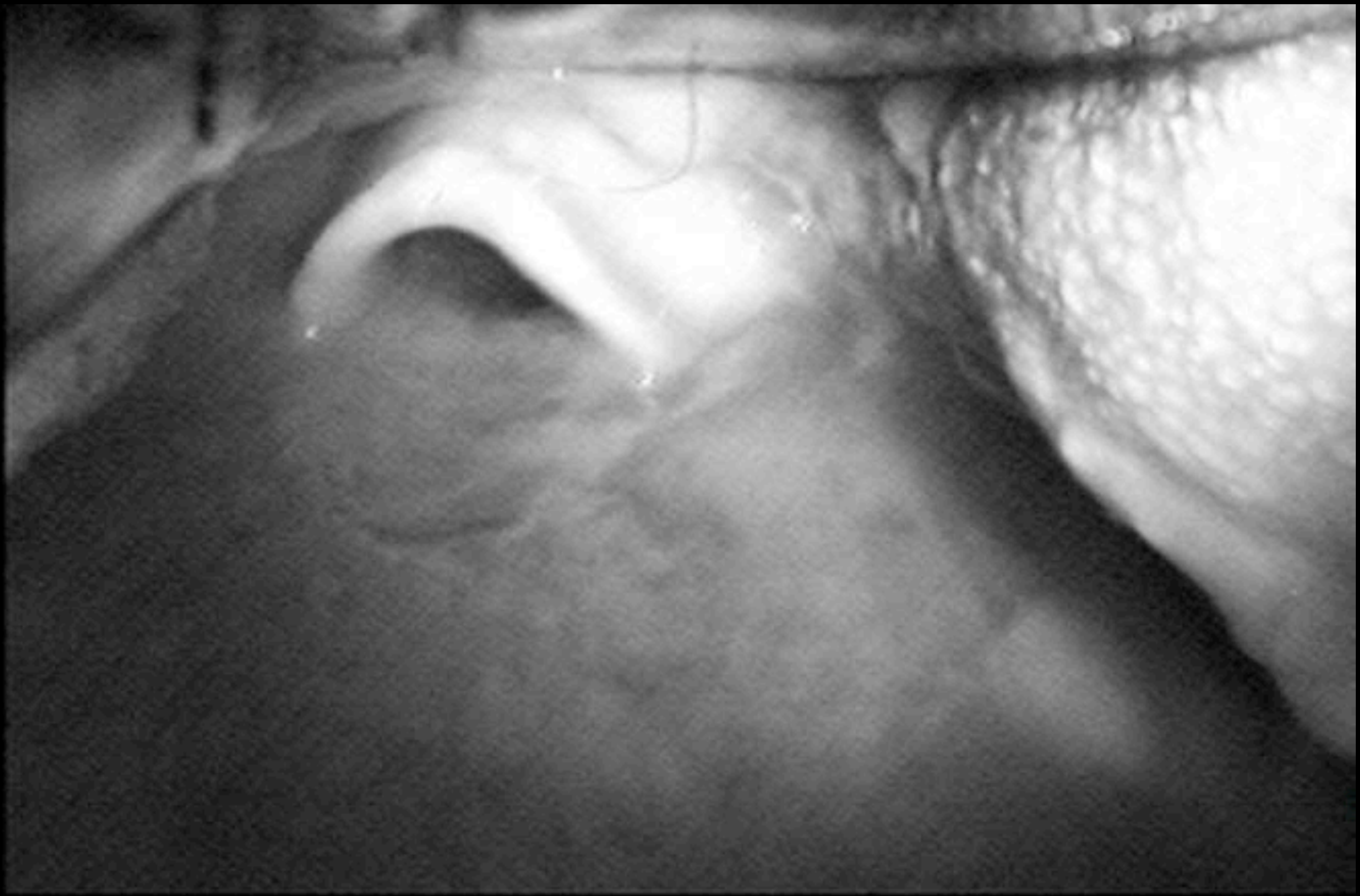
Beware of epiglottis camouflage !

fluids, blood, saliva pool in hypopharynx – use suction tip if needed to clear hypopharynx and see epiglottis edge



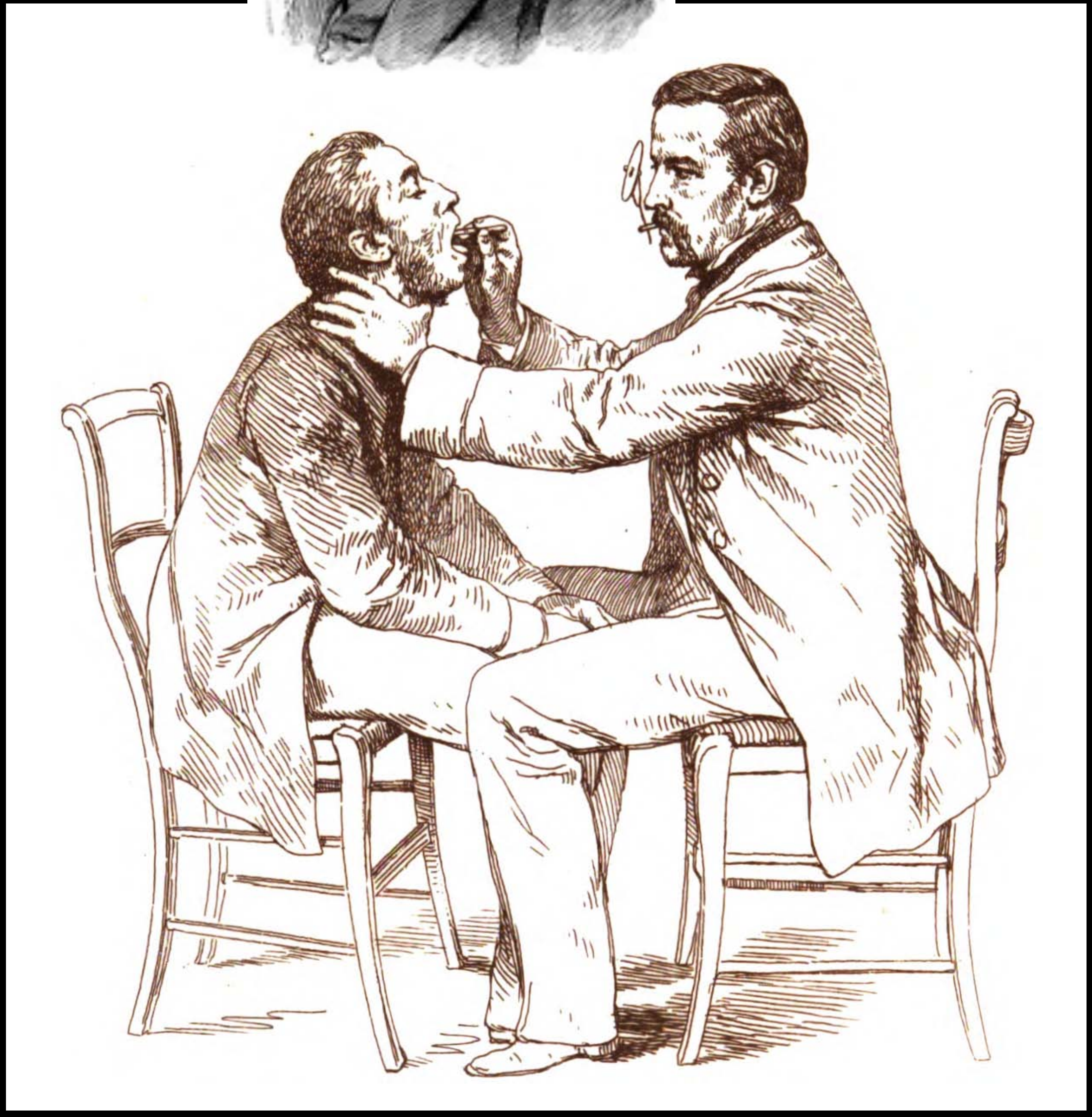
Beware of epiglottis camouflage !





Imaging with Glidescope video system (Verathon)
Epiglottis rests on the posterior pharyngeal wall when starting

Czermak: pioneer of mirror laryngoscopy
Bimanual laryngoscopy 1858



AUTOSCOPY

A. Kirstein.

OF THE

LARYNX AND THE TRACHEA.

(DIRECT EXAMINATION WITHOUT MIRROR.)

BY

ALFRED KIRSTEIN, M.D.,
BERLIN.

AUTHORIZED TRANSLATION (ALTERED, ENLARGED, AND REVISED BY THE AUTHOR) BY

MAX THORNER, A.M., M.D.,
CINCINNATI, O.,
PROFESSOR OF CLINICAL LARYNGOLOGY AND OTOLOGY, CINCINNATI COLLEGE OF MEDICINE AND SURGERY; LARYNGOLOGIST AND AURIST, CINCINNATI HOSPITAL, ETC.

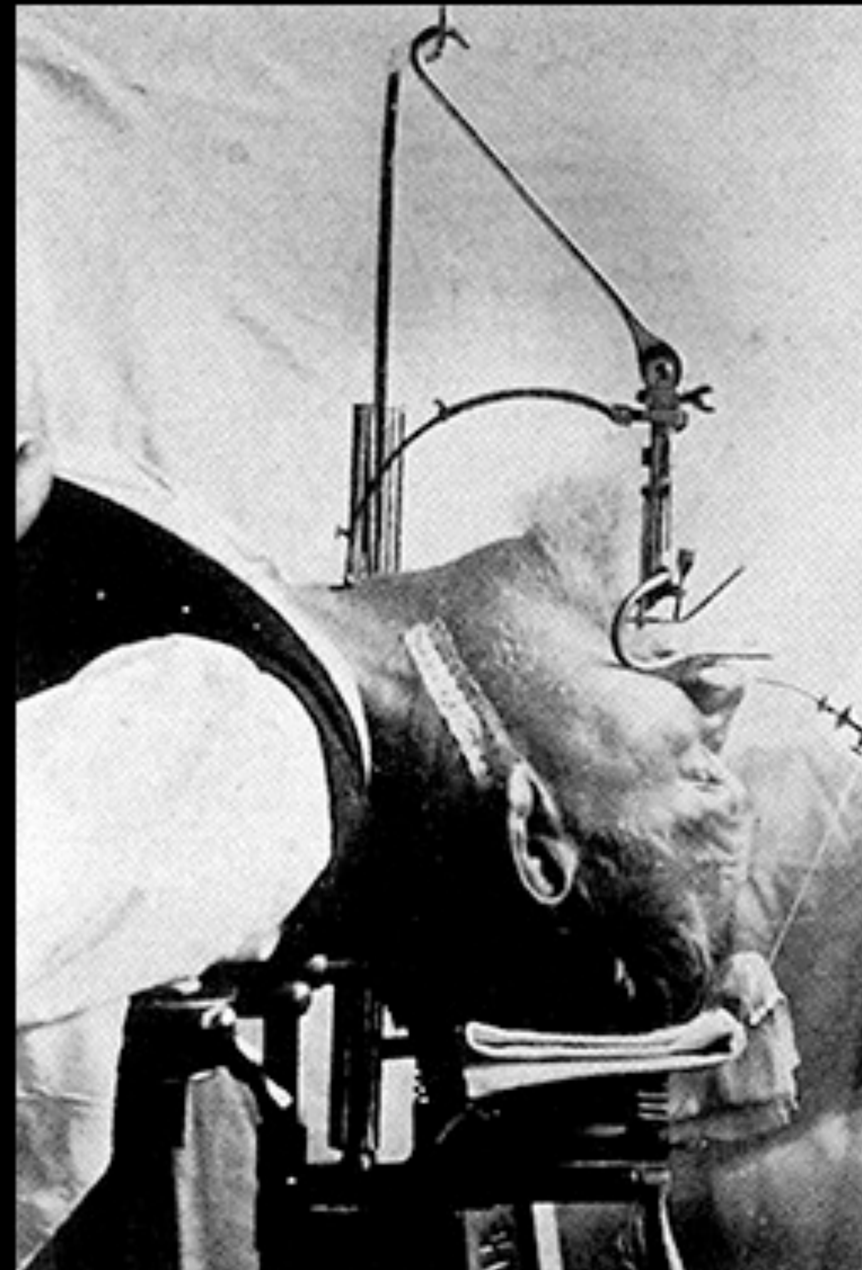
Kirstein 1897

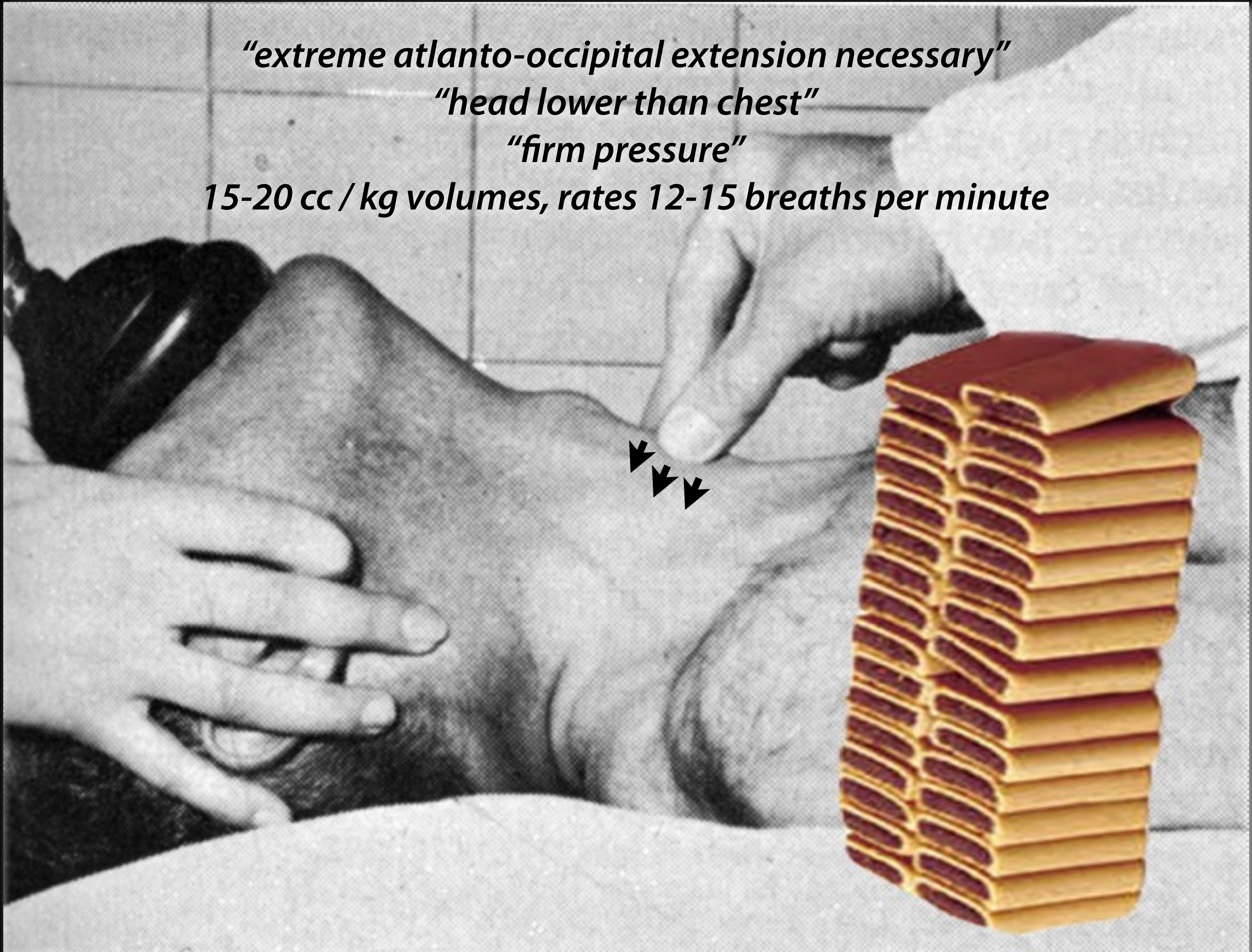
Bimanual laryngoscopy described as a means of improving laryngeal view

By pressure applied with the thumb upon the middle of the thyroid cartilage the autoscopic field of vision toward the front can be considerably enlarged in many, especially in the young. By means of this manipulation—which may in operations be left to an assistant—the anterior commissure can be brought into view rather frequently.

W. Brunnings: DIrect Laryngoscopy, Bronchoscopy, and Oesophagoscopy 1912

Fig. 44.—Direct Operation on the Larynx by Means of Counter-Pressure Autoscopy.





Sellick 1961 photograph in Lancet; arrows & Newtons added

Cricoid Pressure Displaces the Esophagus: An Observational Study Using Magnetic Resonance Imaging

Kevin J. Smith, et al. Anesthesiology 2003; 99: 60-4

– The esophagus lateral to cricoid in 52.6% of necks without CP

– Esophagus lateral to cricoid in 90.5% with CP (20-30 N)

–Unopposed esophagus in 47.4% of necks without CP

– Unopposed esophagus in 71.4% with CP applied

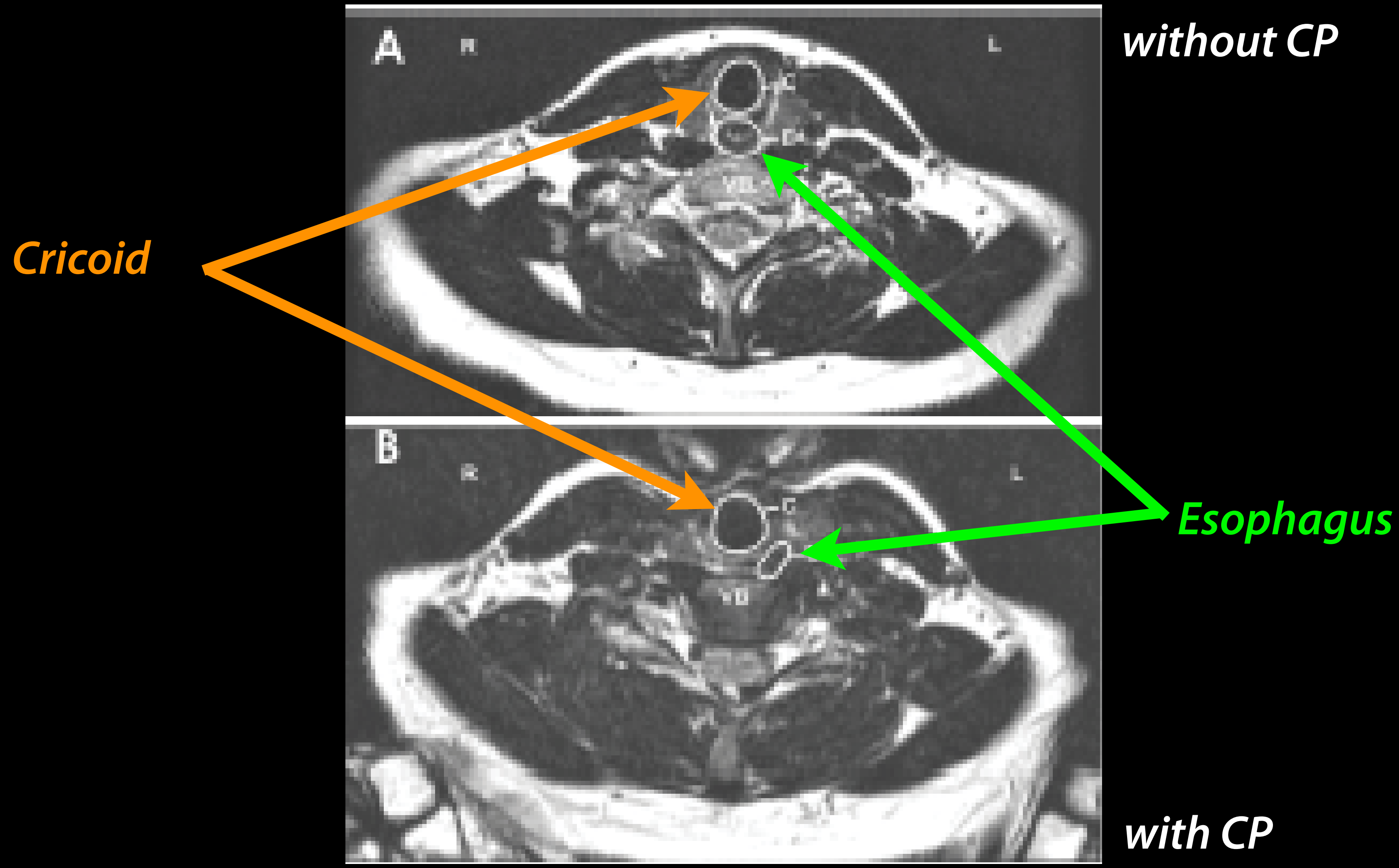
– Lateral laryngeal displacement 66.7%

– Airway compression in 81.0% !

– Without CP, esophagus lateral to the cricoid in > 50%

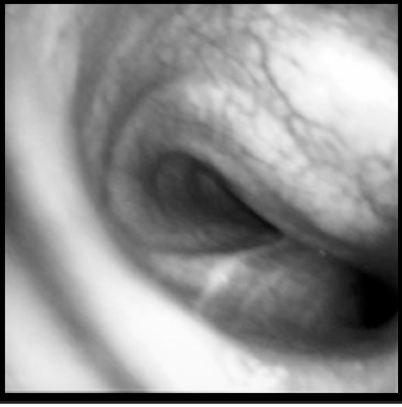
– CP further displaced both the esophagus and the larynx laterally

Cricoid Pressure Displaces the Esophagus:
An Observational Study Using Magnetic Resonance Imaging
Kevin J. Smith, et al. Anesthesiology 2003; 99: 60-4



Cricoid Pressure >> Airway Collapse

The effect of cricoid pressure on the cricoid cartilage and vocal cords: an endoscopic study.
Palmer JHM. Anaesthesia, 2000: 55; 260 – 287.



% Cricoid Deformation	Male (n=15)	Female (n=15)
20 Newtons:		
51-99%	1 (7%)	2 (13%)
100%	0	7 (47%)
30 Newtons:		
51-99%	1 (7%)	0
100%	2 (13%)	11 (73%)
44 Newtons:		
51-99%	1 (7%)	1 (7%)
100%	4 (27%)	11 (79%)

Vocal Cord Closure	Male (n=15)	Female (n=15)
20 Newtons	6 (43%)	6 (50%)
30 Newtons	8 (57%)	7 (58%)
44 Newtons	11 (78%)	7 (58%)

Difficult Ventilation	Male (n=15)	Female (n=15)
20 Newtons	6 (43%)	9 (75%)
30 Newtons	10 (71%)	12 (100%)
44 Newtons	12 (86%)	12 (100%)

Cricoid deformation, vocal cord closure and difficult ventilation all increase with increasing force of CP.
86-100% of patients have difficult ventilation at 44N

The effect of cricoid pressure on airway patency.

Allman KG. J Clin Anesth. 1995; 7: 197-9.

- *50 anesthetized patients; CP applied by anesthesiologists*
- *Ventilated +/- CP and oral airway, observer blinded, order random*
- *CP - decreased mean expired tidal volume (TV)*
- *CP - increased peak inspiratory pressure (PIP)*
- *CP caused COMPLETE AIRWAY OCCLUSION in 11% of patients!*

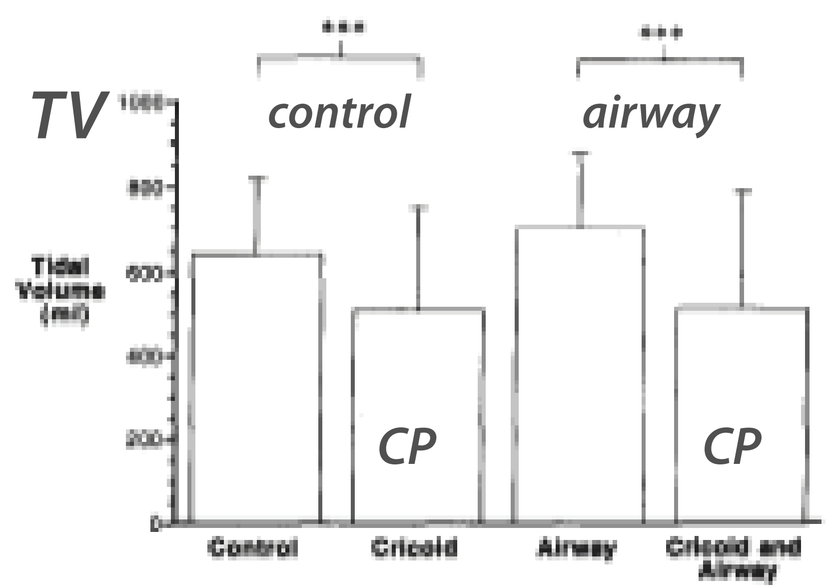


Figure 1. Tidal volume (ml) for each of the four categories. Data are means, with standard deviations. ***$p < 0.001$.

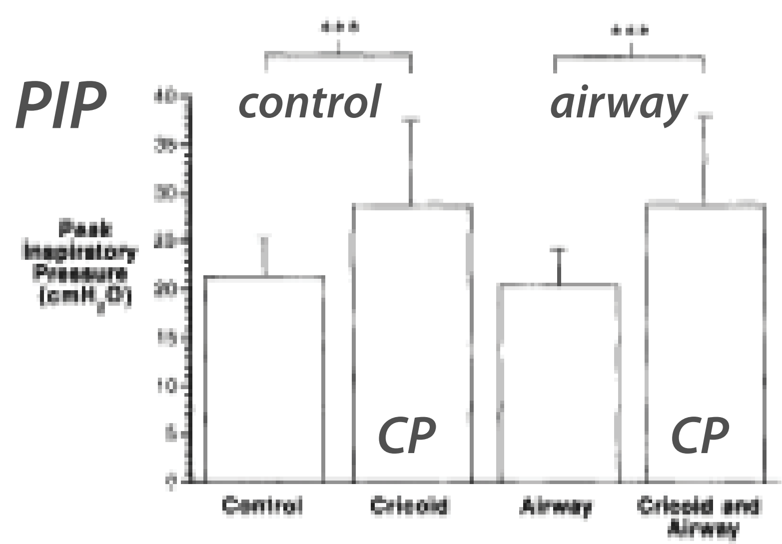


Figure 2. Peak inspiratory pressure (cmH_2O) for each of the four categories. Data are means, with standard deviations. ***$p < 0.001$.

Cricoid Pressure:

THE ROOT OF ALL EVIL !

- Sellick - never validated - Correct force? 44, 40, 30, 20 N
- Poorly performed by all different practitioner groups
- Aspiration despite CP well documented in anesthesia and EM
- Anatomic myth on CT / MRI: esophageal occlusion NOT reliable
- CP collapses cricoid ring, blocks tube passage
- In awake volunteers CP promotes regurgitation (LES effect)
- Detrimental effects on tip of blade positioning and DL view
- Difficult mask ventilation and inability to ventilate
- Detrimental for correct placement of LMA or ETC

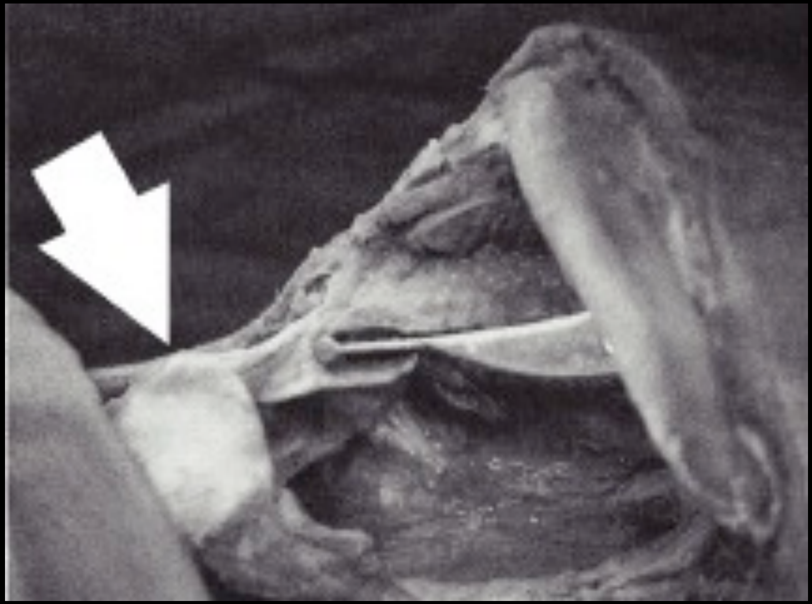
1. Ellis DY: Cricoid pressure in emergency department rapid sequence tracheal intubations: a risk-benefit analysis. Ann EM 2007; 50: 653-66.
2. Neilipovitz DT. No evidence for decreased incidence of aspiration after rapid sequence induction. Can J Anaesth. 2007; 54:748-64.

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*

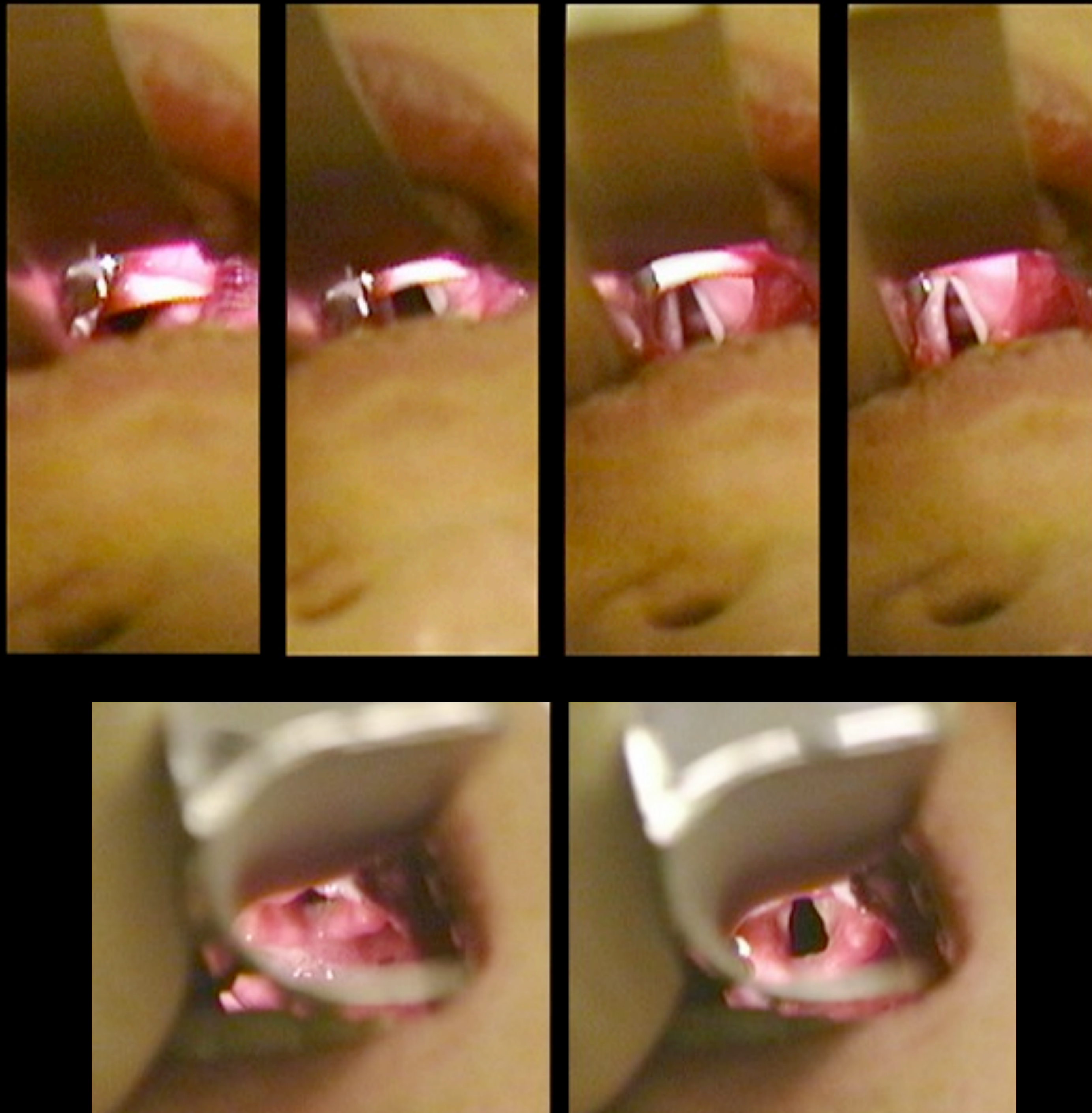
Bimanual Laryngoscopy - By Laryngoscopist

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.



Mobility of larynx with external laryngeal manipulation

Courtesy of George Kovacs, Dalhousie NS

Bimanual laryngoscopy vs. Cricoid vs. BURP

Levitan RM, Kinkle W, Levin W, Butler K.
Annals EM 2006; 47: 548-55.

- *104 participants, 106 cadavers*
- *1530 laryngoscopies*
- *POGO scores to report laryngeal view*
- *Improved exposure*

  (Bimanual vs. CP vs. BURP – all p<.0001)
  - *POGO scores means +25% vs. 5% vs. 4%*
  - *Worsened views: 4% vs. 27% vs. 33%*
  - *Went to zero: 0.5% vs. 3% vs. 6%*
  - *Mean POGOs Bimanual vs. CP, BURP: +20%, +21%*

Cricoid Pressure:
Demoted in new AHA Guidelines

Cricoid pressure in nonarrest patients may offer some measure of protection to the airway from aspiration and gastric insufflation during bag-mask ventilation. However, it also may impede ventilation and interfere with placement of a supraglottic airway or intubation...

If cricoid pressure is used in special circumstances during cardiac arrest, the pressure should be adjusted, relaxed, or released if it impedes ventilation or advanced airway placement.

The routine use of cricoid pressure in cardiac arrest is not recommended (Class III, LOE C).

Part 8: Adult Advanced Cardiovascular Life Support:
2010 American Heart Association Guidelines
for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Hrn Geheimrath Ewald
verehrungsvoll
A. Kirstein.

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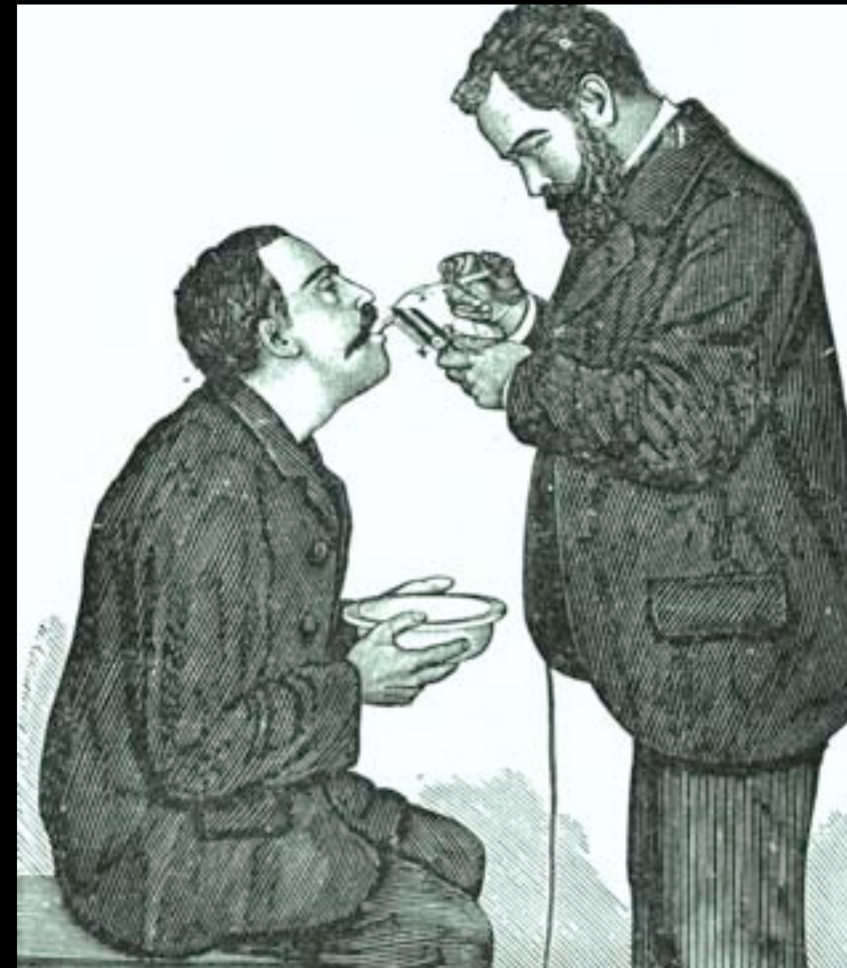
WITH TWELVE ILLUSTRATIONS.

PHILADELPHIA.
THE F. A. DAVIS CO., PUBLISHERS.
1897.



TO

J. SOLIS-COHEN, M.D.,

OF PHILADELPHIA,

THIS TRANSLATION IS DEDICATED,

IN

GRATEFUL RECOGNITION OF MUCH PERSONAL KINDNESS,

BY

THE TRANSLATOR AND EDITOR.

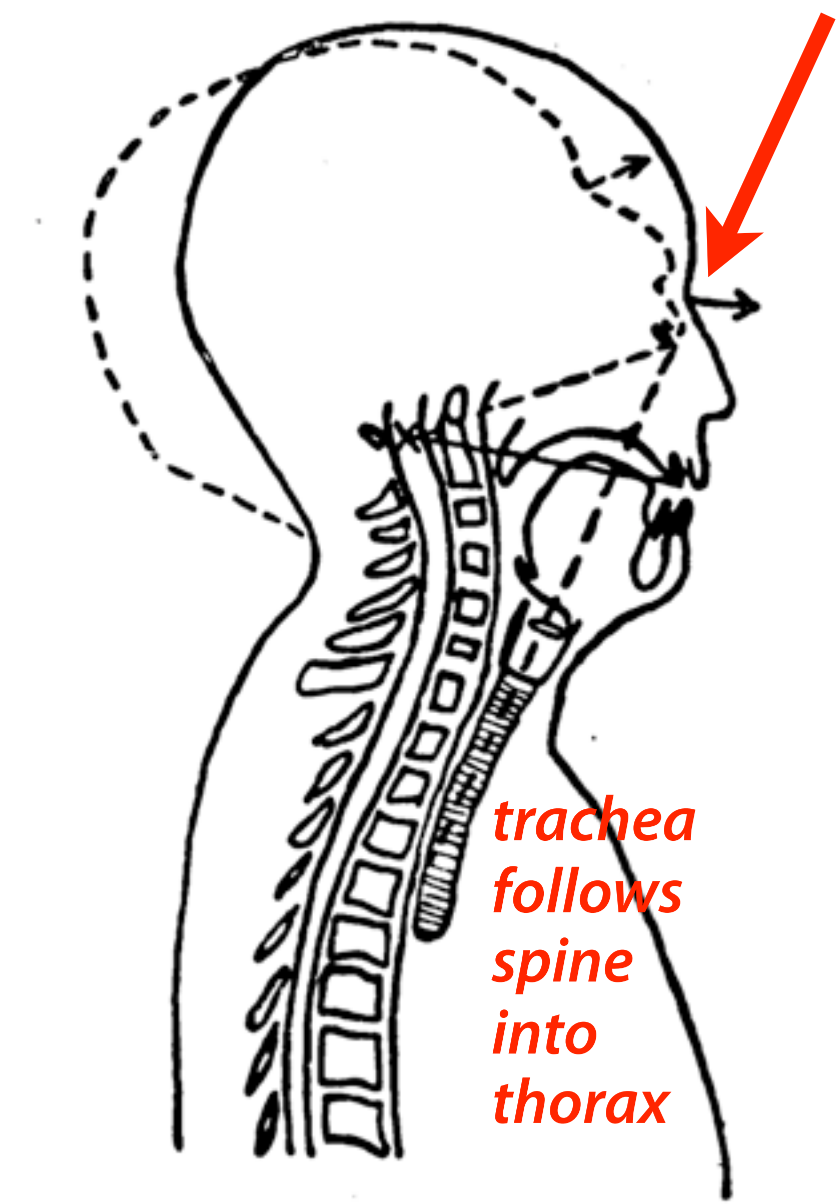


Fig. 1.—Position for Autoscopy.

× = atlanto-occipital articulation. ——> = axis of vision.

AUTOSCOPY.

DEFINITION AND THEORY.

By "autoscopy of the air-passages" I understand the direct linear inspection, through the mouth, of the lower pharynx, the larynx, the trachea, and the entrances into the primary bronchi.

The necessary conditions of such a complete linear inspection can be stated *a priori* to be:—

1. The body must be placed in such a position that an imaginary continuation of the laryngo-tracheal tube would fall within the opening of the mouth.

2. This imaginary straight line must be cleared of those parts of the body (epiglottis and base of the tongue) which obstruct it.

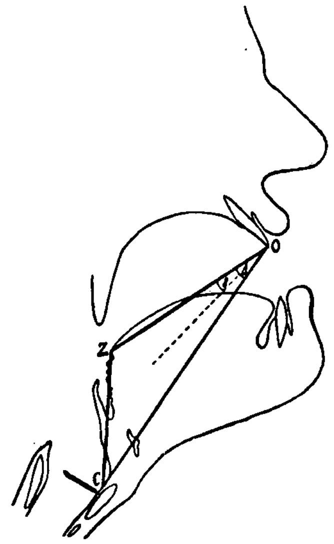


Fig. 8.—Displacement of Tongue in Autoscopy.

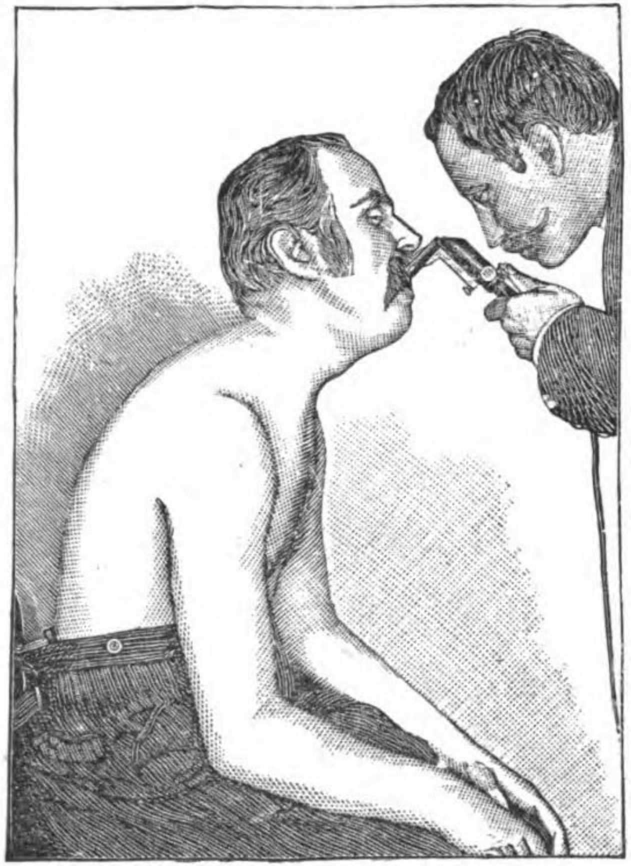
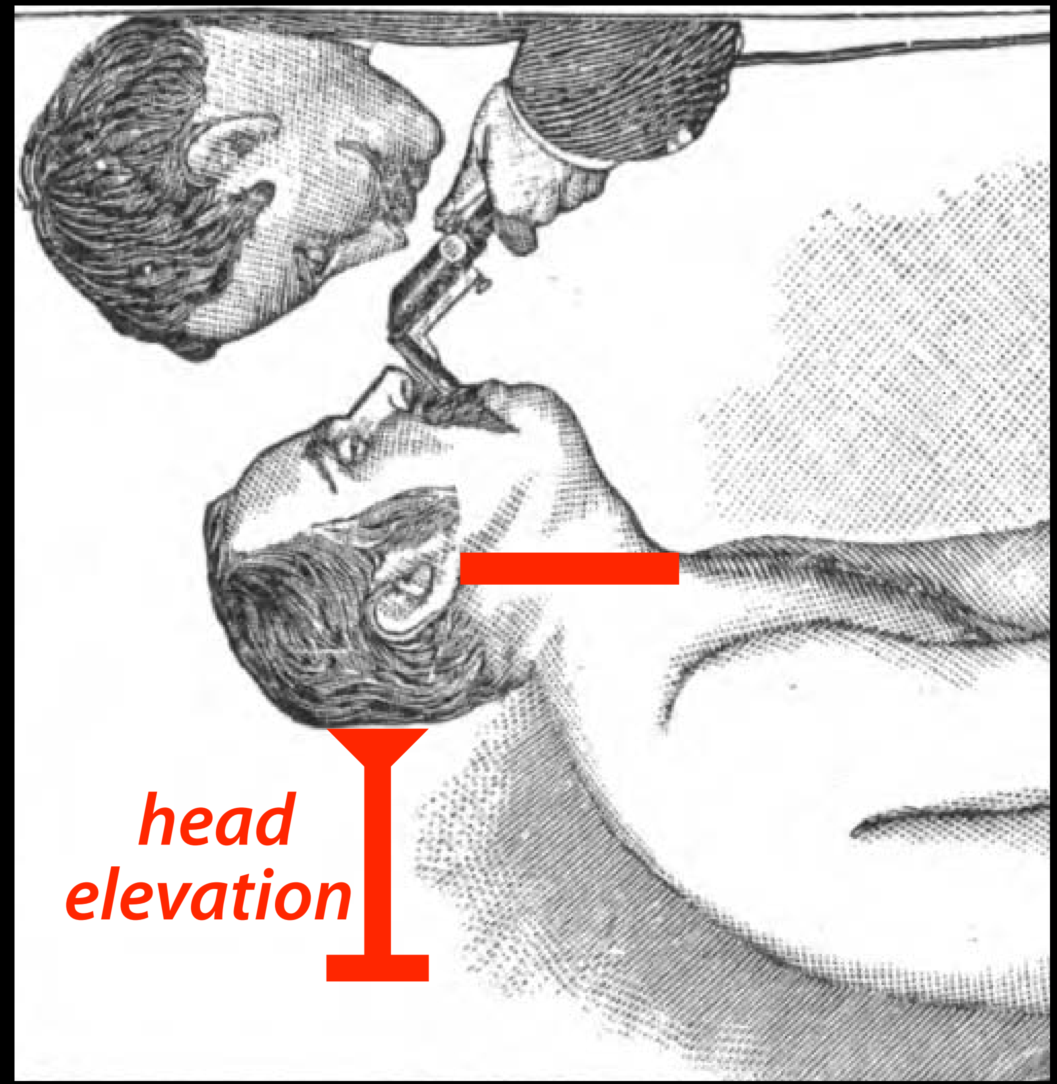


FIG. 6.—POSITION FOR AUTOSCOPY.

This photograph was taken from a partly stripped patient in order to show distinctly the position of head and neck during examination.



Kirstein 1897 : "...the forward inclination of the body has the further advantage that the muscles of the neck become somewhat relaxed..."

BRONCHOSCOPY

AND

ESOPHAGOSCOPY

A MANUAL OF PERORAL ENDOSCOPY AND LARYNGEAL SURGERY

By

CHEVALIER JACKSON, M.D., F.A.C.S.

Professor of Laryngology, Jefferson Medical College, Philadelphia; Professor of Bronchoscopy and Esophagoscopy, Graduate School of Medicine, University of Pennsylvania; Member of the American Laryngological Association; Member of the Laryngological, Rhinological, and Otological Society; Member of the American Academy of Ophthalmology and Oto-Laryngology; Member of the American Bronchoscopic Society; Member of the American Philo sophical Society; etc., etc.

WITH 114 ILLUSTRATIONS AND FOUR COLOR PLATES

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1922

POSITION OF THE PATIENT FOR PERORAL ENDOSCOPY

It is the author's invariable practice to place the patient in the dorsally recumbent position. The sitting position is less favorable. While lying on a well-padded, flat table the patient is readily controlled, the head is freely movable, secretions can be easily removed, the view obtained by the endoscopist is truly direct (without reversal of sides), and, most important, the employment of one position only favors smoother and more efficient team work, and a better endoscopic technic.

General Principles of Position.—As will be seen in Fig. 47 the trachea and esophagus are not horizontal in the thorax, but their long axes follow the curves of the cervical and dorsal spine. Therefore, if we are to bring the buccal cavity and pharynx in a straight line with the trachea and esophagus it will be found necessary to elevate the whole head above the plane of the table, and at the same time make extension at the occipito-atloid joint. By this maneuver the cervical spine is brought in line with the upper portion of the dorsal

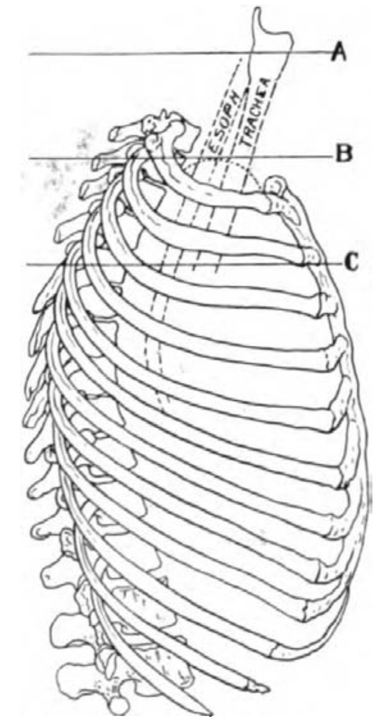


Fig. 47.—Schematic illustration of normal position of the intra-thoracic trachea and esophagus and also of the entire trachea when the patient is in the correct position for peroral bronchoscopy. When the head is thrown backward (as in the Rose position) the anterior convexity of the cervical spine is transmitted to the trachea and esophagus and their axes deviated. The anterior deviation of the lower third of the esophagus shows the anatomical basis for the "high low" position for esophagoscopy

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AND

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PHILADELPHIA AND LONDON
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Jackson applied positioning principles to supine patients

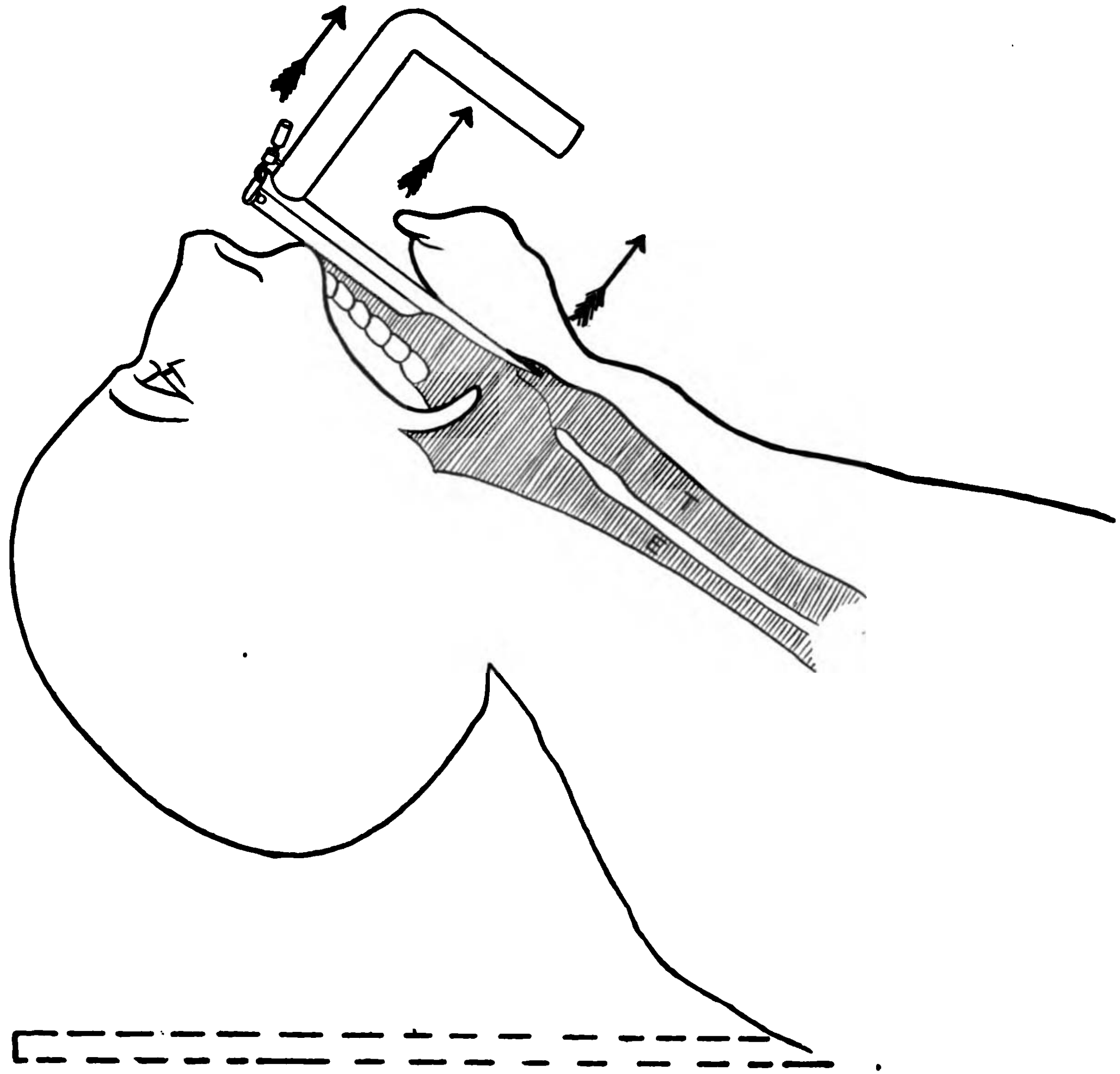
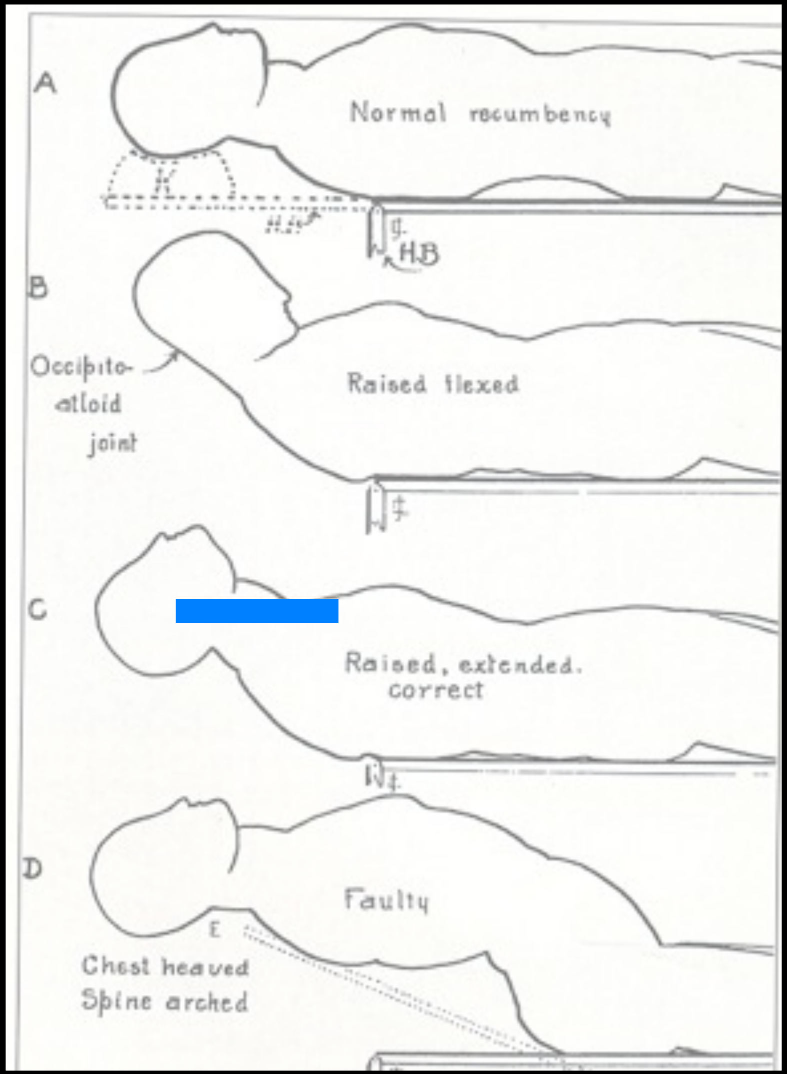


FIG. 55.—Schema illustrating the technic of direct laryngoscopy on the recumbent patient The motion is imparted to the tip of the laryngoscope as if to lift the patient by his hyoid bone. The portion of the table indicated by the dotted line may be dropped or not, but the back of the head must never go lower than here shown, for direct laryngoscopy; and it is better to have it at least 10 cm. above the level of the table. The table may be used as a rest for the operator's left elbow to take the weight of the head. (Note that in bronchoscopy and esophagoscopy the head section of the table *must* be dropped, so as to leave the head and neck of the patient out in the air, supported by the second assistant.)

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



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."

The Modern Theory of Positioning -and 3 axis alignment - comes from Bannister and Macbeth's 1946 article:

Bannister FB, Macbeth RG. Direct laryngoscopy and Tracheal Intubation. Lancet, Nov 1944; 651-654.

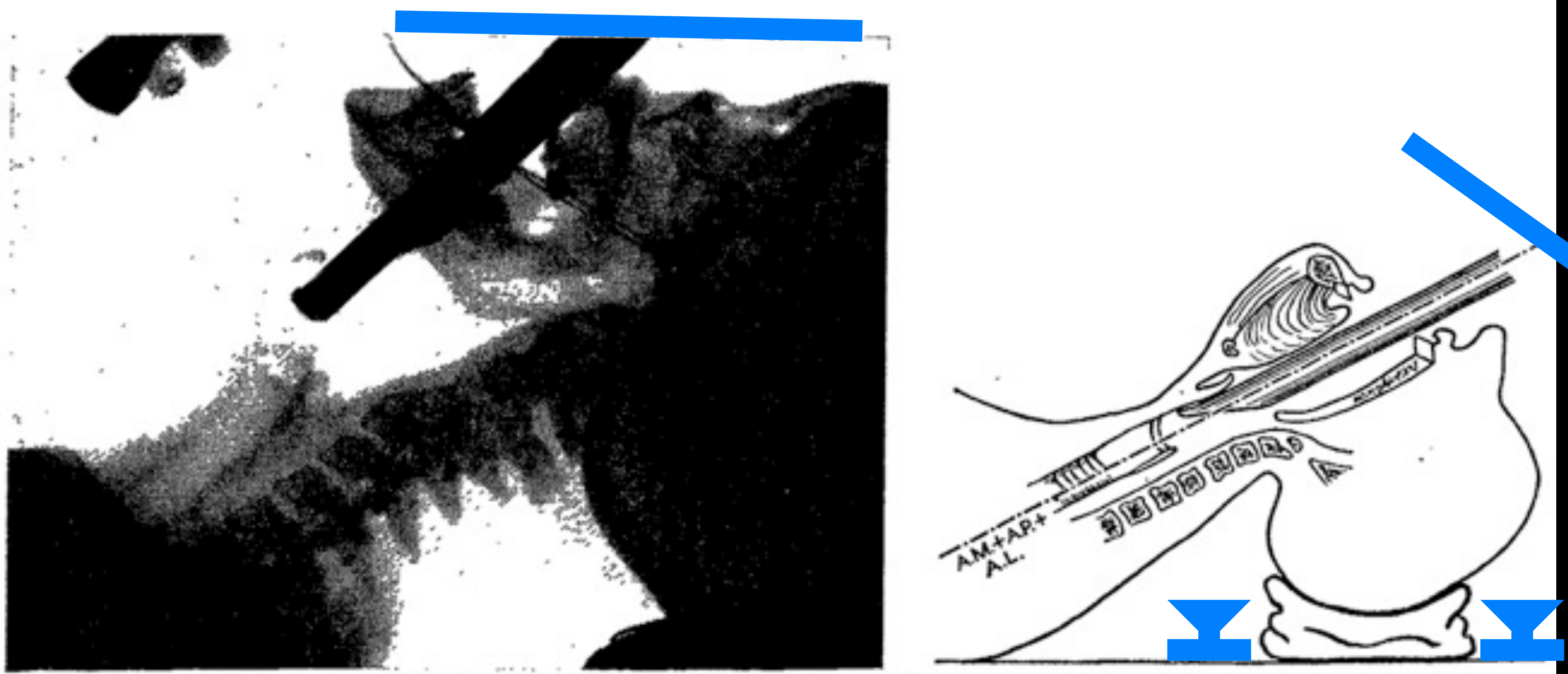


Fig. 3—Axis of the mouth is now made to coincide with the other axes by extension of the head around the atlanto-occipital and *upper* cervical joints.

Radiograph shows face plane parallel to ceiling, drawing over-emphasizes degree of extension and has inadequate lift

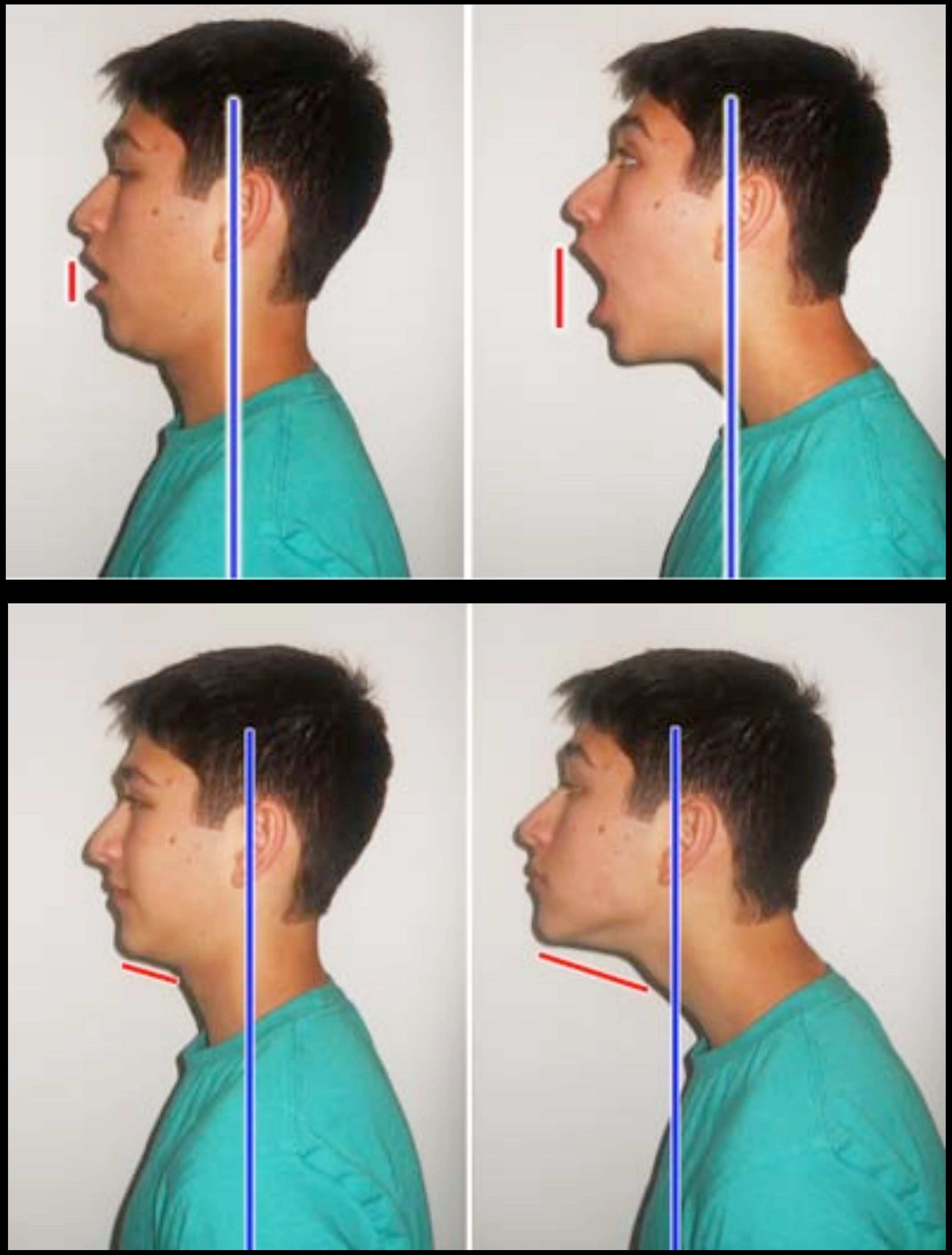
Effect of different head positions on upper airway dimensions and mechanics of jaw opening

Atlanto-occipital Extension | *Neutral* | *Head forward positioning*

...there's a reason everyone in respiratory distress positions their head forward relative to their chest

Atlanto-occipital extension (tilting head backward) does NOT open the airway

Courtesy of
George Kovacs, MD
Dalhousie NS
Emergency Medicine

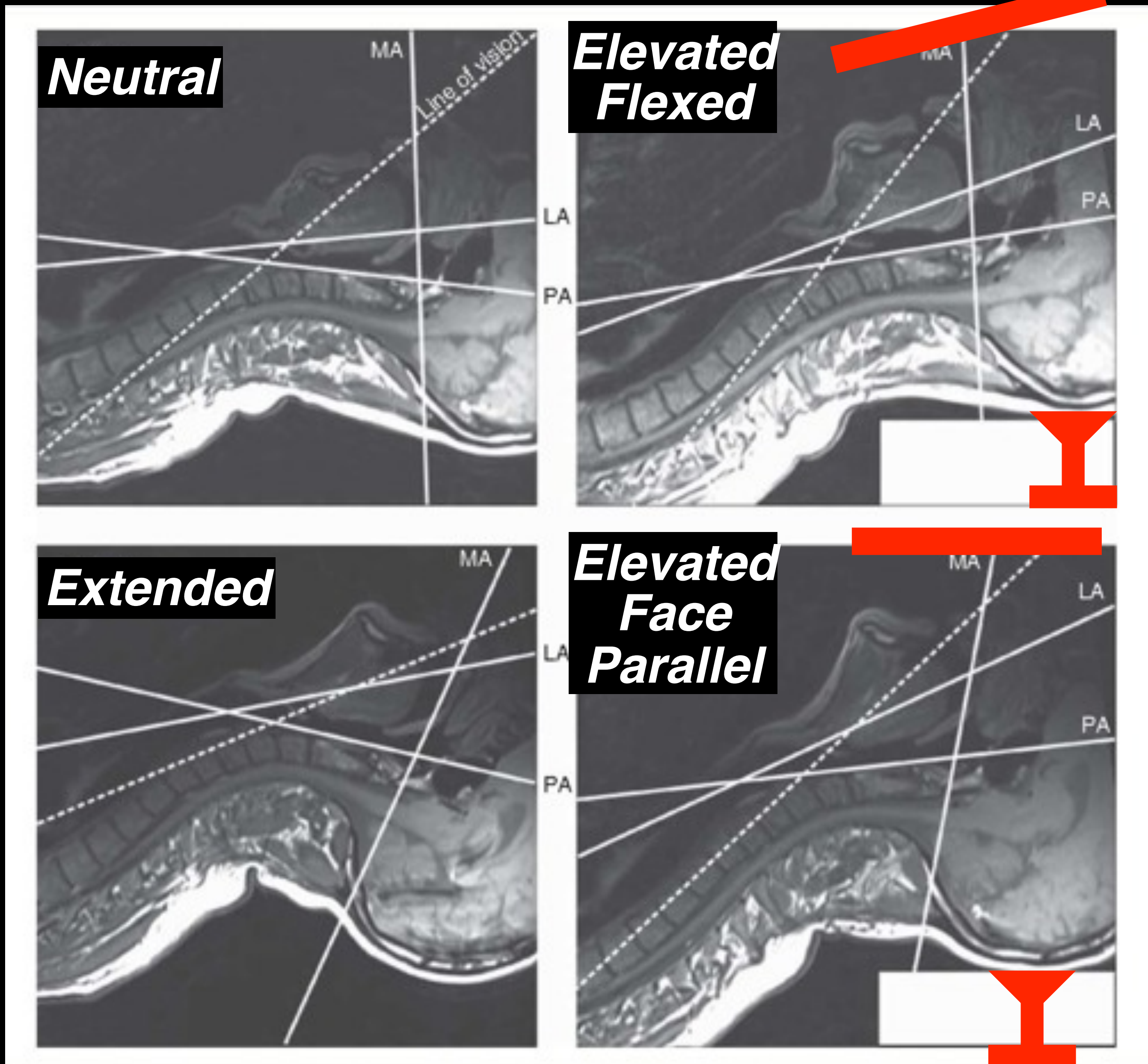


Jaw mechanics:

Mouth opening:
widest with head brought forward relative to chest

Thyromental distance:
space tongue gets pushed into during laryngoscopy, enlarges with head forward

Changes in airway configuration with different head and neck positions using magnetic resonance imaging of normal airways: a new concept with possible clinical applications.



Greenland KB, Edwards MJ, Hutton NJ, Challis VJ, Irwin MG, Sleigh JW. Br J Anaesth. 2010 Nov; 105 (5):683-90.

MRI validation

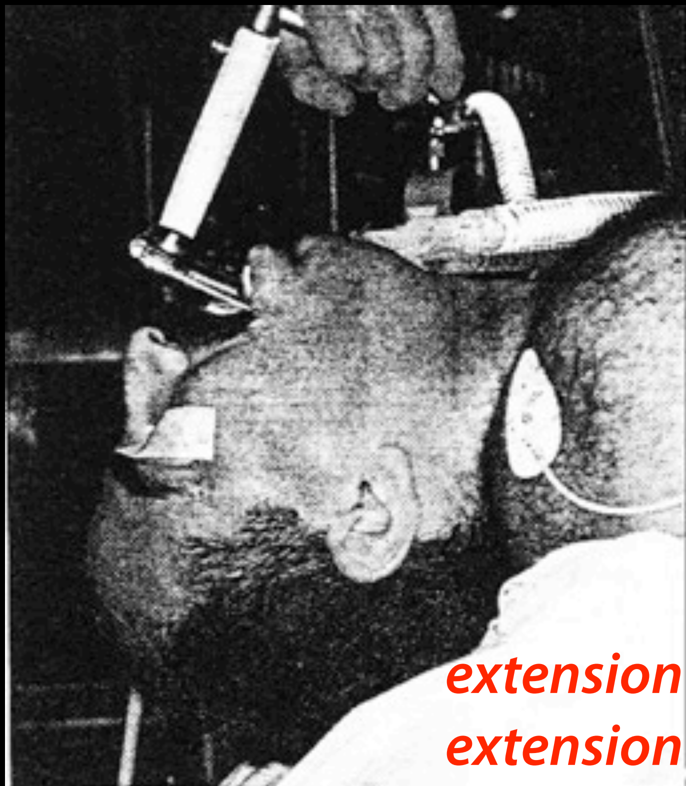
of head elevation

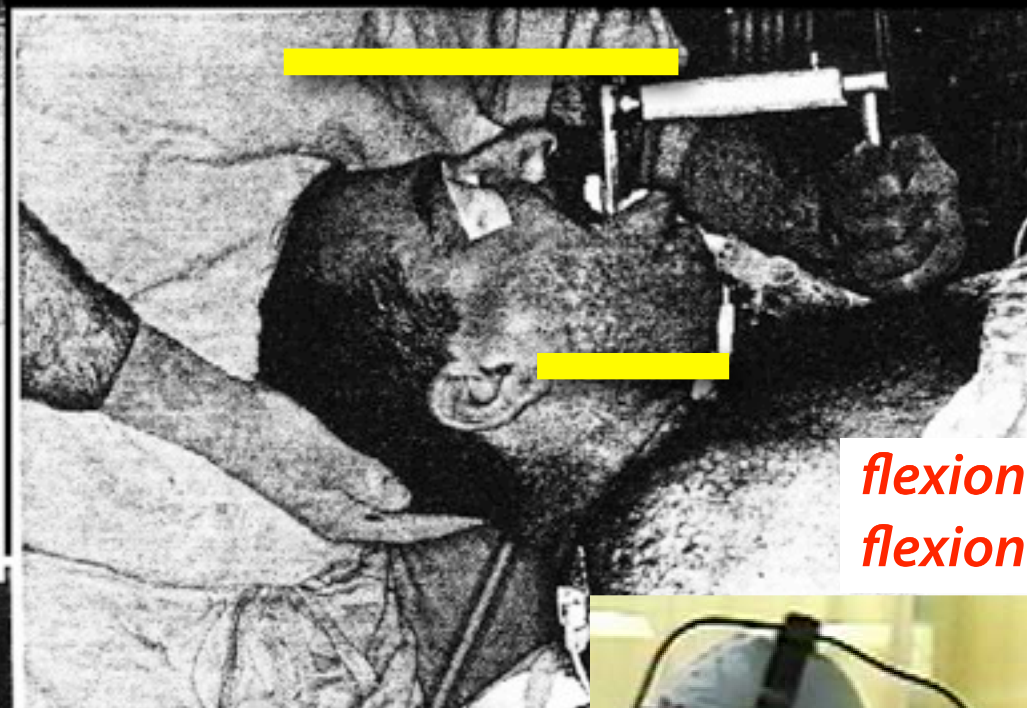
and face plane

parallel to ceiling

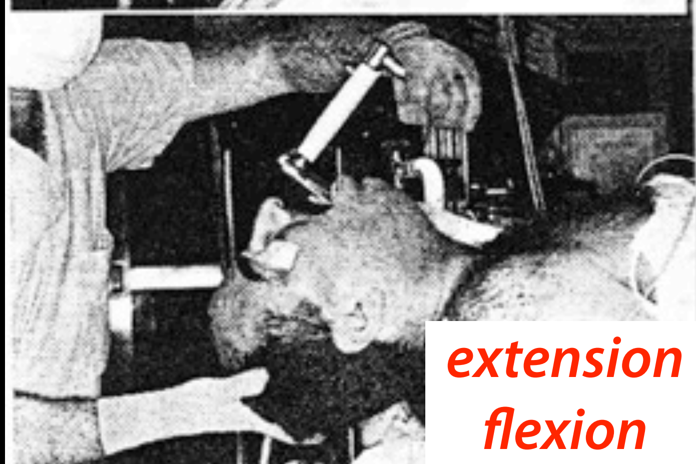
head elevation

Hochman II, Zeitels SM, Heaton JL.
Analysis of the forces and position required for direct laryngocopic exposure of the anterior vocal folds.
Ann Otol Rhinol Laryngol 108; 1999: 715-724

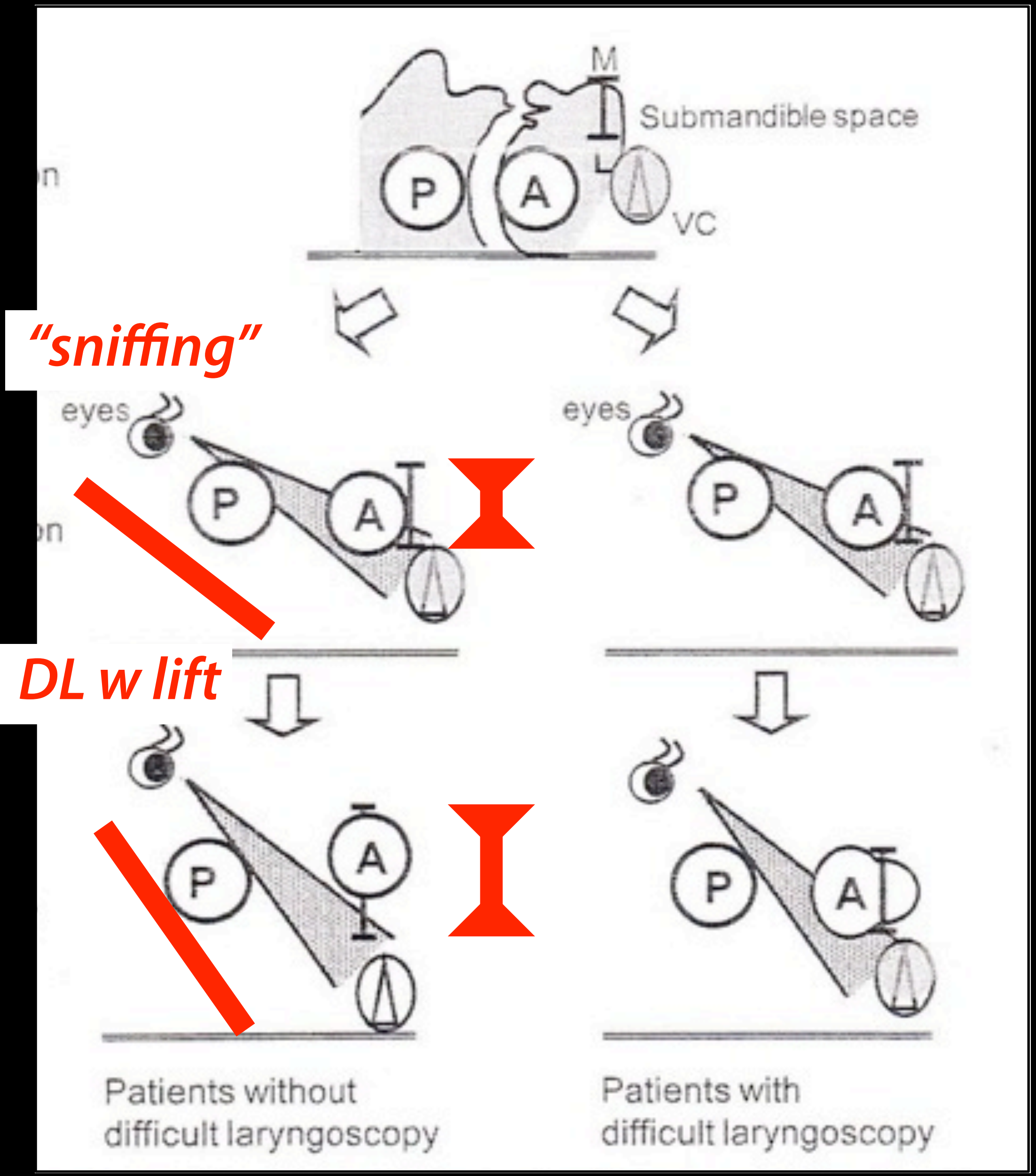




Ear aligned with sternal notch



Zeitels gave 1998 ASA Lewis H. Wright Memorial Lecture on Flexion-Flexion Positioning

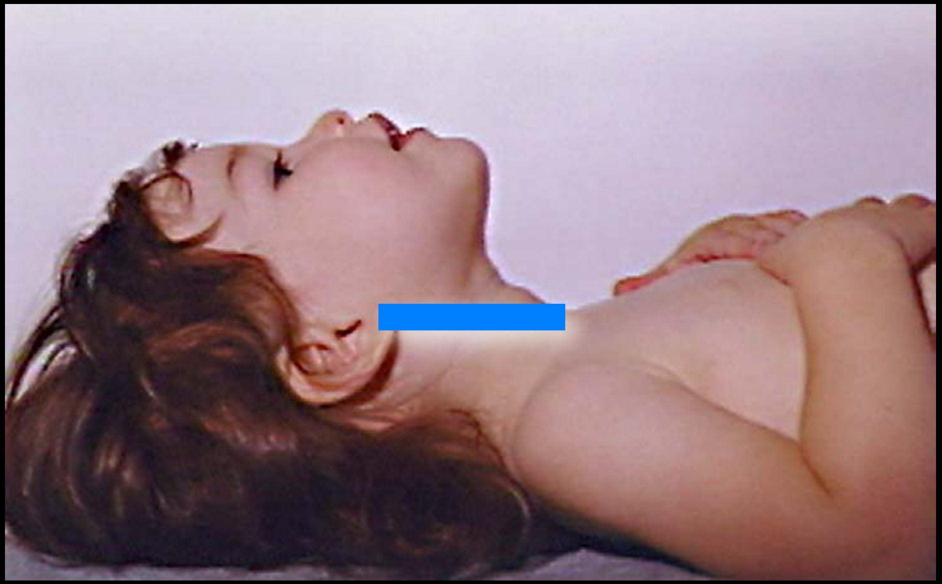


Kitamura Y, et al.
Dynamic interaction of craniofacial structures during head positioning and direct laryngoscopy...
Anesth 2007, 107; 875-83.

Caudal and upward movements of the mandible and tongue base increase the distance between anterior and posterior obstacles ...an increase of the submandibular space may be essential for caudal movements of anterior obstacles, allowing vertical arrangement of the anterior obstacles and larynx.

Lifting the head lengthens the submandibular space (from M – L), allowing the anterior structures to be distracted forward and upward. Note how axis of view steepens between positions.

Ear-to-sternal notch



Elevate the head until the ear is at the sternal notch

Universal intubating and ventilation position
Independent of age and size

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.

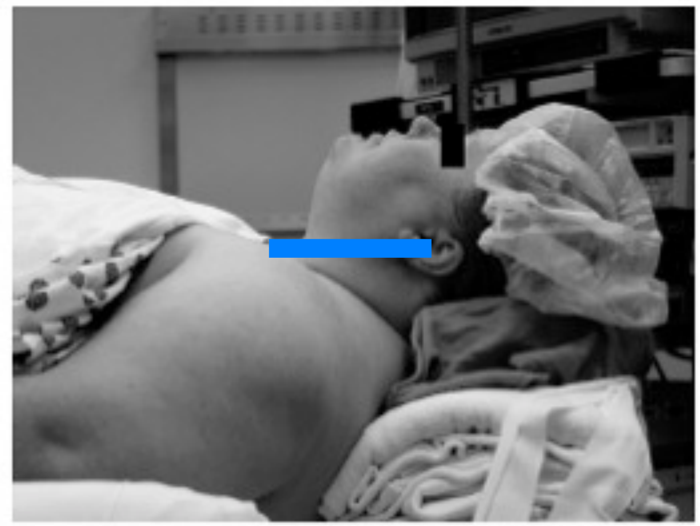


Figure 2. Patients in Group 2 had folded blankets placed under their upper body, head and neck until horizontal alignment between the sternal notch space and the external auditory meatus was achieved.

Laryngoscopy 100% success
View better with head elevation

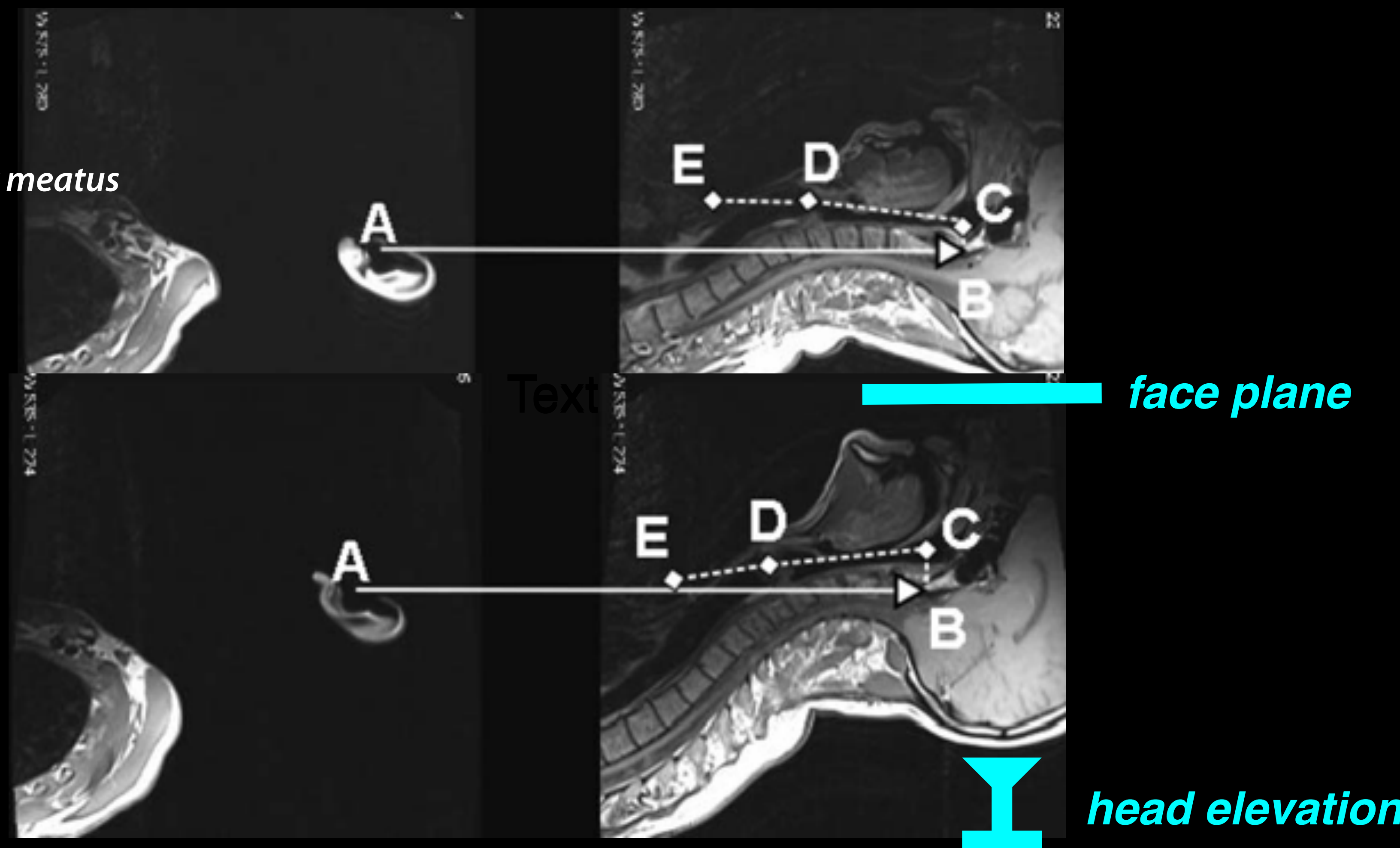
Table 2. Comparison of views during laryngoscopy

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

External auditory meatus–sternal notch relationship in adults in the sniffing position: a magnetic resonance imaging study

Greenland KB, Edwards MJ, Hutton NJ. *Br J Anaesth. 2010 Feb;104(2):268-9.*

A: External auditory meatus
B: Clivus
C: Nasopharynx
D: Glottis
E: Sternal notch



"We have found that the external meatus and sternal notch reflect the positions of the clivus and glottis opening, respectively. These secondary markers may assist in correctly positioning any patients in the sniffing position before direct laryngoscopy in both non-obese and obese patients."

Head Elevated Laryngoscopy Position: Improving Laryngeal Exposure During Laryngoscopy by Increasing Head Elevation

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

Figure 2.

Laryngoscopy with the head flat on the table with an angle finder attached lengthwise to the laryngoscope handle. The laryngoscope angle is approximately 40°. Inset is the view of the larynx as displayed by the direct laryngoscopy video system worn by the laryngoscopist. The POGO score is approximately 30%.

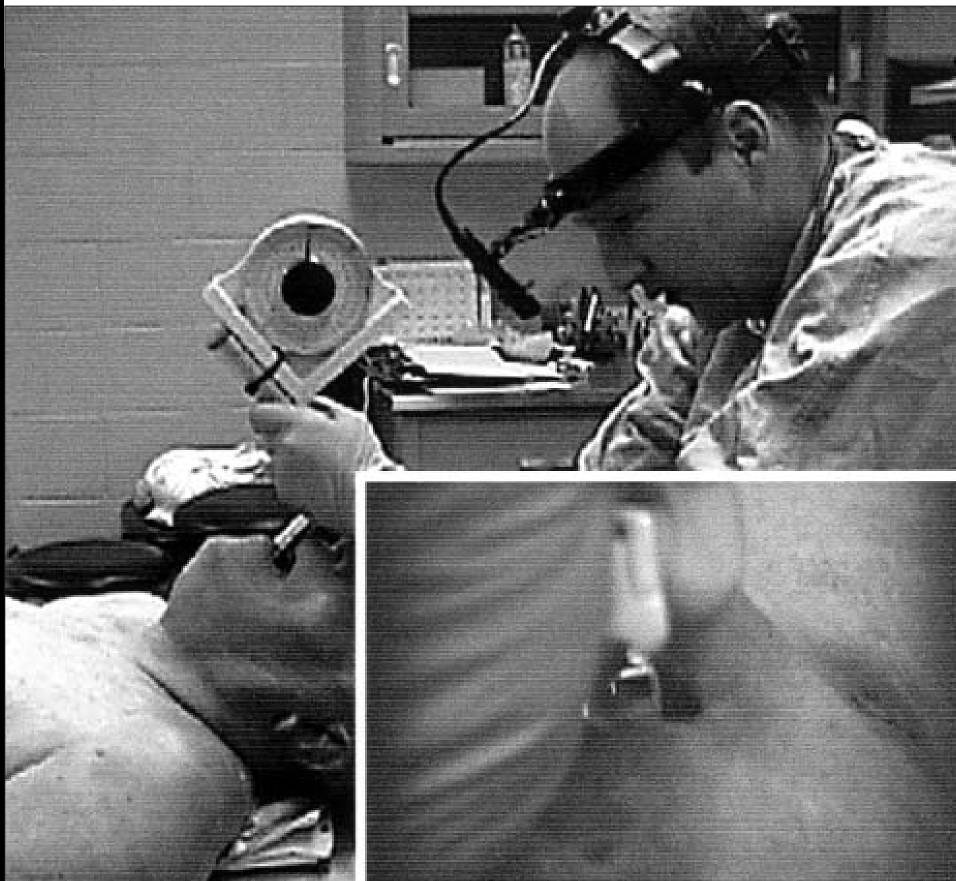
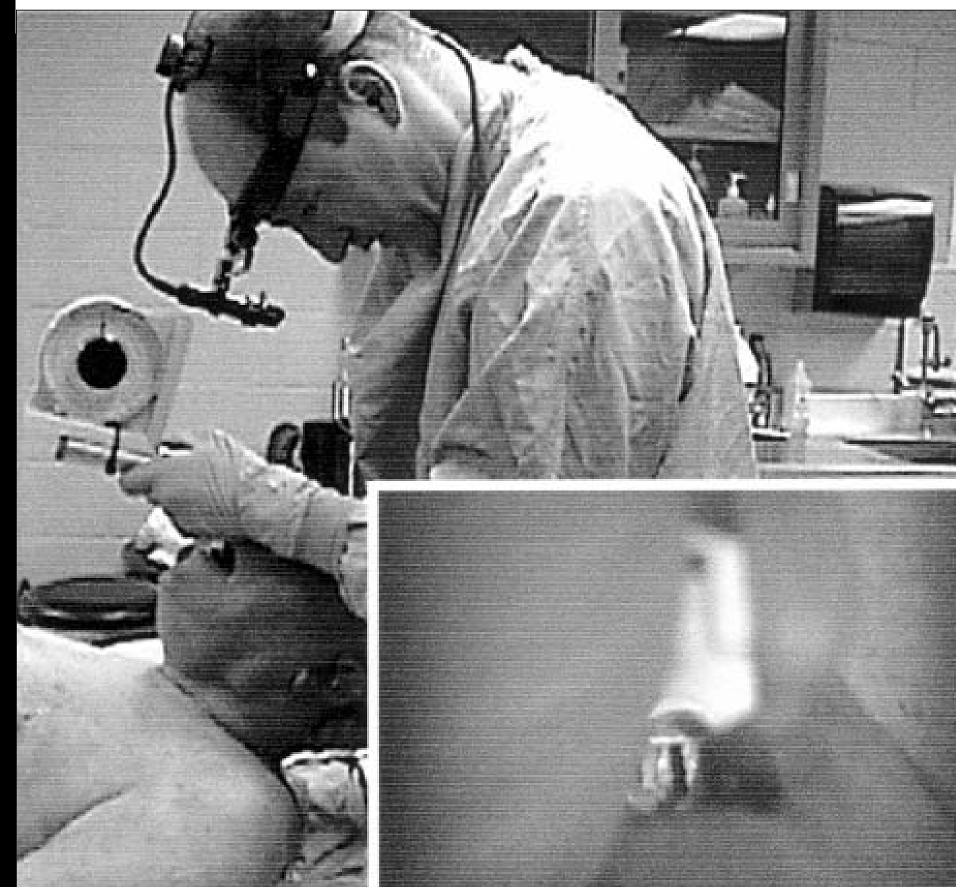


Figure 3.

Laryngoscopy with the head fully elevated (ie, the head-elevated laryngoscopy position). The laryngoscopist is using the right hand to elevate the head. The laryngoscopy angle is approximately 80°, and the POGO score in the inset is approximately 90%.



Head Elevated Laryngoscopy Position
Levitan RM.
Ann Emerg Med 2003; 41: 322-30.

Figure 6.
Mean POGO scores at 3 different head positions in 7 cadavers. Bars represent mean±1 SD.

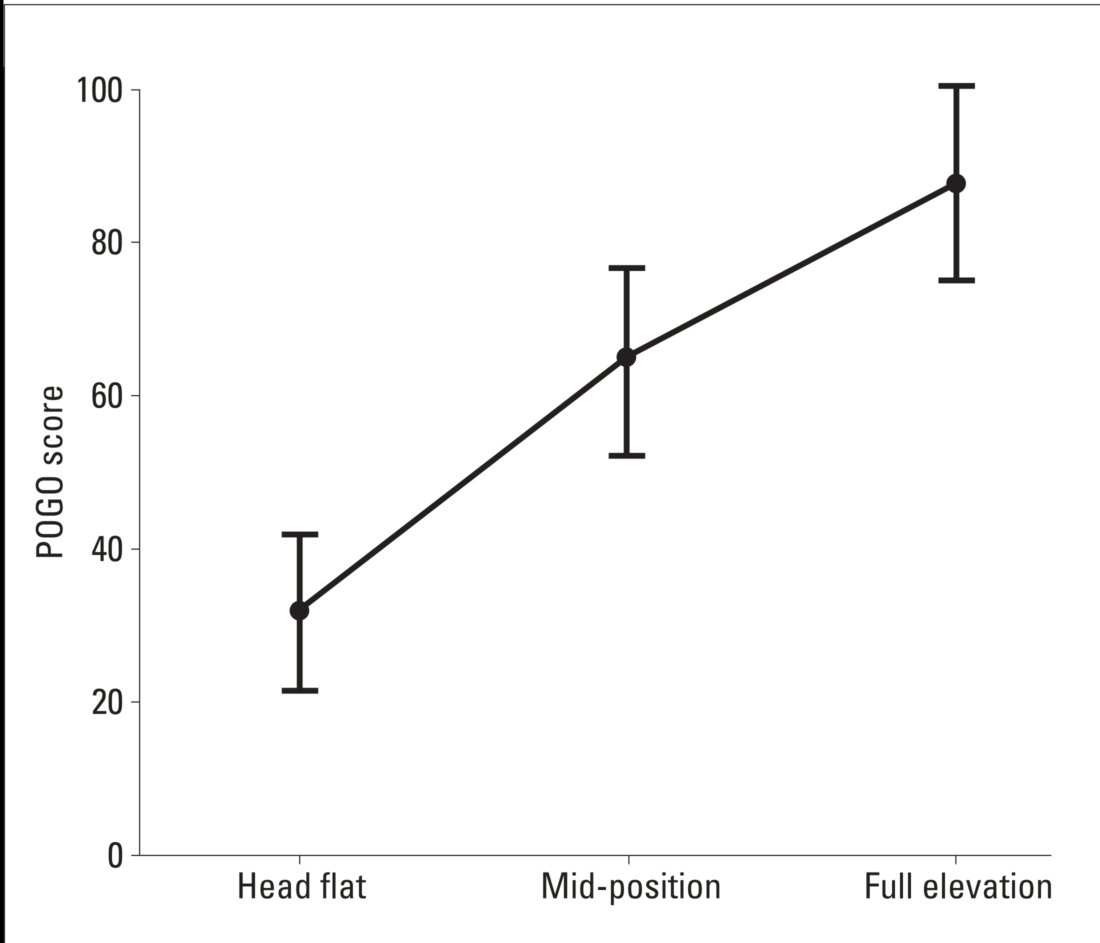


Figure 4.
POGO score. Full visualization of the glottic opening from the anterior commissure to the interarytenoid notch equals 100%. When no portion of the glottis is seen (ie, epiglottis or tongue-only views), the POGO score equals 0%. POGO scoring does not distinguish between these 2 situations.

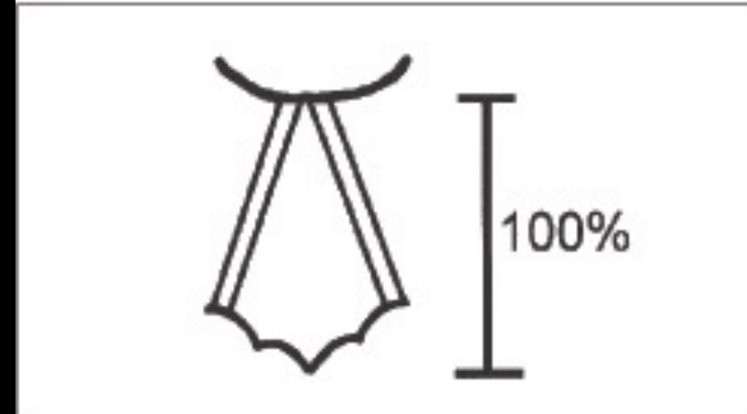
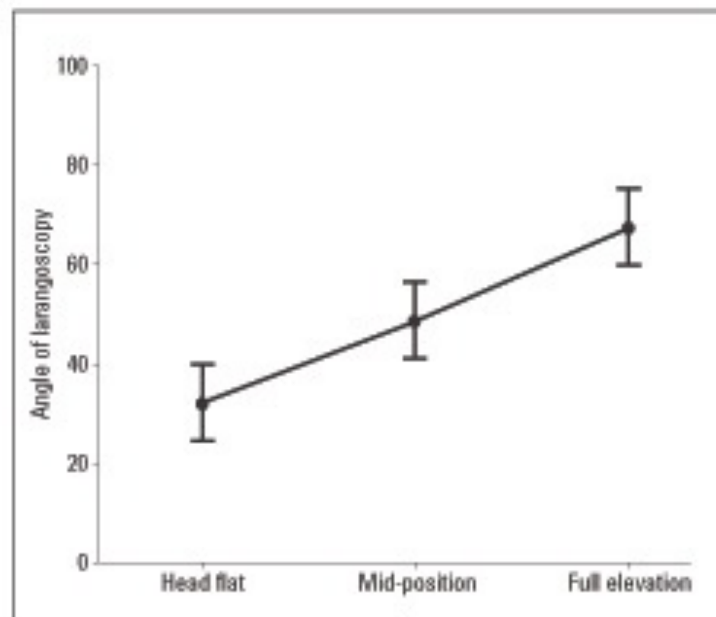


Figure 5.
Mean laryngoscopy angles at 3 different head positions in 7 cadavers. The midposition was determined by reviewing videotaped images of laryngoscopy from a perspective perpendicular to the patient. Bars represent mean±1 SD.



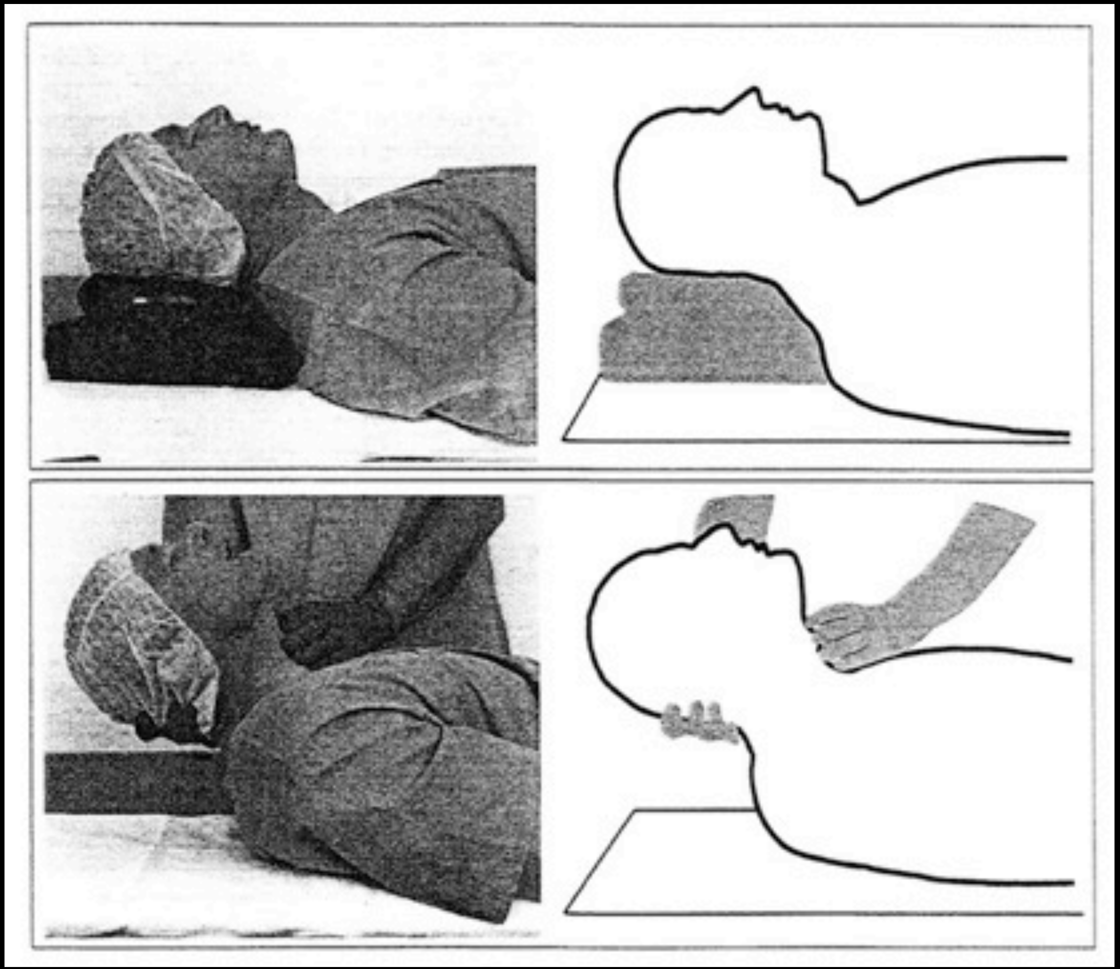
Head Elevated Laryngoscopy Position

Schmitt HJ, Mang H. Head and neck elevation beyond the sniffing position improves laryngeal view in cases of difficult direct laryngoscopy. J Clin Anesth. 2002 14:335-8.

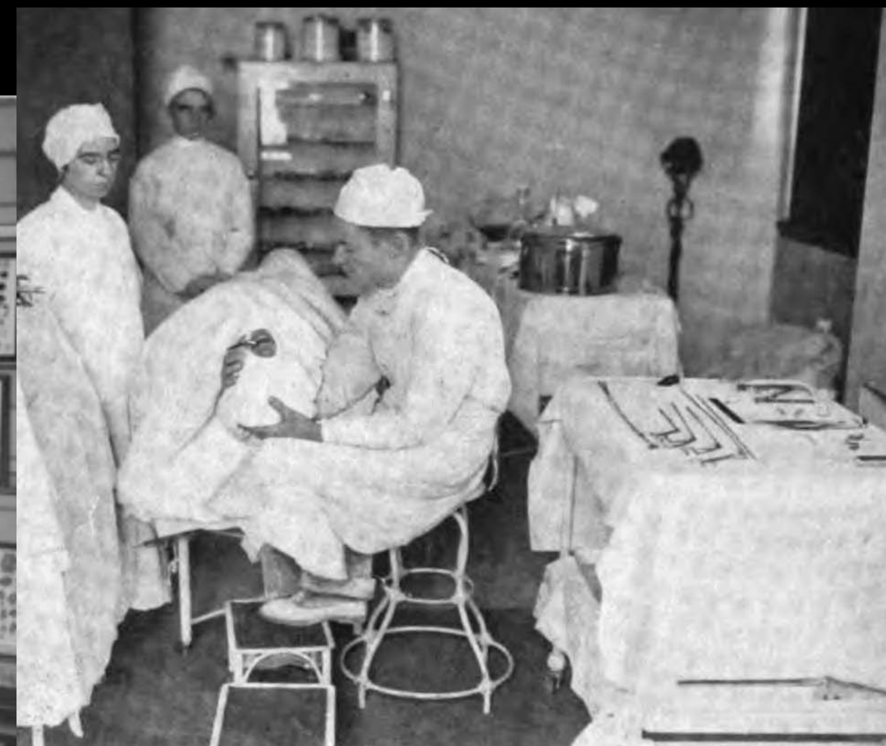
- 1500 consecutive cases in OR

- With laryngeal manipulation - 21/1500 epiglottis views

- Head elevation by assistant combined with laryngeal manipulation - only 2 cases epiglottis only views



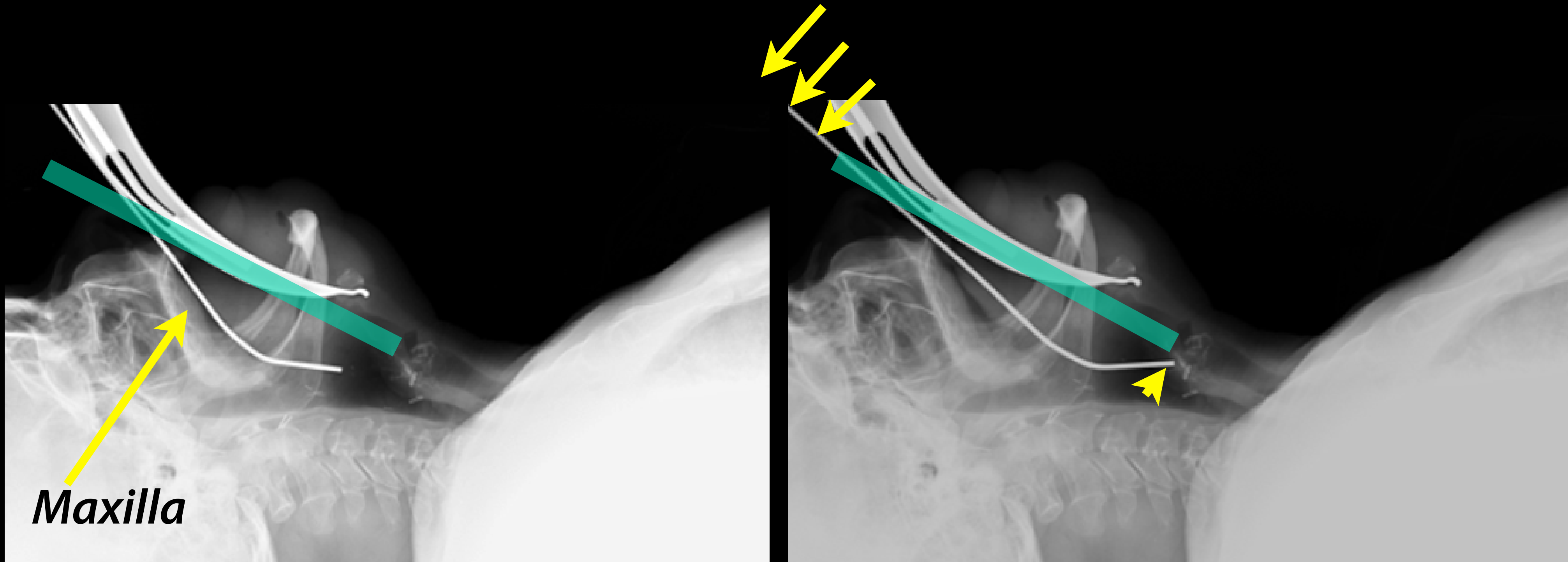
Combining Head Elevation and Laryngeal Manipulation, Jackson 1922



If the anterior commissure of the larynx is not readily seen, the lifting motion and elevation of the head should be increased, and if there is still difficulty in exposing the anterior commissure the assistant holding the head should with the index finger externally on the neck depress the thyroid cartilage.

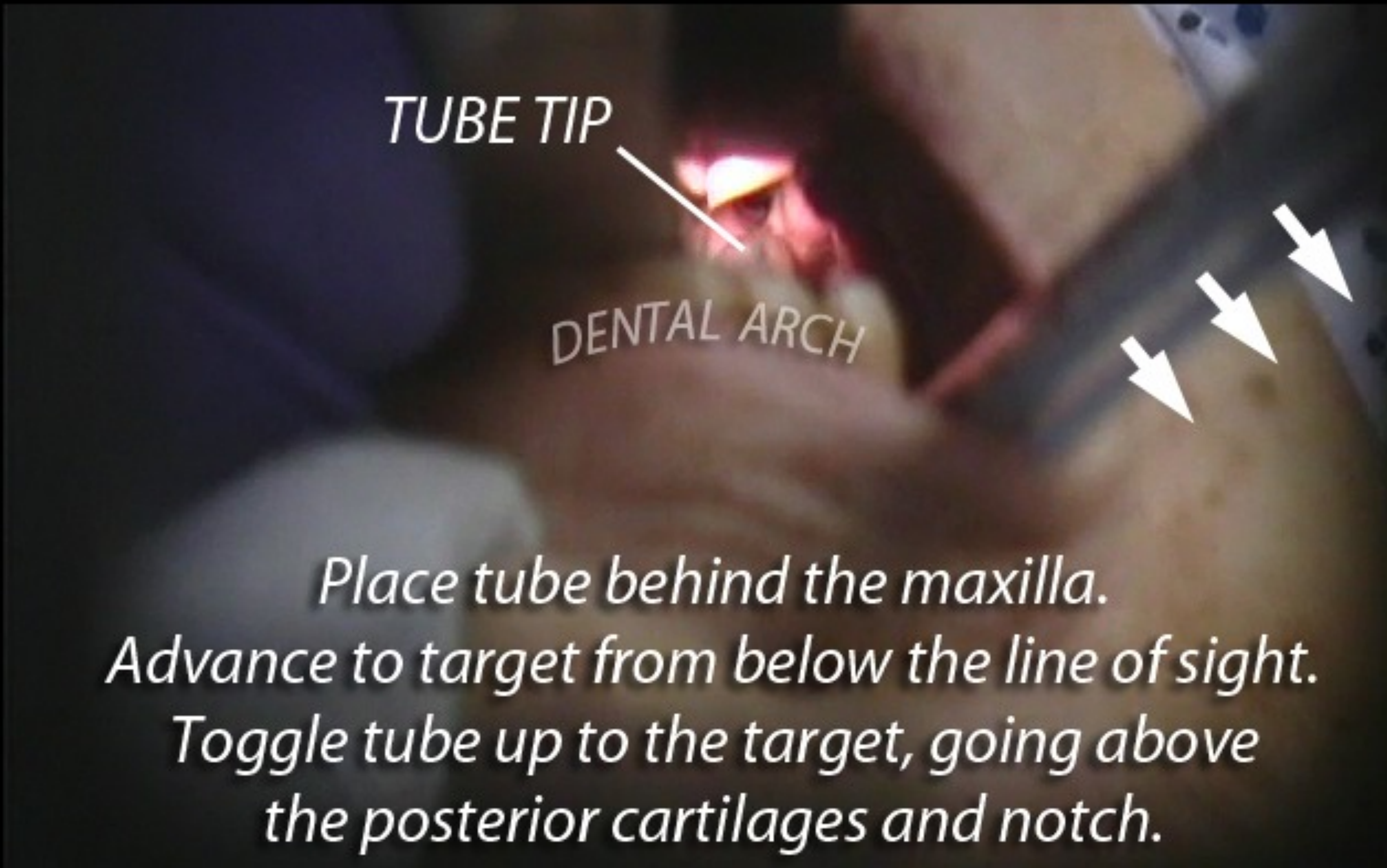
Bimanual Laryngoscopy with Head Elevation

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



Breaking down laryngoscopy - intubation

Low force

Epiglottoscopy
- face parallel to ceiling, roll blade down the tongue
- mid-line if necessary; beware of camouflage

Maximizing laryngeal exposure
- tongue control to open right side for tube delivery
- bimanual laryngoscopy
- increase head elevation if needed

More force

Tube delivery - straight-to-cuff < 35 degrees
- Use right corner of mouth (right lateral dental arch)
- insert tube from behind maxilla
- come up from below line of sight, move tip over notch
- bougie - optical stylet for epiglottis only views

General Rules for Imaging-based Laryngoscopes

1) SUCTION and EPIGLOTTOSCOPY

Suction BEFORE insertion, do not put tip into fluid/blood pool. Epiglottis is the reliable landmark, the on-ramp to the larynx.

2) LIFT the tongue and jaw

Imaging doesn't work well if the jaw and tongue collapse backward. Lifting upward permits a set-off view of landmarks, and opens delivery space.

3) TILT the optics AWAY from the larynx

If you're too close to the larynx, the area for tube delivery is reduced. Being too close, you cannot see the tube come into view. Tilt the device handle forward, creating more distance, wider view.

4) 2-STAGE DELIVERY

Bring the tube into view of the optics by following the blade slowly. After you see where the tube is going, adjust to bring tip to target.

Glidescope: Too close…tube delivery issue

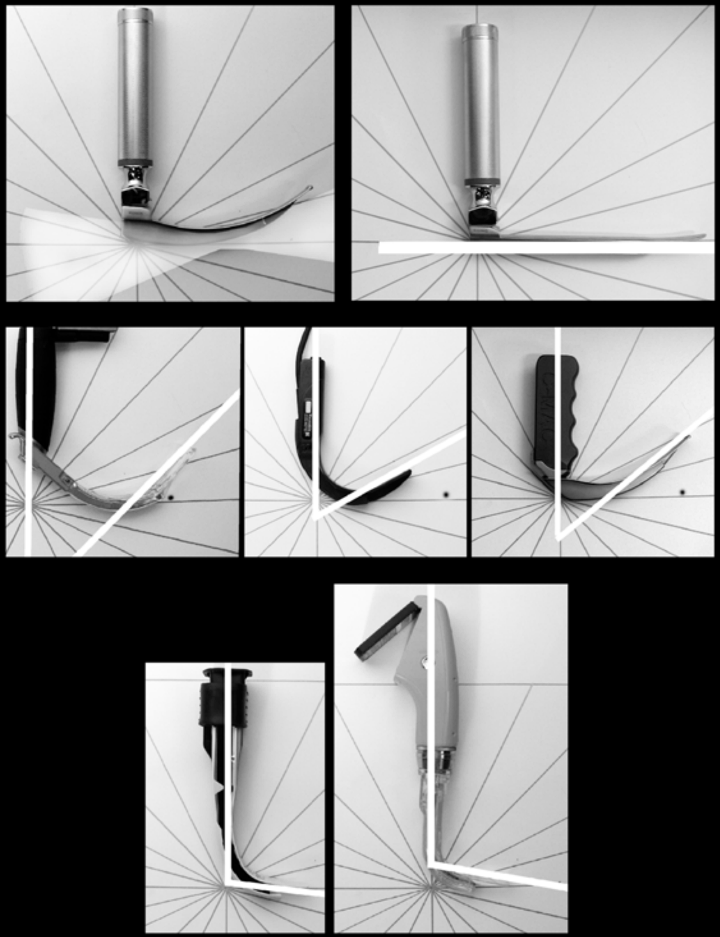
elapsed time ~ 55 seconds

Glidescope: Excellent technique

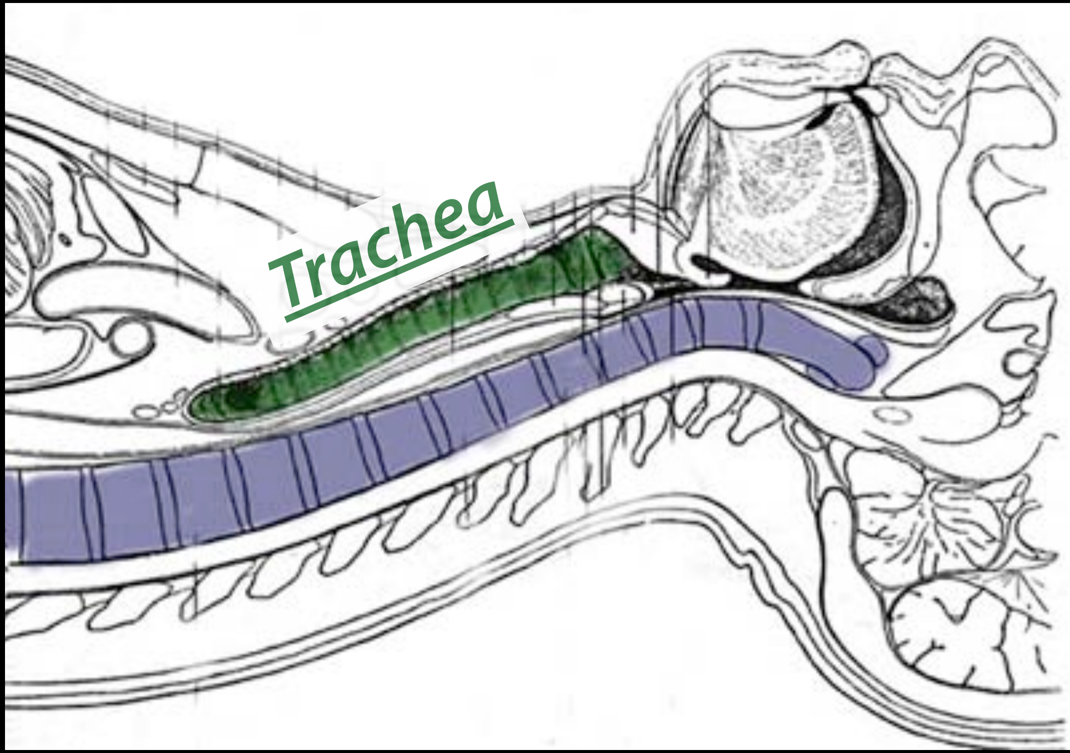
Suctioning, epiglottoscopy, right distance, good tube placement

Glidescope: Epiglottitis -- Failed intubation
Imaging above the epiglottis limitation

Epiglottoscopy & suctioning ; Courtesy Marvin Wayne, MD

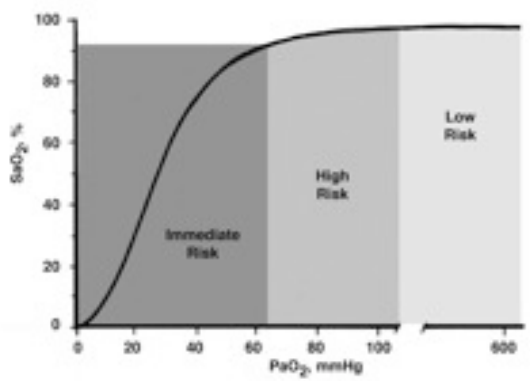


For every device, three separate issues:
1) exposing larynx
2) getting tube to glottis
3) tube into trachea



Video or optics can get you around tongue, but you still have to get tube to the glottis, and then pass it into the trachea...

Levitan RM, et al. The Complexities of Tracheal Intubation With Direct Laryngoscopy and Alternative Intubation Devices. Ann Emerg Med. 2011; 57:240-7.



Oxygenation and Ventilation Strategy Based on Pulse Oximetry

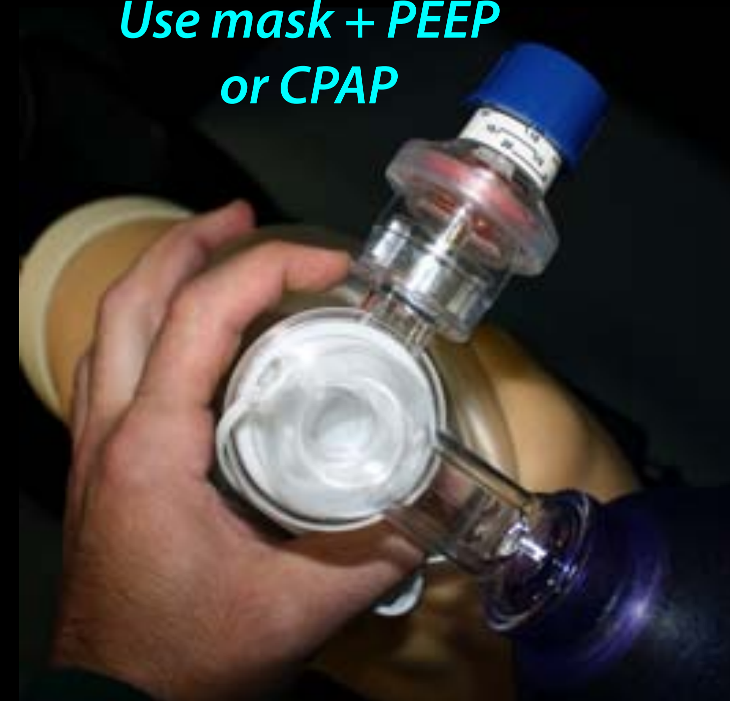
Weingart S, Levitan RM

Preoxygenation and Prevention of Desaturation During Emergency Airway Management, Ann Emerg Med, in press.

Risk Category **based on pulse oximetry while on high-flow oxygen**	**Preoxygenation Period** (3 minutes)	**Onset of Muscle Relaxation** (~60 seconds)	**Apneic Period during Intubation** (variable duration depending on airway difficulty; ideally < 30 seconds)
Hypoxemic **SpO2 90% or less**	CPAP *or* BVM with PEEP	CPAP or BVM with PEEP *and* Nasal Oxygen at 15 lpm	Nasal Oxygen at 15 lpm
High risk **SpO2 91-95%**	Non-Rebreather Mask *or* CPAP *or* BVM with PEEP	Non-Rebreather Mask, CPAP, or BVM with PEEP *and* Nasal Oxygen at 15 lpm	Nasal Oxygen at 15 lpm
Low risk **SpO2 96-100%**	Non-Rebreather Mask with maximal oxygen flow rate	Non-Rebreather Mask *and* Nasal Oxygen at 15 lpm	Nasal Oxygen at 15 lpm

BVM only
delivers O2
with ventilation.
Holding BVM
over face without
squeezing bag
causes FiO2
of only 21%

Consider positive
pressure if
pre-intubation SaO2
<95% with 100%
oxygen.
Use mask + PEEP
or CPAP



Awaiting onset of relaxation...keep airway patent

Slow, small, easy squeeze. Low volume (6-7 cc/kg), slow rate (8/min)

Distends alveoli, opening more surface area for oxygen absorption

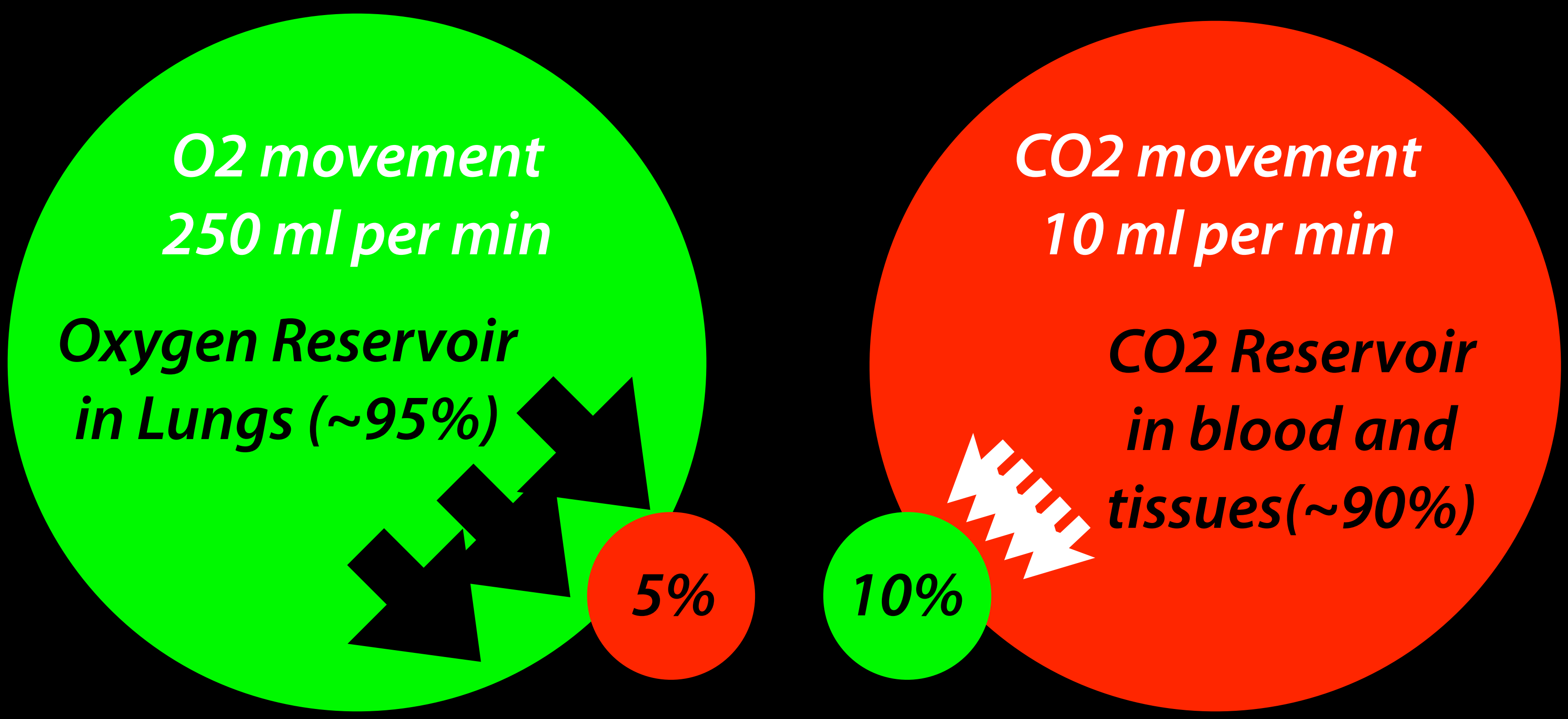
How apneic diffusion oxygenation works

- 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 out than O_2 gas in * * *

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

The net effect: O_2 is PULLED down the airway!



Apneic Oxygenation in Man

Frumin MJ, Epstein RM, Cohen G.

Anesthesiology, Nov-Dec 1959, pp 789-798

Apneic Oxygenation in Man

Subject Number	Duration of Apnea (minutes)	Lowest Arterial Saturation (per cent)	Lowest Arterial pH	Highest $PaCO_2$ (mm. Hg)	Average Rate of Rise of $PaCO_2$ (mm. Hg/minute)
1	30	100	—	—	—
2	45	100	—	—	—
3	55	100	—	—	—
4	45	100	6.88	160	3.0
5	18	99	6.97	130	4.9
6	45	98	6.87	160	3.0
.7	53	98	6.72	250	3.5
8	38	100	6.96	130	2.7

18-55 minutes without any ventilation, PaO2 98%-100%

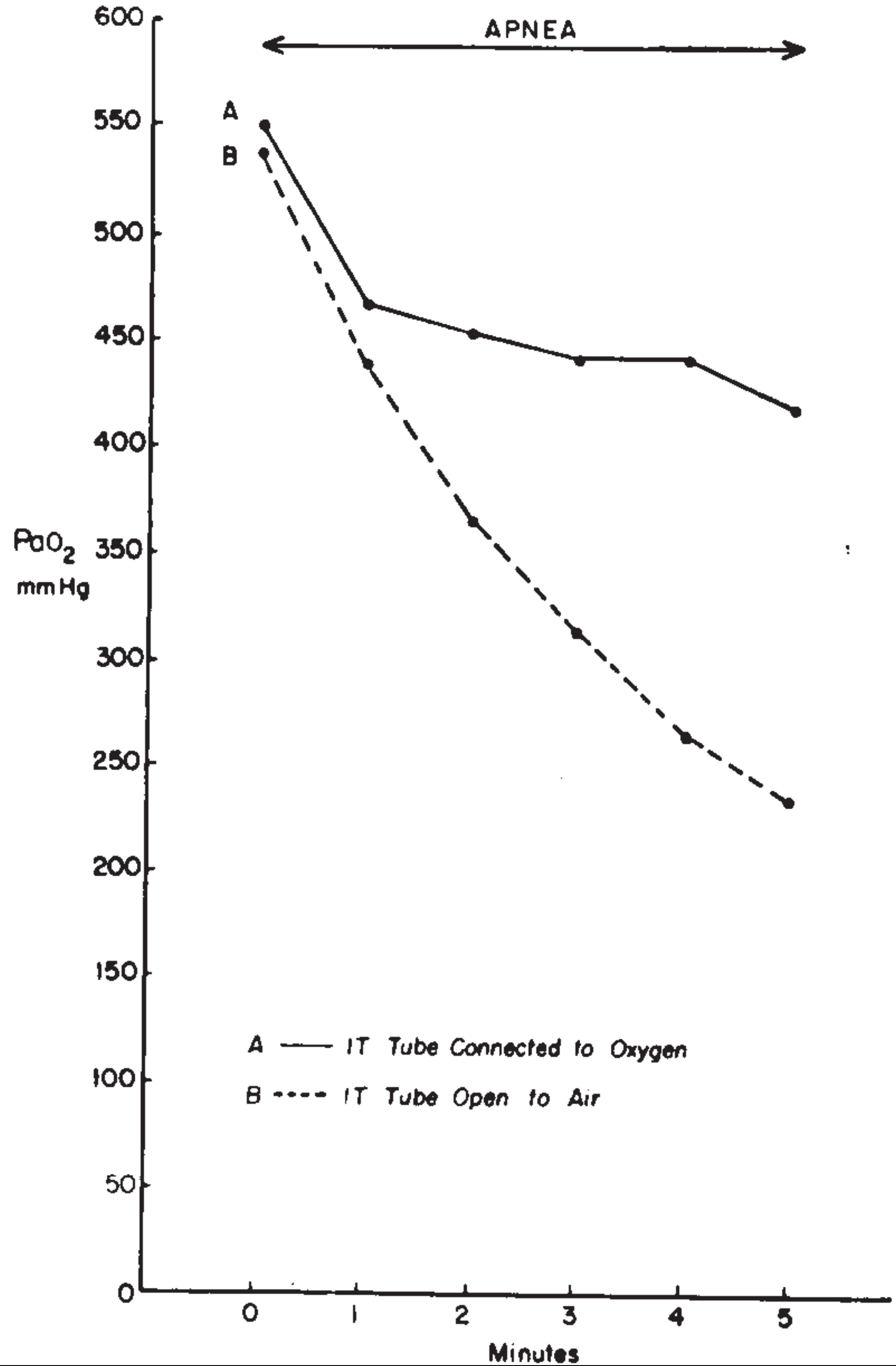
Apneic Oxygenation in Man

Heller ML, Watson R, Imredy DS
Anesthesiology, Jan-Feb 1964, pp 25-30

When man becomes apneic after preliminary oxygenation, there is a marked difference in the rate of arterial deoxygenation on whether the airway is open to room air or attached to an oxygen reservoir.

Polarographic arterial studies PO2 studies show a rapid fall in PaO2 when atmospheric air (containing 80% nitrogen) moves down the airway. In the case of pure oxygen reaching the alveolar space, high PO2 values greater than 400mm of mercury were observed even after 5 minutes of apnea.

On the other hand, air with high nitrogen content dilutes alveolar oxygen...
Oxygen uptake is inhibited as alveolar oxygen tension falls.



Pharyngeal Insufflation of Oxygen Prevents Arterial Desaturation During Apnea

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

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.

- 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 via nasal cannula during oral intubation

NO DESAT: Nasal Oxygen During Efforts Securing A Tube

Passive Apneic Oxygenation During Laryngoscopy