THRIVE: Clinical Applications of High Flow Humidified Nasal Oxygen

Jimmy Ma
Assistant Professor of Anesthesiology, Emory University

No conflicts of interest

Overview

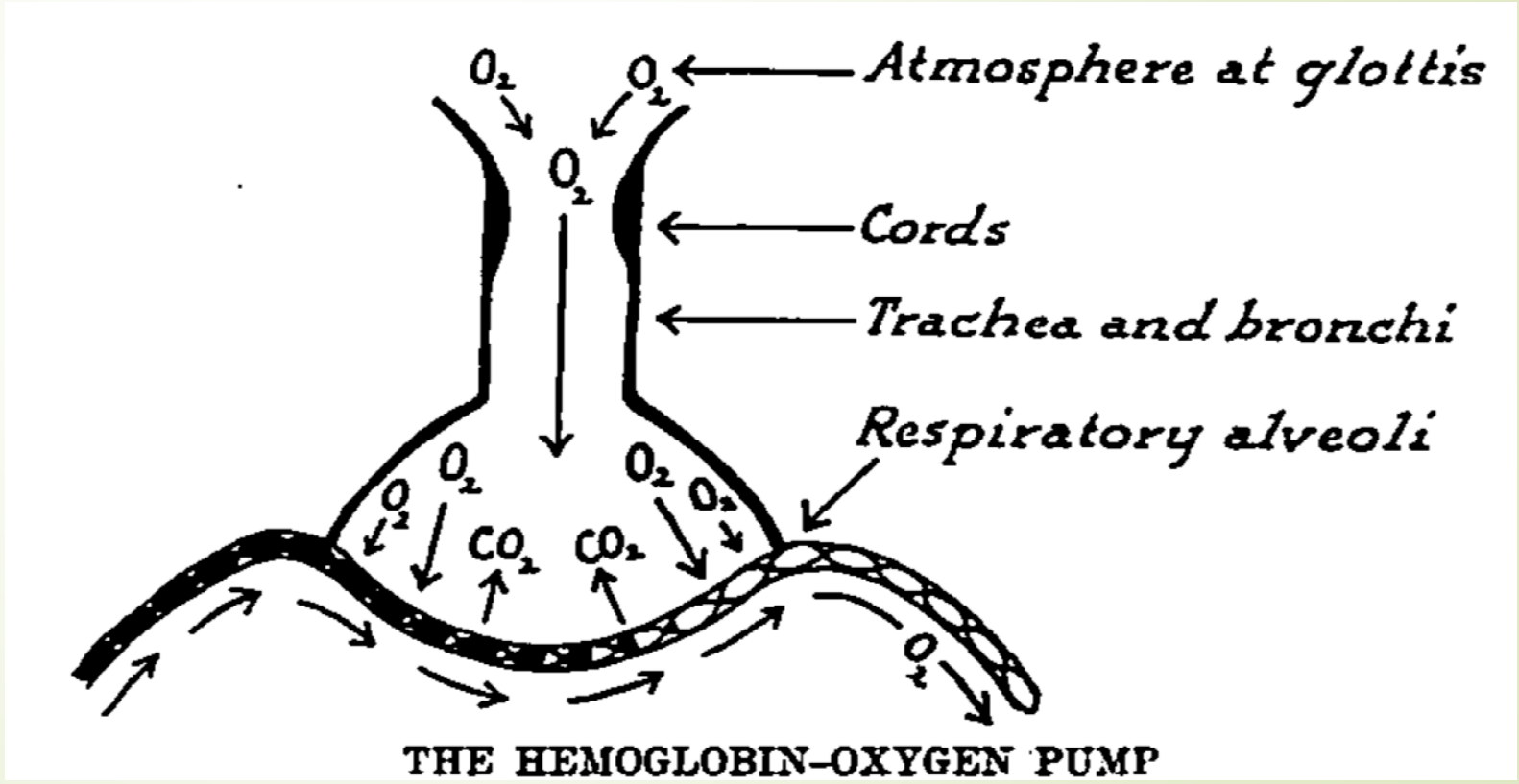
- History of apneic oxygenation
- Physiological principles
- Clinical applications
- Review of cases

History: 1947 - "Diffusion Respiration"

STUDIES ON DIFFUSION RESPIRATION.* III. ALVEOLAR GASES AND VENOUS BLOOD pH OF DOGS DURING DIFFUSION RESPIRATION †

WILLIAM B. DRAPER, M.Sc., M.D., RICHARD W. WHITEHEAD, M.A., M.D., AND JOSEPH N. SPENCER, PH.D.
WITH THE TECHNICAL ASSISTANCE OF DAVID L. G. BESHORE, B.S., AND THOMAS M. PARRY, B.A., M.D.

Denver, Colorado



THE HEMOGLOBIN–OXYGEN PUMP

History: 1959 - Apneic Oxygenation

APNEIC OXYGENATION IN MAN

M. JACK FRUMIN, M.D., ROBERT M. EPSTEIN, M.D., GERALD COHEN, PH.D.

- "Aventilatory mass flow"
- "Apneic oxygenation"
- Mass flow ventilation
- Occurs without chest or diaphragmatic movement

History: 1985 - Tracheal insufflation of O2

Anesthesiology
63:278–286, 1985

Tracheal Insufflation of O_2 (TRIO) at Low Flow Rates Sustains Life for Several Hours

Arthur S. Slutsky, M.D., John Watson, Ph.D.,† David E. Leith, M.D.,‡ Robert Brown, M.D.§*

History: 1994 - Critical care applications

Originals

Intensive Care Medicine

Intensive Care Med (1994) 20:407–413

Rapid publication

Tracheal gas insufflation reduces the tidal volume while $PaCO_2$ is maintained constant

G. Nakos, S. Zakinthinos, A. Kotanidou, H. Tsagaris, C. Roussos

Pre-oxygenation

Nasal
Oxygenation
During Efforts at
Securing A Tube

1. Facemask

3 - 8 mins

2. Nodesat

+ 2 - 3 mins

3. THRIVE

+ 20 - 30 mins

"THRIVE": A NEW FRONTIER

Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways

A. Patel[1,2] and S. A. R. Nouraei[3]

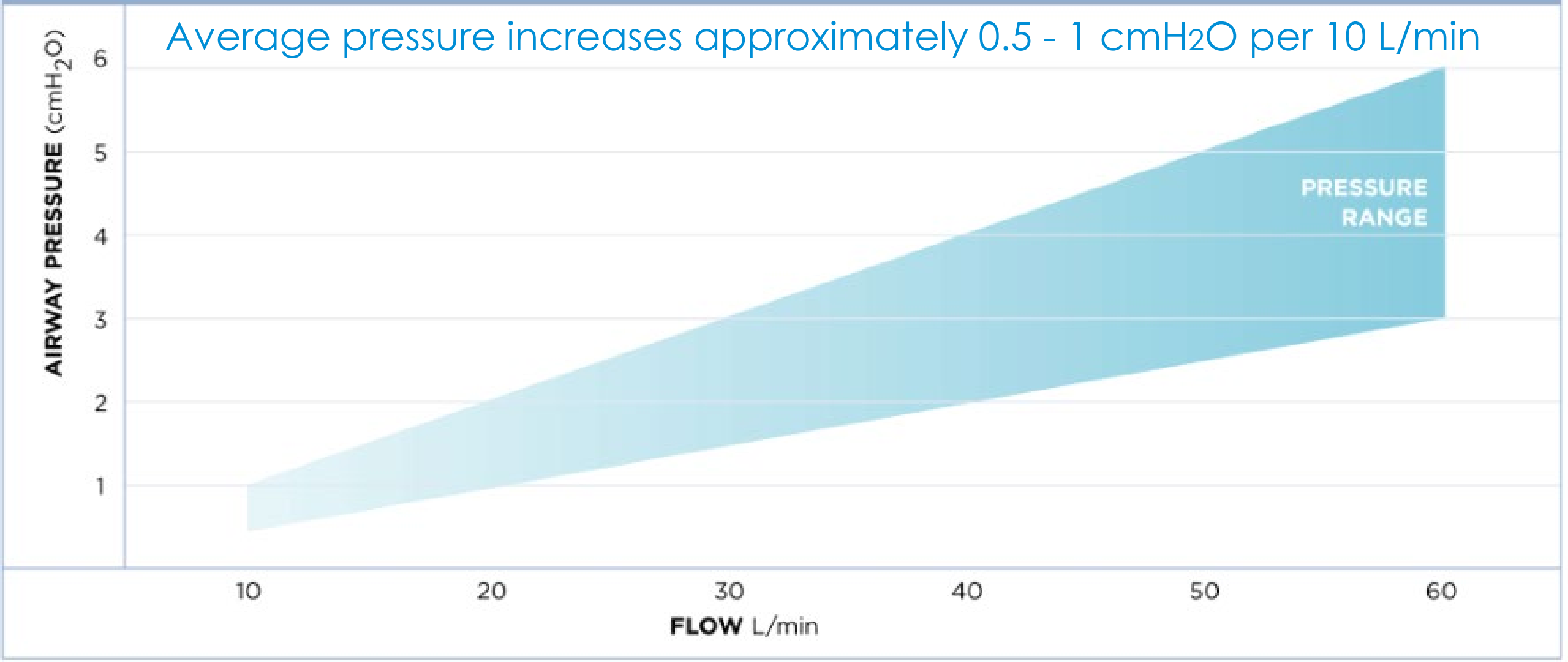
1 Consultant Anaesthetist, The Royal National Throat Nose and Ear Hospital, London, UK
2 Consultant Anaesthetist, 3 Specialist Registrar in Academic Otolaryngology, University College Hospital NHS Foundation Trust, London, UK

Patel A, Nouraei SAR. Anaesthesia 2015; 70:323-9.

- 25 patients with difficult airways
- Laryngologic & hypopharyngeal surgery
- 9 patients with stridor and acute airway compromise
- Average apnea time 17 min
- $SpO_2 \geq 90\%$

Rapid insufflation generates CPAP

Average Airway Pressure



Ritchie JE, Williams AB, Gerard C, Hockey H. Evaluation of a humidified nasal highflow oxygen system, using oxygraphy, capnography and measurement of upper airway pressures. Anaesth Intensive Care. 2011; 39(6):1103–10.

Physiology - spontaneous respiration

- Supraglottic vortex with enhanced gas mixing
- Reduced atelectasis
- Splinting during inspiration
- Reduced upper airway resistance reduces WOB
- Enhanced lung volumes with FRC increase

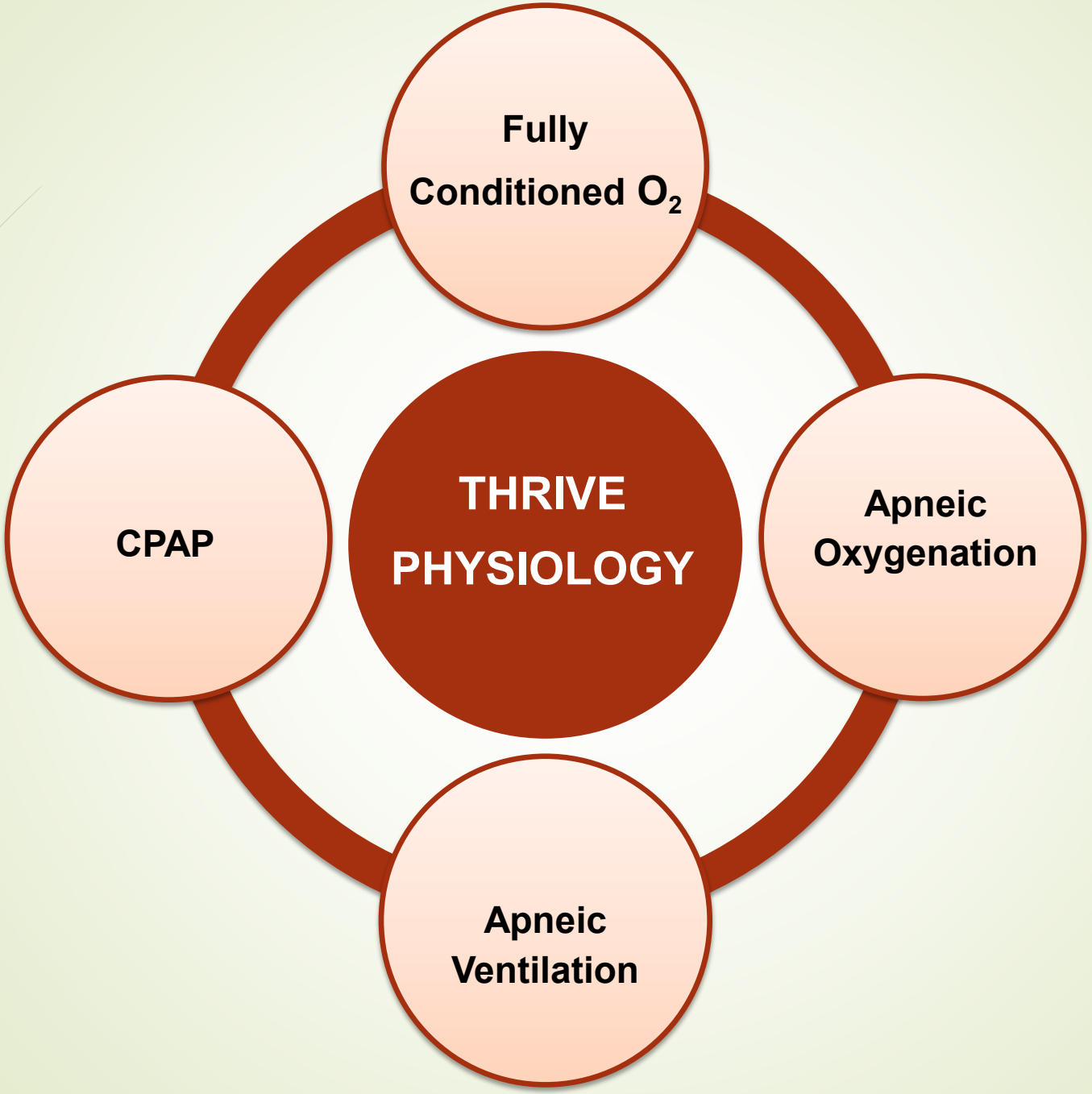
THRIVE: LOW-LEVEL CPAP

- CPAP ~ 7cmH20
- Alveolar recruitment
- Improved V/Q matching
- Reduced shunting
- Esophageal pressure ~ 3 cm H_2O

Video courtesy Fisher & Paykel. With permission.

Corley A. *BJA.* 2011

Enhanced ventilatory exchange during apnea


Fully Conditioned O_2
CPAP
THRIVE PHYSIOLOGY
Apneic Oxygenation
Apneic Ventilation

THRIVE: APNEIC VENTILATION

Anaesthesia 2019 doi:10.1111/anae.14541

Original Article

A physiological study to determine the mechanism of carbon dioxide clearance during apnoea when using transnasal humidified rapid insufflation ventilatory exchange (THRIVE)*

L. A. Hermez,[1] C. J. Spence,[1] M. J. Payton,[2] S. A. R. Nouraei,[4] A. Patel[5] and T. H. Barnes[3,6,7]

THRIVE: ENHANCED CARDIOGENIC OSCILLATIONS

- Pulsatile blood flow in pulmonary vessels
- Compression/expansion cycling of small airways (7-15mls)
- 3-D modelling of fluid flow patterns

Applications

- Awake
- Sedated
- GA with spontaneous ventilation
- GA with prolonged apnea

Pre-oxygenation

Nasal
Oxygenation
During Efforts at
Securing A Tube

1. Facemask

3 - 8 mins

2. Nodesat

+ 2 - 3 mins

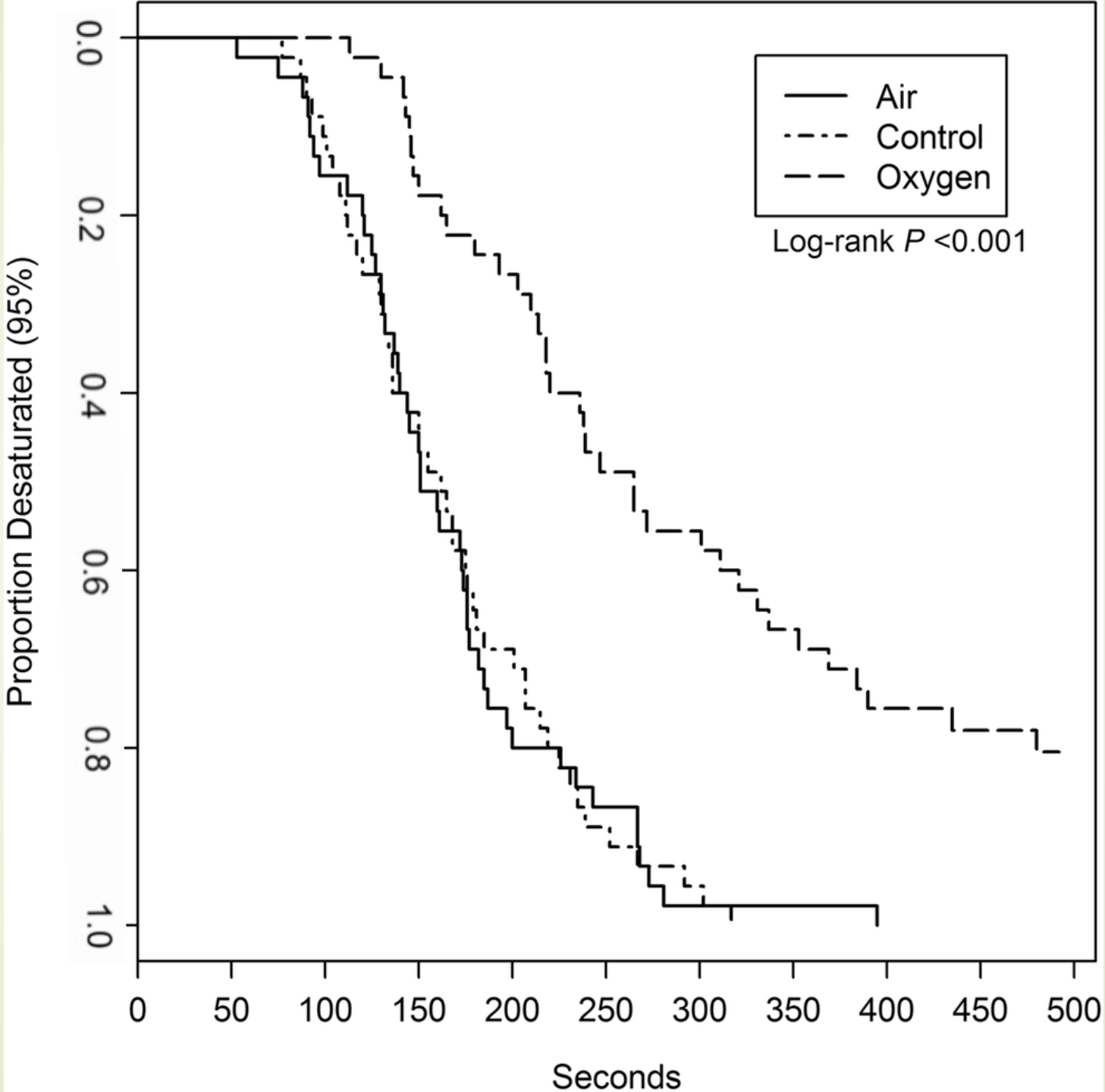
3. THRIVE

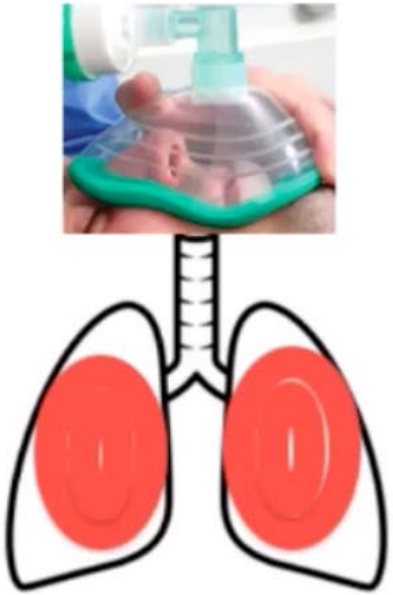
+ 20 - 30 mins

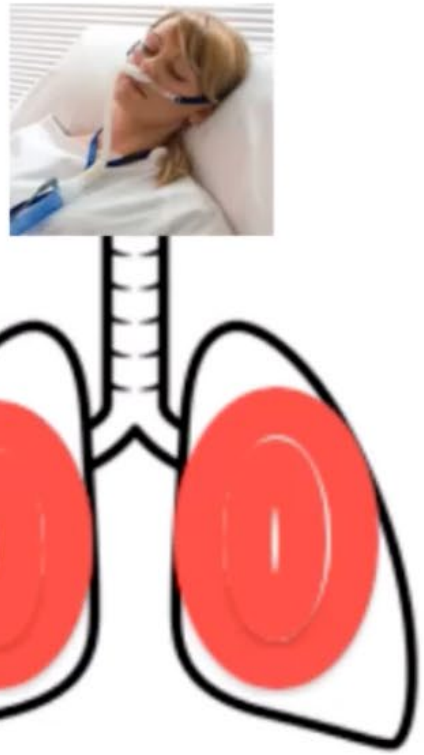
Apneic Oxygenation During Prolonged Laryngoscopy in Obese Patients: a Randomized, Double-Blinded, Controlled Trial of Nasal Cannula Oxygen Administration

Tiffany S. Moon[1] · Katie Tai[1] · Agnes Kim[1] · Michael X. Gonzales[1] · Rachael Lu[1] · Taylor Pak[1] · Katelynn Smith[1] · Joy L. Chen[1] · Abu T. Minhajuddin[1] · Nwamaka Nnamani[1] · Pamela E. Fox[1] · Babatunde Ogunnaike[1]

Moon, T et al Obesity Surgery(2019) 29:3992–3999







Efficacy = alveolar ventilation/FRC

Efficiency = total oxygen content

Increased FiO2

Improved CO2 clearance

Positive Airway Pressure

Washout of anatomical deadspace

Improved pulmonary mechanics

Decreased upper airway resistance

Applications

- Awake
- Sedated - enhanced patient safety
- GA with spontaneous ventilation
- GA with prolonged apnea

CASE REPORT

Use of Transnasal Humidified Rapid-Insufflation Ventilatory Exchange for Emergent Surgical Tracheostomy: A Case Report

Neel Desai, FRCA, and Anna Fowler, FRCA

Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) is a novel airway technique that utilizes high-flow humidified nasal oxygen. It can extend apnea time and maintain oxygen saturation. Here we report the use of THRIVE in a 35-year-old man who required emergent surgical tracheostomy for a clinically relevant compromised airway secondary to acute supraglottic and glottic pathology. Intravenous sedation resulted in hypoventilation close to apnea. THRIVE maintained oxygen saturation for 40 minutes until transient desaturation developed after complete airway obstruction. (A&A Case Reports. 2017;9:268–70.)

Awake fiberoptic intubation

- Complex airway population
- Reported incidence of desaturation < 90%: 12% -16% with low flow oxygenation

Optimizing oxygenation and intubation conditions during awake fibre-optic intubation using a high-flow nasal oxygen-delivery system

S. Badiger, M. John, R. A. Fearnley and I. Ahmad*

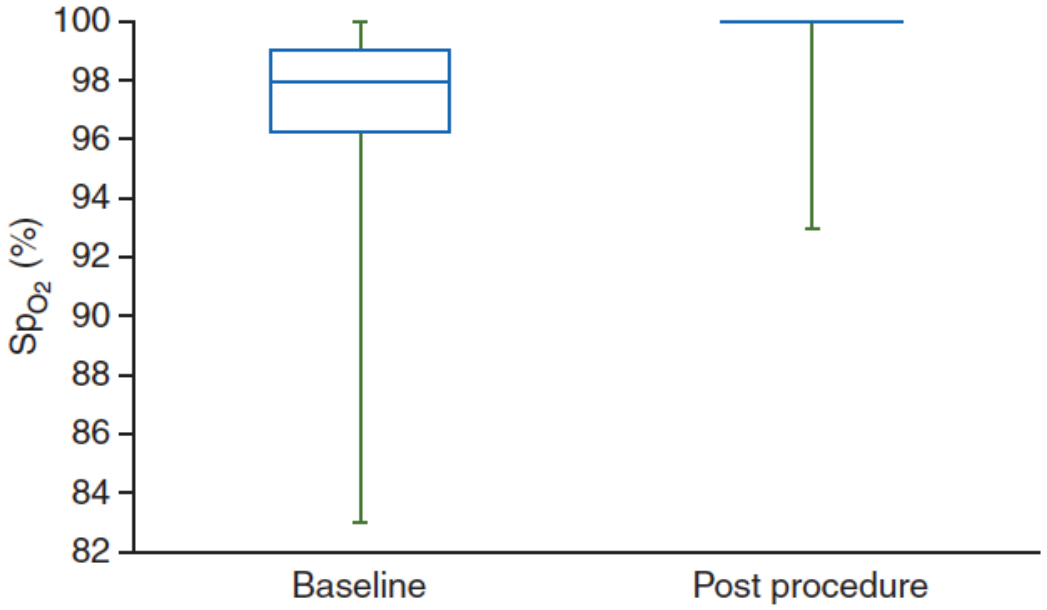


Fig 2 Baseline and immediate postprocedure oxygen saturation (Sp_{O_2}) for all patients. Box plot shows median and first and third quartiles. Vertical extensions indicate minimum and maximum observed measurements.

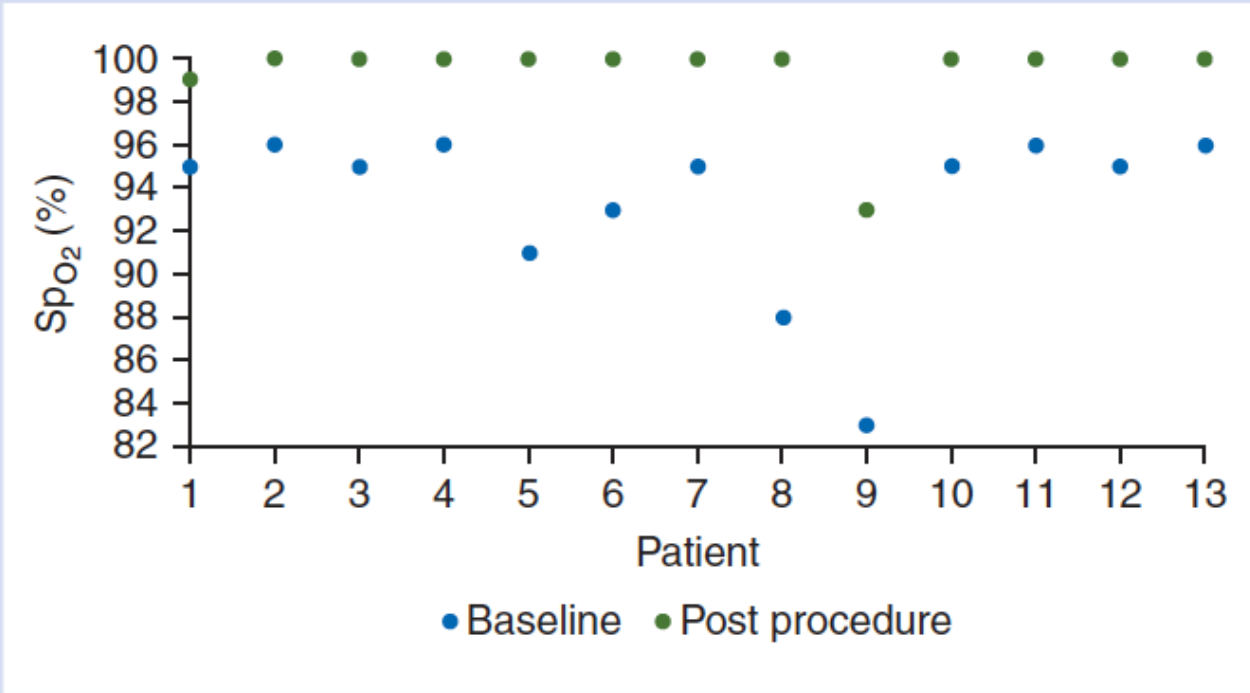


Fig 3 Improvement in Sp_{O_2} with high-flow nasal cannulae in the 13 patients who had baseline Sp_{O_2} less than 97%.

Anaesthesia 2019 doi:10.1111/anae.14904

Guidelines

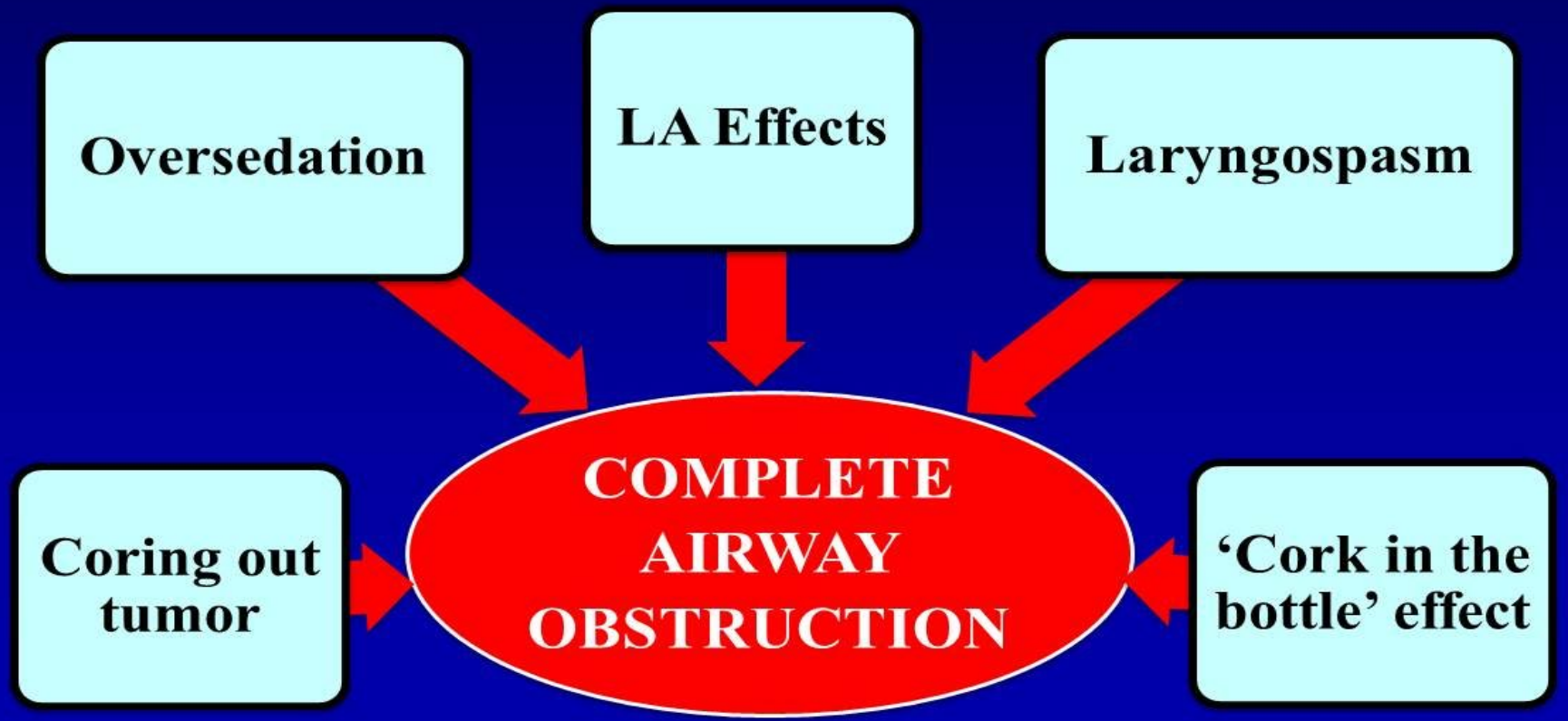
Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults

I. Ahmad[1,2] K. El-Boghdadly,[1,2] R. Bhagrath,[3] I. Hodzovic,[4,5] A. F. McNarry,[6] F. Mir,[7] E. P. O'Sullivan,[8] A. Patel,[9] M. Stacey[10] and D. Vaughan[11]

Applications

- Awake
- Sedated
- GA/MAC with spontaneous ventilation - management of the obstructed airway
- GA with prolonged apnea

Potential Problems with Awake Flexible FOB



Anesthesiology 2005; 103:33–9

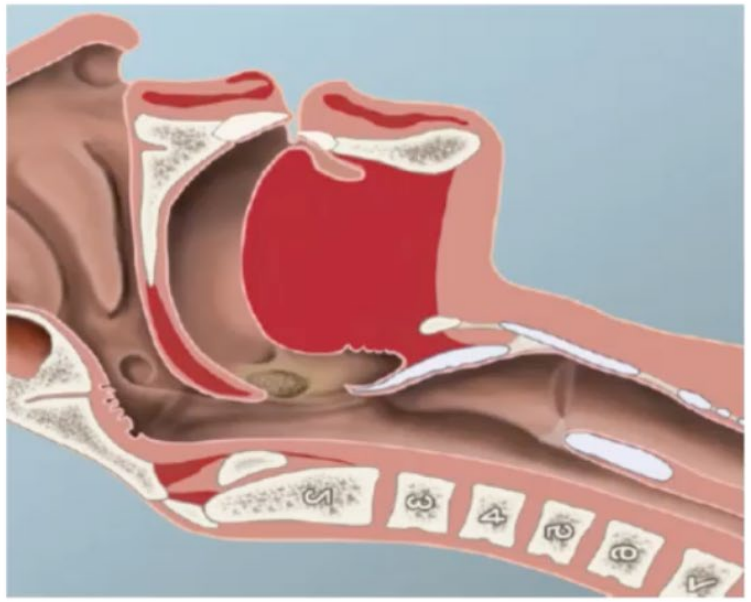
Management of the Difficult Airway

A Closed Claims Analysis

Gene N. Peterson, M.D., Ph.D., Karen B. Domino, M.D., M.P.H.,† Robert A. Caplan, M.D.,‡ Karen L. Posner, Ph.D.,§ Lorri A. Lee, M.D.,* Frederick W. Cheney, M.D.‖*

"Awake intubation was attempted but unsuccessful in 12 claims, resulting in death/BD in 75%. In 5 of these claims, upper airway obstruction developed after minimal sedation or airway instrumentation and bleeding.

MAC/GA with spontaneous ventilation



NO AIRFLOW

Tissue Pressure ↑ ↑

P upstream

P downstream

Tissue Pressure ↑ ↑

RESPIRATION AND THE AIRWAY

SponTaneous Respiration using IntraVEnous anaesthesia and Hi-flow nasal oxygen (STRIVE Hi) maintains oxygenation and airway patency during management of the obstructed airway: an observational study

A.W.G. Booth*, K. Vidhani, P.K. Lee, C.-M. Thomsett

- 30 adult patients
- 16 stridulous, 10 dyspneic
- Procedure time 44 minutes
- Excellent oxygenation
- CO_2 rise 0.22mmHg/min

High risk sedation cases

- Dental, endoscopic
- OSA
- Obese
- Partial airways obstruction
- Post extubation and PACU

Applications

- Awake
- Sedated
- GA with spontaneous ventilation
- GA with prolonged apnea

Applications

- Prolonged intubation sequence
- Microlaryngeal surgery
- Interventional bronchoscopy
- OB
- Pediatric difficult airway

Applications - prolonged intubation sequence

- Minimize human error
- Maximize decision making
- Trainee education

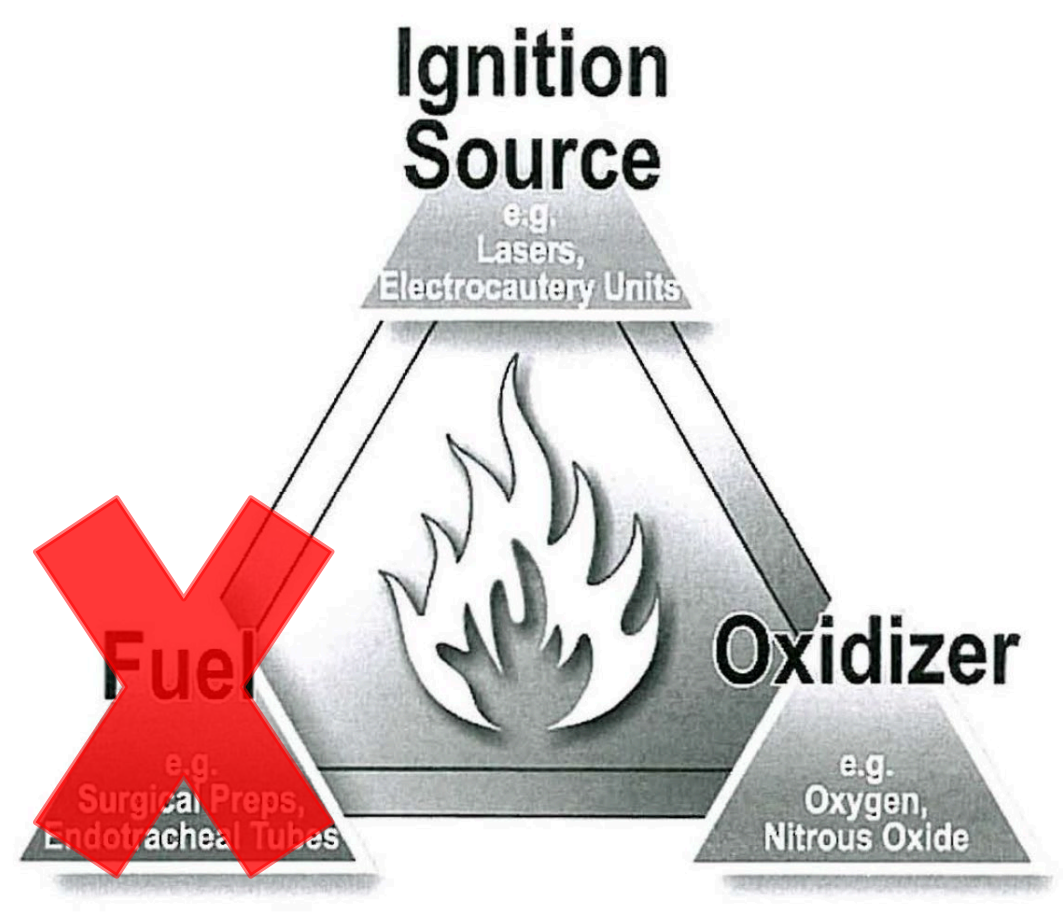
THRIVE: tubeless, motion-less field

- **Wide bore nasal cannula**
- **100% oxygen**
- **Gas flow 70+ L/min**
- **Heated humidification**

Transoral laser microsurgery

- Tube in surgical field
- Barotrauma
- Vocal cord movement with jet ventilation
- Supraglottic desiccation & mucosal edema
- Inhalation of laser fumes
- Movement

THRIVE & LASER LARYNGOLOGIC SURGERY



APSF October 2018 Newsletter; Dhar V et al. J Laryng Otol 2008;122:1335-8; Yan Y et al., J Voice 2010;24:102-9; Stuermer KJ et al., Eur Arch Otorhinolaryngol 2013;270:2701-7 .

Laser & THRIVE precautions

- Cover face and O2 tubing with wet towels
- No electrocautery use
- Lowest power possible
- Short bursts
- Put in standby mode when possible, ASAP

Backup Ventilation Strategies:

- 5.0 mm ID MLT
- Apneic intermittent ventilation (AIV)
- Jet ventilation

Limitations

- Total Airways Obstruction
- Supermorbid Obesity
- Rescue for desaturation - pressure too low for re-expansion
- Should not replace airway management plan

THRIVE LEADS TO ↑$PaCO_2$ and ↓pH

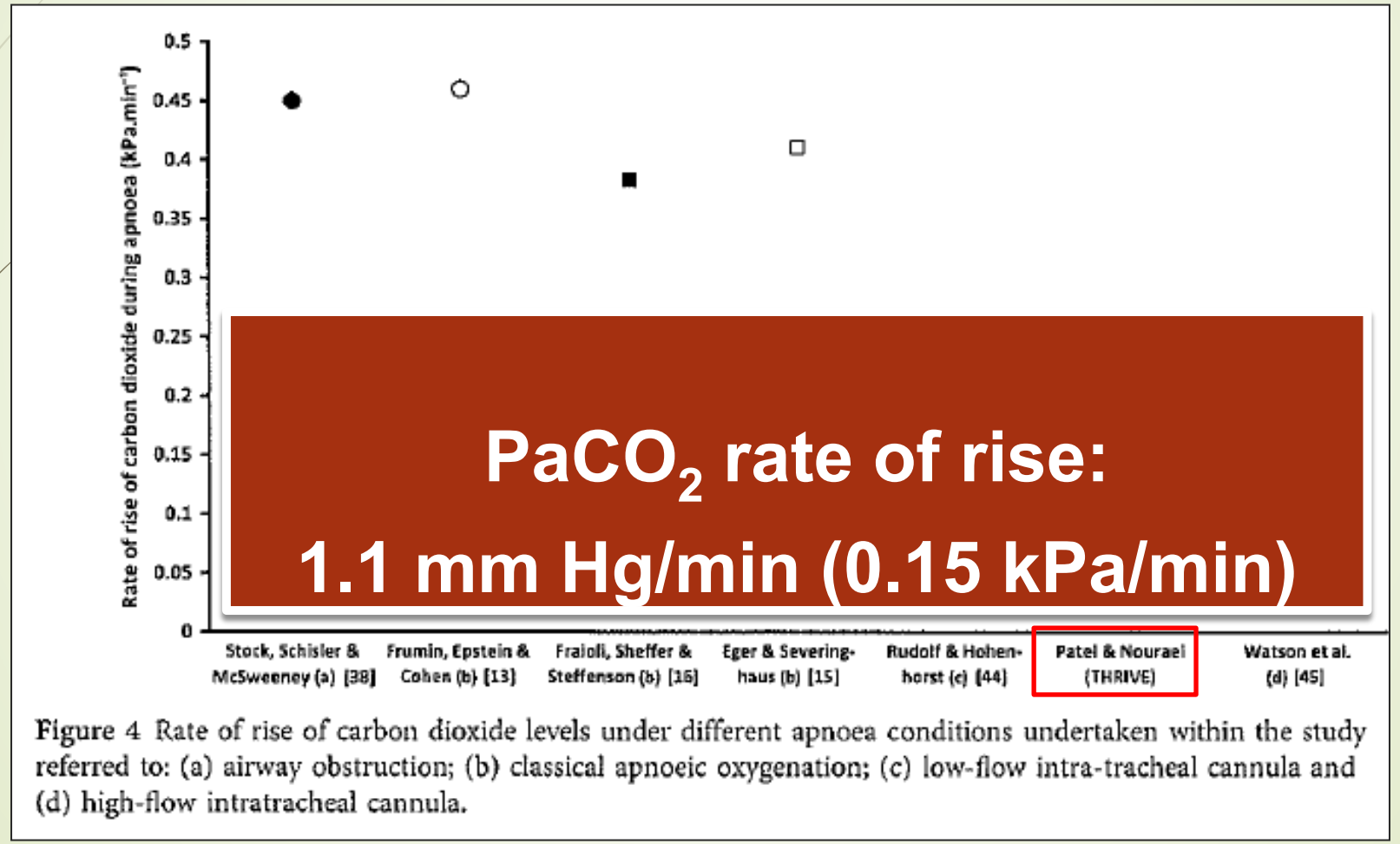


Figure 4 Rate of rise of carbon dioxide levels under different apnoea conditions undertaken within the study referred to: (a) airway obstruction; (b) classical apnoeic oxygenation; (c) low-flow intra-tracheal cannula and (d) high-flow intratracheal cannula.

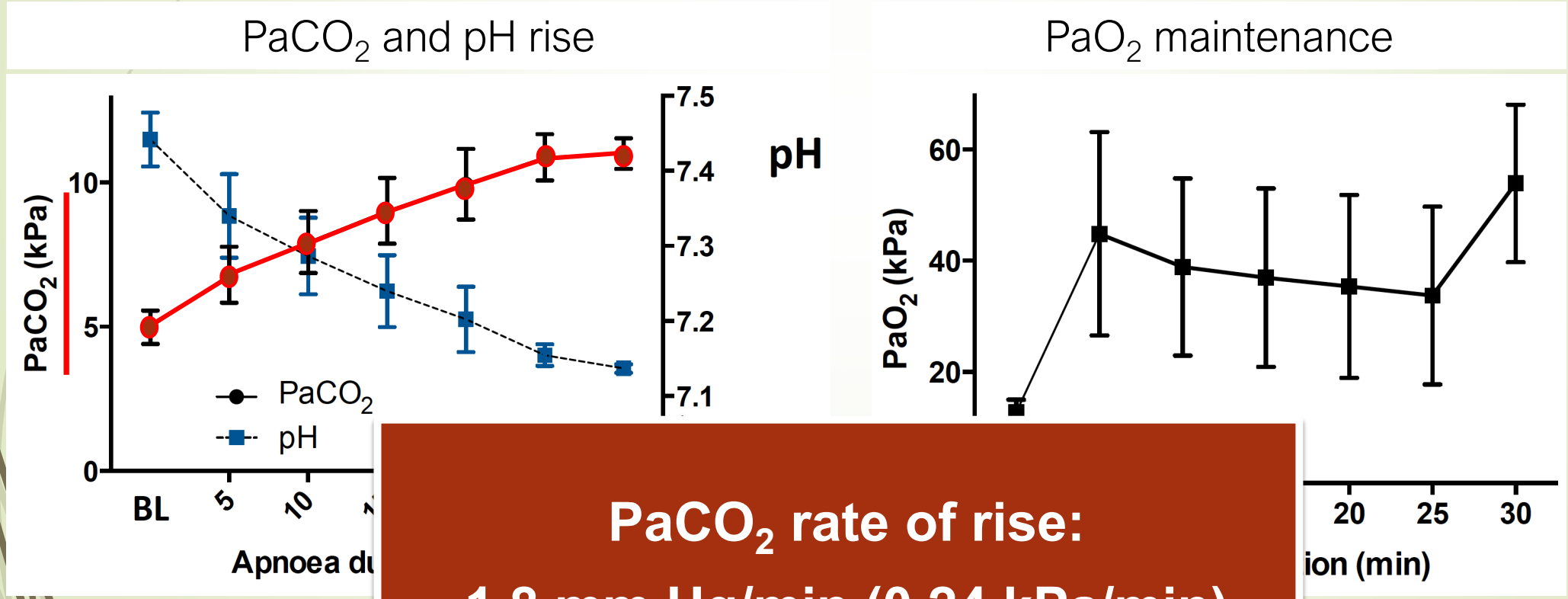
Patel A, Nouraei SAR. Anaesthesia 2015; 70:323-9.

Apnoeic oxygenation in adults under general anaesthesia using Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE) – a physiological study

I.-M. Gustafsson[1,2,†], Å. Lodenius[1,2,†], J. Tunelli[1], J. Ullman[1,2] and M. Jonsson Fagerlund[1,2,*]

[1]Perioperative Medicine and Intensive Care, Karolinska University Hospital, Stockholm, Sweden and [2]Section for Anesthesiology and Intensive Care Medicine, Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden

THRIVE LIMITATIONS: ↑$PaCO_2$ and ↓pH



$PaCO_2$ rate of rise:

1.8 mm Hg/min (0.24 kPa/min)

THRIVE: SUMMARY

- Easy to use
- Improves patient safety
  - Difficult airways
  - Reduced O2 reserve
  - Procedural sedation
- Improves operating conditions for airway surgery
- Does not require complex airway management

- **Patient selection**
- **”Newer” technique and equipment**
- **Does require airway patency (e.g. suspension laryngoscopy)**
- **Does require back up strategies**
- **Not a rescue technique**
- **Limiting factors: ↑ $PaCO_2$ & ↓ pH**