**Safe Apnea Time**

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**What is Safe Apnea Time?**

- Starts when *apnoea/obstruction* occurs, until any situation in which adequate alveolar *oxygen delivery* can be confirmed before critical desaturation.

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**Aim of lecture**

- Oxygen delivery  
- Relevant technique  
- It is **NOT** directly about difficult ventilation or intubation

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**Why is it relevant?**

- The goal in airway management is to provide *oxygenation* and ventilation.  
- M&M result when *oxygenation* cannot be provided. *
**Approach**

- Oxygen reserve, determinants of desaturation speed
- Techniques per phase of induction:
  - Preoxygenation phase
  - Post induction/ventilation phase
  - Apneic oxygenation phase
- Case report

**Speed of desaturation**

- \( \text{O}_2 \) Reserve
- \( \text{O}_2 \) Consumption
- \( \text{O}_2 \) Delivery

**\( \text{O}_2 \) Reserve**

- Blood
  - Plasma
    - 7 ml \( \text{O}_2 \) on air
    - 45 ml \( \text{O}_2 \) on \( \text{O}_2 \)
  - Hemoglobin
    - 788 ml on air
    - 804 ml on \( \text{O}_2 \)
- Lung
  - 630 ml on air
  - 2850 ml on \( \text{O}_2 \)
**O₂ Consumption**

- Age
  - Pediatrics
  - Elderly
- Pregnant
- Trauma Patienten
- Septic
- Depth of anesethie
- Drug used for induction * **

**O₂ delivery**

- FAO2
- FRC
- Shunting
- Hb concentration
- Etc ...

**What I’m trying to say**

"Blah! Blah!"

- O₂ Consumption and Delivery will give you an idea about the speed of desaturation
- FRC has the greatest extend on Safe Apnea Time

**Preoxygenation: definitions**

- Preoxygenation “denitrogenation”:
  - administration of oxygen before induction
- Failure:
  - defined as an FeO₂<90% after three minutes of tidal volume breathing *
- Desaturation:
  - SpO₂ < 90%
Why is it so important?

- With SARI less than 2% were unanticipated difficult intubation *
- BUT, in daily clinical practice:
  - 93% were unanticipated intubations.
  - When anticipated, 25% had an actual difficult intubation.
- Difficult mask ventilation:
  - 94% were unanticipated
  - When anticipated, 22% had an actual difficult mask ventilation

Effect on Safe apnea time

- FIO2 0.21 ->
  - 1–2 min of apnea time
- FIO2 1.0 ->
  - 8 min
- Obese FIO2 1.0 -> 2–3 min

Preoxygenation techniques

- Spontaneous breathing at FiO2 of 1 for 3 min
  - O2 flow 5L/min is enough “MV”
  - FeO2 of 95% in the first min
- Vital capacity manoeuvre “4 deep breaths within 30 sec”
  - Safe apnea time is shorter
  - O2 flow 10L/min
- Modified vital capacity “8 deep breaths within 60 sec”
  - Comparable results to spontaneous breathing even in obese population
Preoxygenation techniques

- The voluntary hyperventilation technique
  - 1 minute at FiO2 1
  - followed by 2 minutes of voluntary hyperventilation
  - PaCO2 after intubation was similar

- Pressure support
  - improve the quality by:
    - Acceleration of denitrogenation
    - Better mask seal
    - 90-100% reached FE02 of 90% compared with 65% with spontaneous breathing *
  - Suggested settings
    - PS 4 cm H2O with PEEP 4

FiO2 & Atelectasis

- Post induction atelectasis
  - FiO2 1.0 vs lower
    - Atelectasis has also been observed when a FiO2 0.4 is used
    - FiO2 of 0.8 does not prevent atelectasis
  - So, always preoxygenate with 100% O2 *

Monitoring of Preoxygenation

- SpO2
  - Doesn’t reflect the quality of preoxygenation

- CO2 wave shape
  - Indicator of quality of the mask seal
  - Most common reason of failure is loos mask *
  - Leaks of 4 mm2 causes significant reduction in FiO2 **

- FeO2
  - Small tidal volume leads to false high FeO2, thus overestimation of FAO2

Preoxygenation: Obese

- Problems
  - Shunt, can exceed 20%
  - Decrease in FRC
  - Increase in O2 consumption

- Techniques
  - CPAP doesn’t improve safe apnea time
  - PS with PEEP improves post intubation PaO2
  - 25° head-up position prolongs safe apnea time
**Preoxygenation: Pregnancy**

- Complete denitrogenation need shorter time
- Safe apnea time can be only 60 sec

**Preoxygenation: Pediatrics**

- 2 min of spontaneous breathing, desaturation time
  - < 6 months: 97 sec
  - 2-5 years: 160 sec
  - 11-18 years: 382 sec
- No benefit of longer preoxygenation than 3 min
- Cave: Preoxygenating with N2O/O2 can decrease safe apnea

**Preoxygenation: Altered mental status, claustrophobia**

- Claustrophobia
  - Let hem hold the mask!
  - THRIVE
- DSI “Delayed Sequence Intubation”
  - Induction with Ketamine to achieve dissociation

**Ventilation Phase**

- Goal is a good mask seal:
  - FeO2
  - CO2 curve shape
- If one hand is not enough, why not 2!
  - Claw grip VS Vice grip
- LMA
Rapid Sequence Induction

- Gentle face mask ventilation?
  - 20 cm H$_2$O **
  - 10 vs 15 cm H$_2$O***
  - 33% with 15 cm H$_2$O, 12% unable to ventilate
  - 19% with 10 cm H$_2$O, 75% unable to ventilate
  - Manual vs Mechanical ventilation ****

Apneic oxygenation: history

- Is it new?
  - 1908 Volhard
  - 1956 Holmdahl
  - 1959 Frumin

- Same phenomenon, many names:
  - Diffusion respiration
  - AVMF
  - Apneic oxygenation
  - ...

Apneic oxygenation: history

**TABLE 1**

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Duration of Apnea (sec)</th>
<th>Loss of Arterial Respiration to Next</th>
<th>Loss of Arterial Life</th>
<th>Highest PaCO$_2$ (mm Hg)</th>
<th>Average Rate of Loss PaCO$_2$</th>
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<td>6.5 to 6.5 mg/dL</td>
<td>100</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Frumin et al. *

Physiology of apneic oxygenation

Image from AANA journal, 2016
Physiology of apneic oxygenation

- Aventilatory Mass Flow (AVMF)
- Pharyngeal gas composition
- Diffusion of O2
- Elasticity of lungs → collapse and atelectasis

Hypercarbia

- Production of CO2: 200 – 250 ml/min
- ApOx: 90% CO2 in circulation, 10% enters alveoli
- PaCO2 rise: 1.12 – 2.4 mmHg/min
- Uncompensated respiratory acidosis
- Complications: seizures, arrhythmia’s, cardiovascular collapse, death

Results of Apneic Oxygenation

- Apneic oxygenation was associated with increased peri-intubation oxygen saturation, decreased rates of hypoxemia, and increased first-pass intubation success.

Results of Apneic Oxygenation

- ApOx significantly reduces the incidence of hypoxemia during emergency endotracheal intubation. Inclusion in everyday practice.
**Conditions and restrictions**

- Patent airway between alveoli and pharynx
  - Edentulous
  - Obstetric
  - Obese
  - OSAS
- Limited by hypercarbia
- Pathologic lung: collaps, atelectasis, shunt, VQ mismatch

**How to perform it?**

- Nasal Prongs
  - NO DESAT*
  - THRIVE**
- Nasopharyngeal catheters

**How to perform it?**

- Modified laryngoscope
- Buccal oxygen delivery

**Hollow Catheters**

- Frova catheter/ Tube exchanger
  - Gum-elastic bougie VS Frova
  - Administration of oxygen
    - RAPI-FIT adapter
    - Does it work?

* Terms & Conditions

**How to perform it?**

- RAPI-FIT ADAPTER 15 mm connector
- RAPI-FIT ADAPTER Luer lock connector
O₂ during fiberoptic intubation

- Endoscopy mask
O₂ during fiberoptic intubation:

- Endoscopy mask
- 2 man job
- LMA
  - Second generation "i-gel" + bronchoscopy elbow
  - Classical LMA + Aintree Intubation Catheter
- Connecting oxygen instead of suction

THRIVE:

- Transnasal Humidified Rapid Insufflation Ventilatory Exchange
- Matches peak inspiratory flow and prevent room air entrainment
  - Flow rate 60L/min
- Nasopharyngeal dead space as reservoir
- PEEP 6mmHg
- Greater patient comfort.
- Increased safe apnea time
**Examples**

- THRIVE: significant longer safe apnea time compared to apneic oxygenation

**THRIVE**

- Possible applications:
  - Preoxygenation
  - RSI
  - Pediatric patients
  - Difficult airway and reduced FRC
  - Critically ill

  Ang et al.
  Mir et al.
  Raineri et al.
  Patel et al.
  Vourc'h et al.

**In difficult airway**

- THRIVE = APOX + CPAP + gaseous exchange

  Patel A. 2014

- Lower rise in CO2 compared to airway obstruction/ classic APOX

  Patel A. 2014
In critically ill

• THRIVE minimizes risk of hypoxia in emergency intubation. *

• HFNC O2 significantly improved preoxygenation and reduced prevalence of severe hypoxemia compared with nonrebreathing bag reservoir facemask. Its use could improve patient safety during intubation. **

In critically ill, cont.

• THRIVE does not prevent deep desaturation during intubation in severely hypoxemic patients. Vourc’h et al.

Case Reports: ECMO *

• 45 Case reports
• All cases reported a favorable patient outcome with all patients surviving to hospital discharge without significant complications

• 77-yr-old male
• complex cardiac history: CABG, PM
• Obese BMI 35 Kg.m²
• Thyroid carcinoma
• CT showed a 1-mm opening at the level of the glottis
Case Reports: ECMO

- Patient was sedated with Midazolam
- ECMO was placed by a cardiac surgeon with local anesthetics
- General Anesthesia was induced
- Anesthetist failed to intubated the patient with video-laryngoscope
- The ENT surgeon skipped rigid bronchoscopy and placed a tracheotomy through the thyroid carcinoma
- ECMO then was removed, and heparin was antagonized

Take home messages

- Preoxygenation to avoid M&M
- Preoxygenation is your safety net, as we are in general not that good in anticipating difficult airway
- Optimize preoxygenation technique
  - Risk population: obese, pregnant and pediatric patients
- Concept of safe apnea time, and it always starts with preoxygenation
- Apneic oxygenation prolongs safe apnea time
  - NO DESAT
  - THRIVE

Take home messages

- Preoxygenation
- Preoxygenation
- Preoxygenation
- Preoxygenation
Sources

• Erbguth PH, Bergman NA. The effect of a single dose of succinylcholine on oxygen consumption and carbon dioxide production in man. Anesthesiology 1973
• Incidence of unanticipated difficult airway using an objective airway score versus a standard clinical airway assessment: the DIFFICAIR trial – trial protocol for a cluster randomized clinical trial Anders Kehlet Nørskov1
• Critical Hemoglobin Desaturation Will Occur before Return to an Unparalyzed State following 1 mg/kg Intravenous Succinylcholine Jonathan L. Benumof, MD; Rachel Dagg, MS; Reuben Benumof, PhD

Recommended Resources

• Basics: Preoxygenation and general anesthesia: a review
  • By G. BOUROCHE, J. L. BOURGAIN, 2015, Minerva Anestesiologica
  • Website: http://vortexapproach.org/
• THRIVE: a physiological method of increasing apnoea time in patients with difficult airways.
  • By A. Patel, SA Nouraei