COVID19 & Oxygenation support: Is there any solution for low resource hospitals ?

Lessons learned from the literature and from the top of the Kilimanjaro Mountain

Dr Lionel Dumont
Anesthesiologist
Geneva University Hospital
2ND Chance
Switzerland

Hôpitaux Universitaires Genève

2ND CHANCE

Anaesthesia in
Africa
Central America
Asia

Low resources
Disasters setting

2ND CHANCE

Anaesthesia in
Africa
Central America
Asia

Low resources
Disasters setting

2ND CHANCE

COVID19 // Material & Human resources +++ for management of the respiratory failure… What about low resource setting?

Aim of this lecture… food for thought

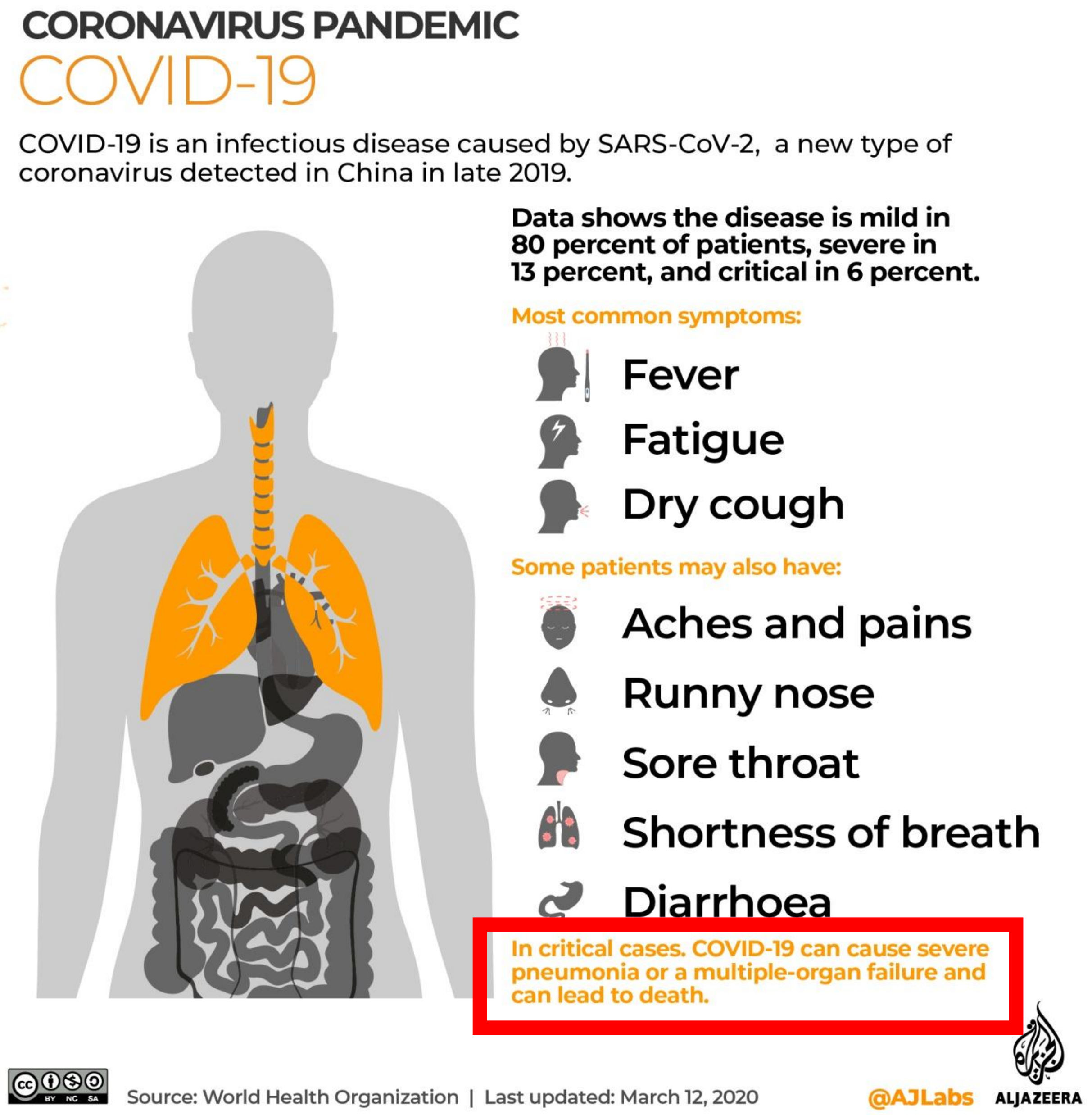
- Focus on one of the main life threatning symptoms of Covid19: Dyspnea / respiratory failure /ARDS

- Review & Discuss actual guidelines for **ARDS (Adult Respiratory Distress Syndrom) adapted to low resource settings**
  - Alternative to highly specialized intensive care for oxygenation

- Thoughts about Human tolerance to Hypoxemia – hypoxia

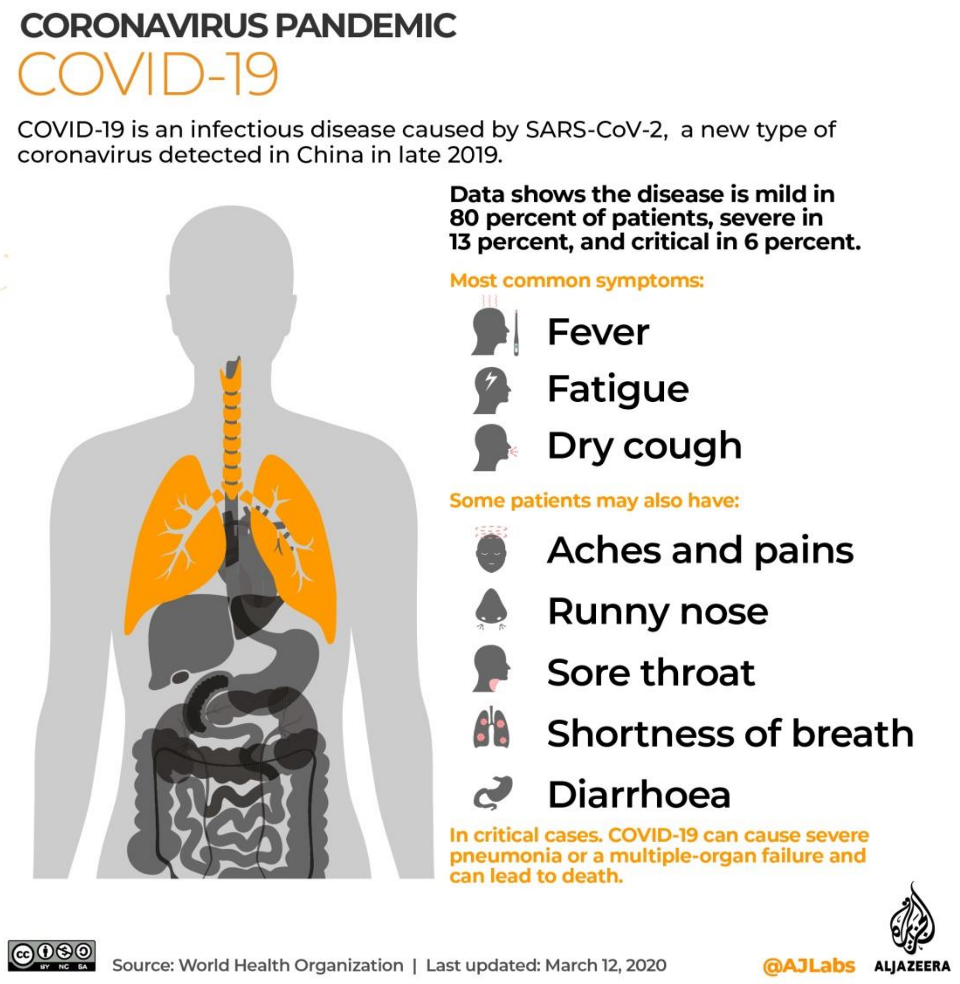
Generalities

- Everybody Knows…
- Severe pneumonia… death



What are patients dying from during COVID19 infection?

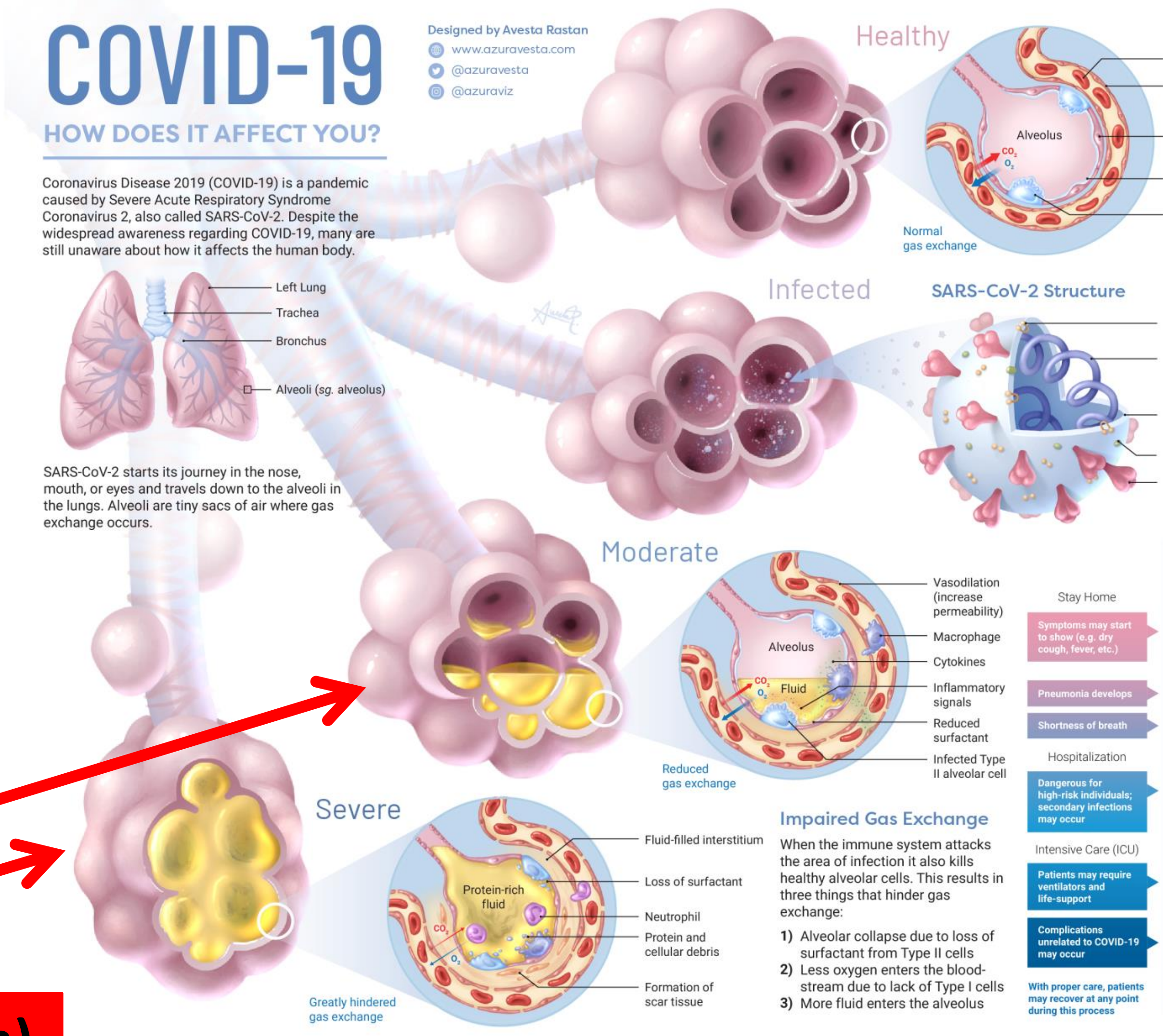
- Acute hypoxemic respiratory insufficiency or failure requiring oxygen and ventilation therapies
- Admission in ICU < Hypoxemia / dyspnea // ARDS
- Mortality related to complications (Inflammatory storm/ Mechanical ventilation/ adverse effects / iatrogenic…)
  - Pulmonary embolism
  - Cardiac failure
  - Renal failure
  - Infection
  - Brain hemorrhage
  - Acute hypoxia



Where does hypoxemia come from in COVID19 ?

The lungs are the organs most affected by COVID-19 because the virus accesses host cells via the enzyme angiotensin-converting enzyme 2 (ACE2), which is most abundant in the type II alveolar cells of the lungs

https://www.sciencemag.org/news/2020/04/how-does-coronavirus-kill-clinicians-trace-ferocious-rampage-through-body-brain-toes



ARDS (Adult Respiratory Distress Syndrom)

ARDS (Adult Respiratory Distress Syndrom)

- Respiratory failure in COVID-19 is ARDS and should be treated as such (FLARE group MGH April 2020)

Table 1. ARDS Berlin definition.

The Berlin definition of acute respiratory distress syndrome	
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities — not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mmHg $< PaO_2/FIO_2 \leq$ 300 mmHg with PEEP or CPAP $\geq$5 cmH_2O[c]
Moderate	100 mmHg $< PaO_2/FIO_2 \leq$ 200 mmHg with PEEP $\geq$5 cmH_2O
Severe	$PaO_2/FIO_2 \leq$ 100 mmHg with PEEP $\geq$5 cmH_2O

Normal conditions PaO_2 = 100 mmHg FiO_2 =21%

PaO_2/FiO_2 = 100 /0,21= 476 mmHg

ARDS (Adult Respiratory Distress Syndrom

(Adapted to low resources – **Kigali modified)**

	Berlin Criteria	Challenges in Resource Poor Settings	Kigali Modification of the Berlin Criteria
Timing	Within 1 wk of a known clinical insult or new or worsening respiratory symptoms	None	Within 1 wk of a known clinical insult or new or worsening respiratory symptoms
Oxygenation	$Pa_{O_2}/FI_{O_2} \leqslant 300$	Scarcity of arterial blood gas diagnostics	$Sp_{O_2}/FI_{O_2} \leqslant 315$
PEEP requirement	Minimum 5 cm H_2O PEEP required by invasive mechanical ventilation (noninvasive acceptable for mild ARDS)	Scarcity of mechanical ventilators	No PEEP requirement, consistent with AECC definition
Chest imaging	Bilateral opacities not fully explained by effusions, lobar/lung collapse, or nodules by chest radiograph or CT	Scarcity of chest radiography resources	Bilateral opacities not fully explained by effusions, lobar/lung collapse, or nodules by chest radiograph or ultrasound
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload (need objective assessment, such as echocardiography, to exclude hydrostatic edema if no risk factor present)	None	Respiratory failure not fully explained by cardiac failure or fluid overload (need objective assessment, such as echocardiography, to exclude hydrostatic edema if no risk factor present)

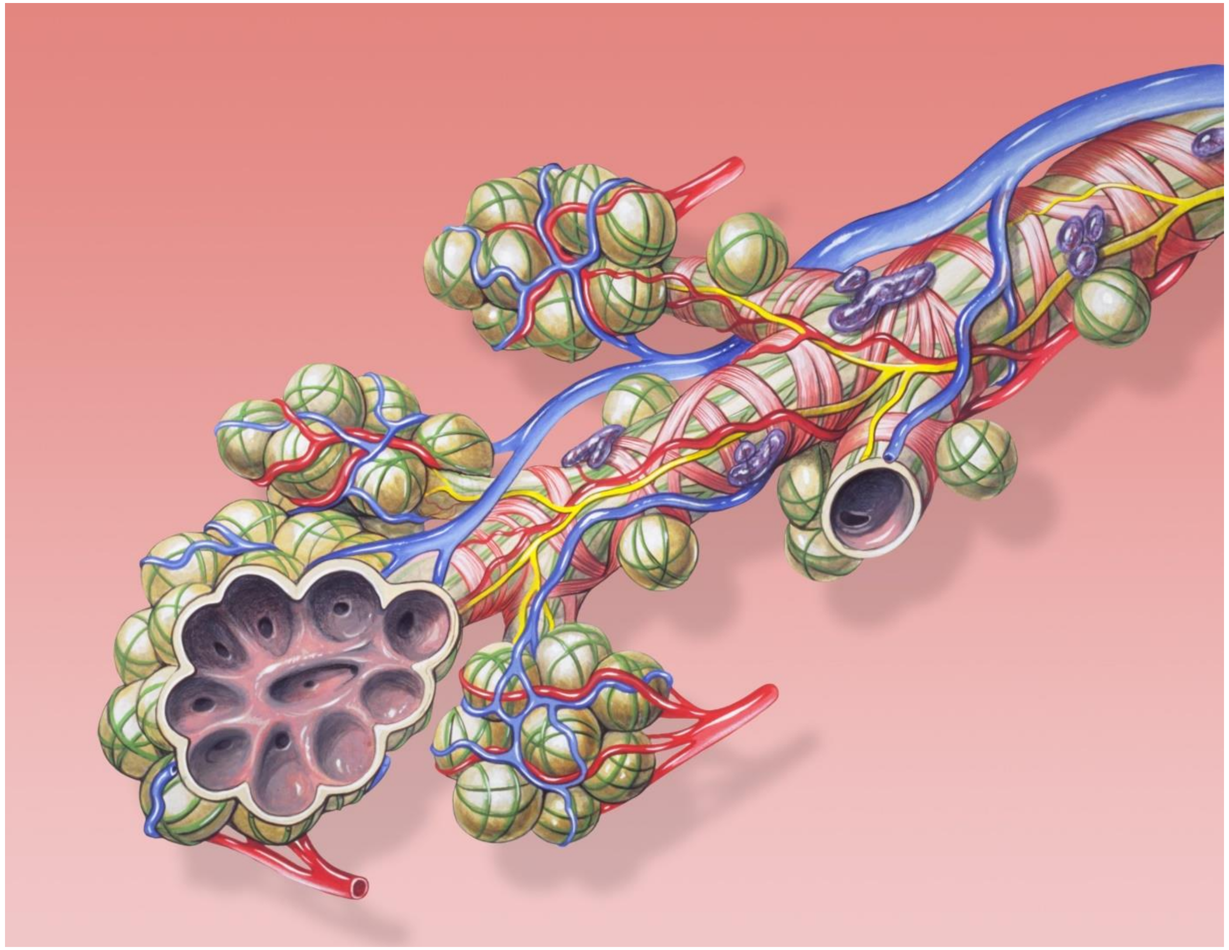
Definition of abbreviations: AECC = American-European Consensus Conference; ARDS = acute respiratory distress syndrome; CT = computed tomography; PEEP = positive end-expiratory pressure; Sp_{O_2} = oxygen saturation as measured by pulse oximetry.

Normal conditions Sp O_2 = 98 %FiO_2 =21%

SpO_2/FiO_2 = 98 /0,21= 466 mmHg

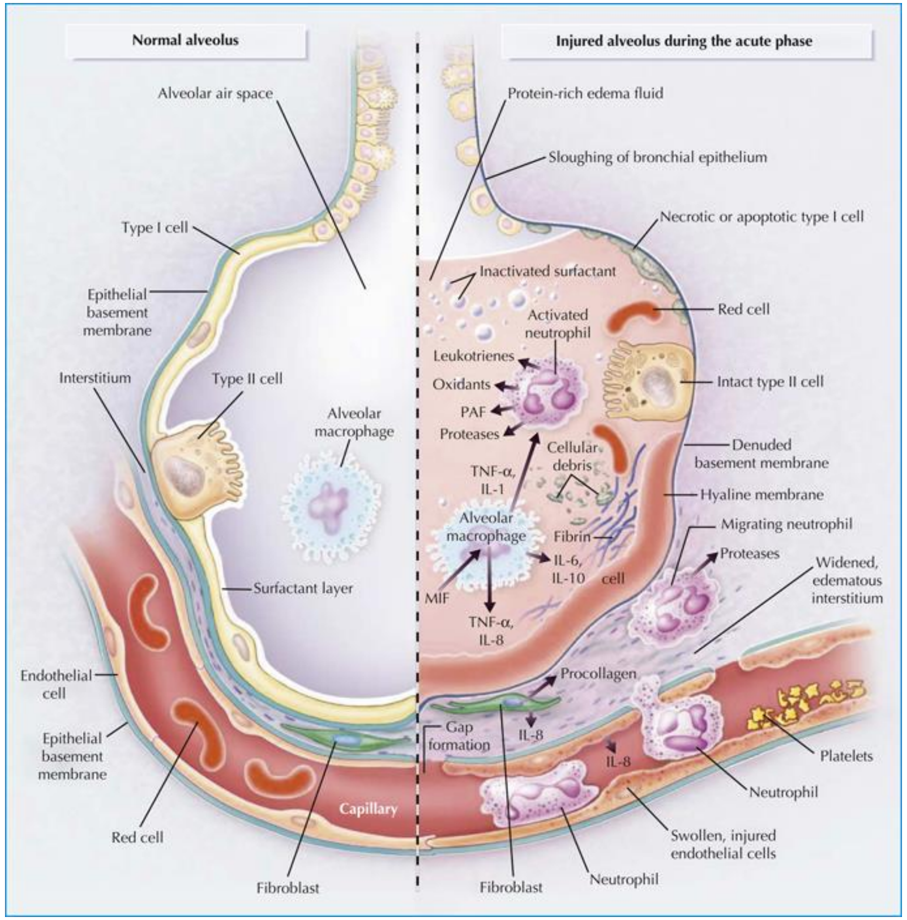
The cause of hypoxemia in COVID19 pneumonia

- **Alveolar instability (Gas & vascular structure)**
- surfactant inactivation
  - Due to increased permeability of the alveolar capillary membrane and extravasation of fluid and proteins into the airspaces.
- Without surfactant, alveoli need greater transpulmonary pressures to remain inflated, and without these pressures they remain underinflated or collapse -- contributing to areas of V/Q mismatch or shunt.
- The application of PEEP can promote reinflation of collapsed alveoli (called recruitment).



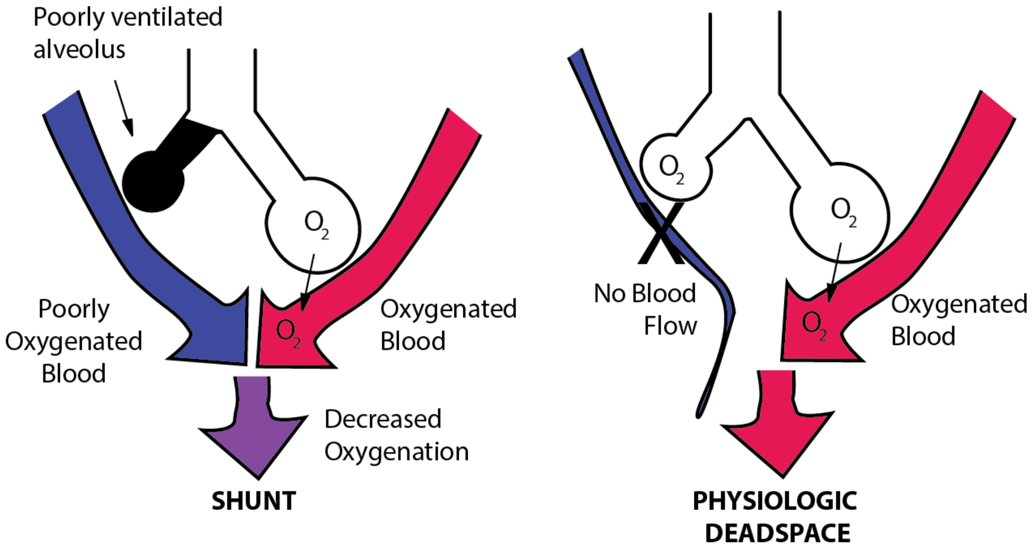
The cause of hypoxemia in ARDS

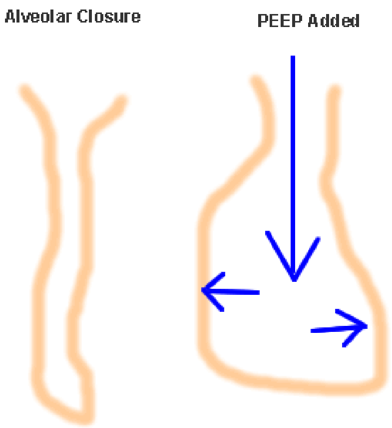
- Alveolar instability
- surfactant inactivation,
  - Due to increased permeability of the alveolar capillary membrane and extravasation of fluid and proteins into the airspaces.
- **Without surfactant, alveoli need greater transpulmonary pressures to remain inflated, and without these pressures they remain underinflated or collapse** -- contributing to areas of V/Q mismatch or shunt.
- The application of PEEP can promote reinflation of collapsed alveoli (called recruitment).



The cause of hypoxemia in ARDS

- Alveolar instability
- surfactant inactivation,
    - Due to increased permeability of the alveolar capillary membrane and extravasation of fluid and proteins into the airspaces.
- Without surfactant, alveoli need greater transpulmonary pressures to remain inflated, and without these pressures they remain underinflated or collapse -- contributing to areas of V/Q mismatch or shunt.
- **The application of POSITIVE END EXPIRATORY PRESSURE (PEEP) can promote reinflation of collapsed alveoli (called recruitment).**



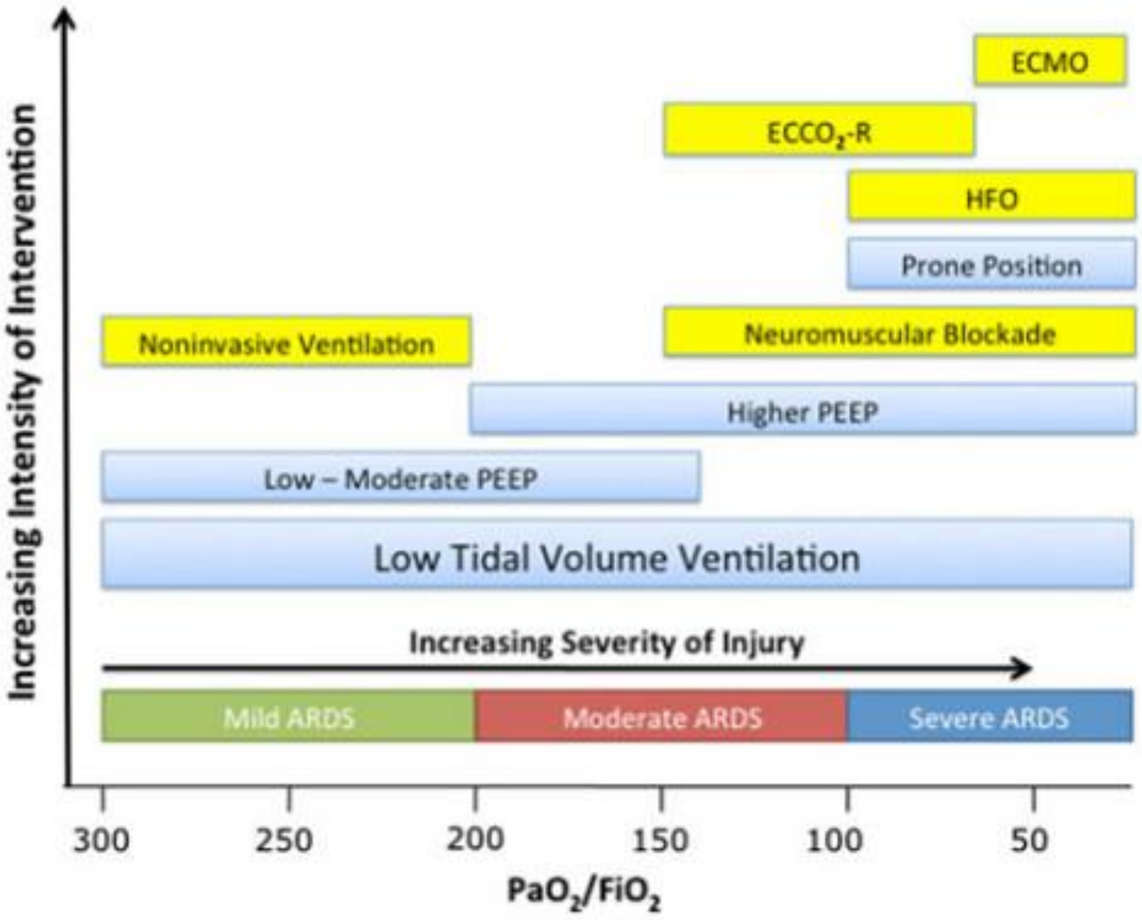


ARDS (Adult Respiratory Distress Syndrom)

Treatment

No real cure for ARDS

- **Supporting the patient while the lungs heal**
- The goal of supportive care is getting enough oxygen into the blood and delivered to your body to prevent damage and removing the injury that caused ARDS.
  - **Ventilator support**
  - **Prone position**
  - **Sedation & Medication to prevent movement**
  - **Fluid Management**
  - **Extracoporeal membrane oxygenation**

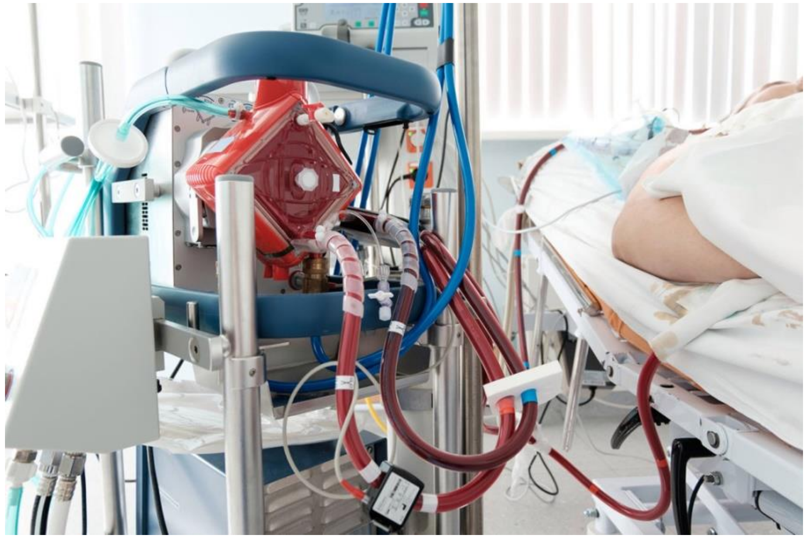


ARDS (Adult Respiratory Distress Syndrom)

Treatment

No real cure for ARDS

- **Supporting the patient while the lungs heal**
- The goal of supportive care is getting enough oxygen into the blood and delivered to your body to prevent damage and removing the injury that caused ARDS.
    - **Ventilator support**
    - **Prone position**
    - **Sedation & Medication to prevent movement**
    - **Fluid Management**
    - **Extracoporeal membrane oxygenation**



Mortality related to Covid19 ARDS

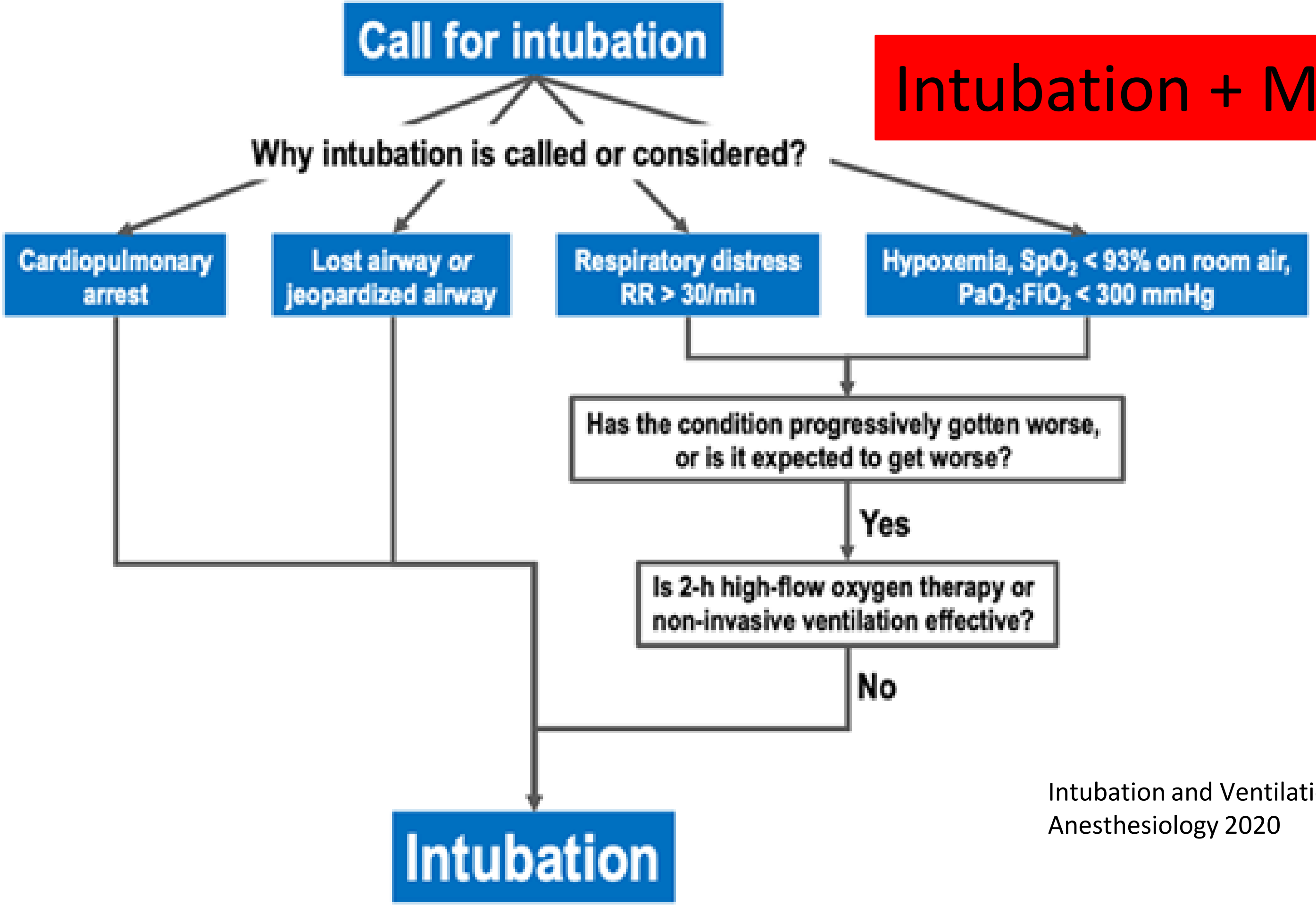
- Richardson et al. 2020 – JAMA (New York - USA) : 88.1 % mortality / intubated patient
- Wu et al, 2020 – JAMA (Wuhan – China): 49 % mortality/intensive care patients
- Ruan et al, (Wuhan China) Intensive Care Med 2020: 97% mortality / multicentric/intubated patient
- Namendys-Silva 2020 Lancet respiratory: Review 86 % Mechanical ventilation
- Geneva around 25% (unpublished data)

- It does not mean that mechanical ventilation kills patients… but it means patients needing mechanical ventilation have a very bad outcome whatever we do

Recovering from ARDS (American Lung Association)

- Ventilation for long periods of time 7 to 14 days
- Tracheostomy
- Several weeks to recover from ventilator support.
- Concerning people who survive ARDS:
  - They will not require oxygen on a long-term basis and will regain most of their lung function.
  - Others will struggle with muscle weakness and may require re-hospitalization or pulmonary rehabilitation to regain their strength.
- Many survivors of acute respiratory distress syndrome (ARDS) remain functionally disabled in multiple ways after five years [Gever et al, Crit Care 2011]

Recommendations for management: Respiratory failure in COVID-19 is ARDS and should be treated as such (FLARE group MGH April 2020) https://us19.campaign-archive.com/?u=ef98149bee3f299584374540a&id=48d2c0484f

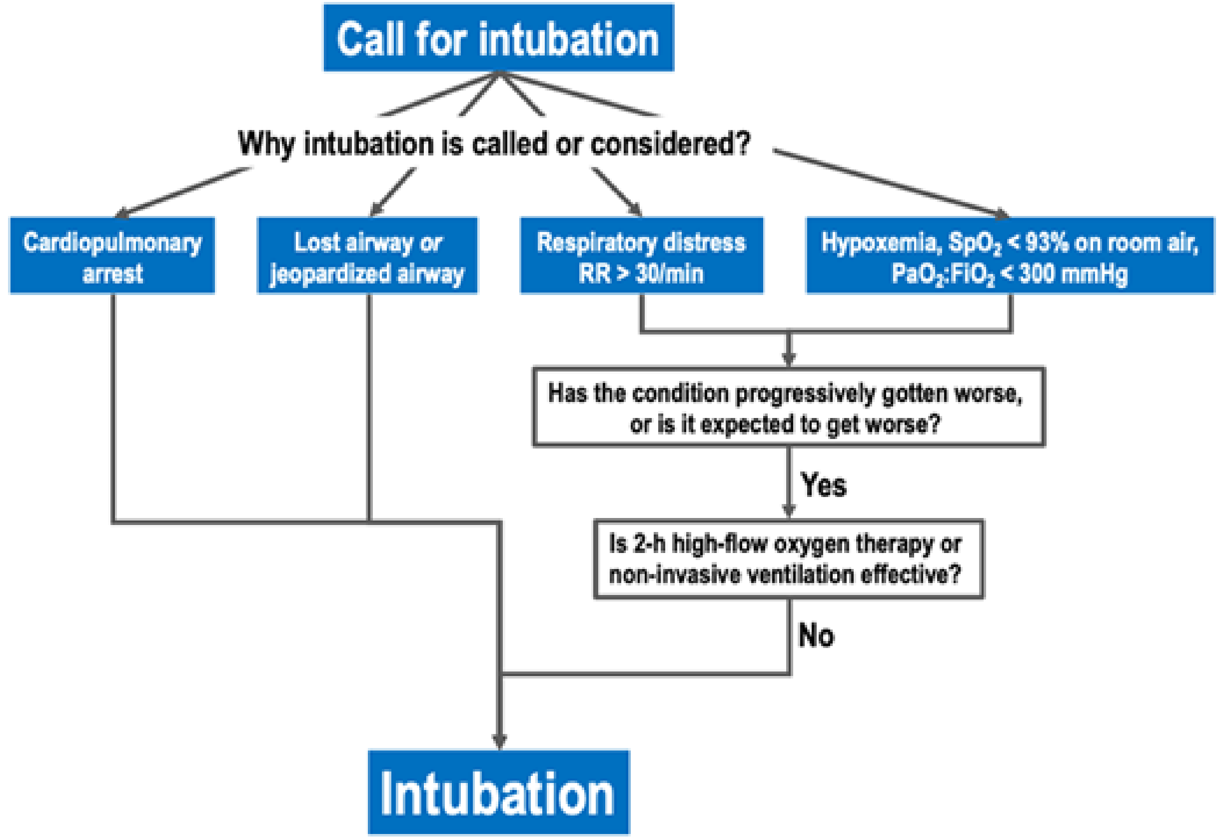


Intubation + Mechanical Ventilation (ARDS)

Intubation and Ventilation amid the COVID-19 Outbreak: Wuhan's Experience. Meng et al. Anesthesiology 2020

Respiratory failure in COVID-19 is ARDS and should be treated as such (FLARE group MGH April 2020) https://us19.campaign-archive.com/?u=ef98149bee3f299584374540a&id=48d2c0484f

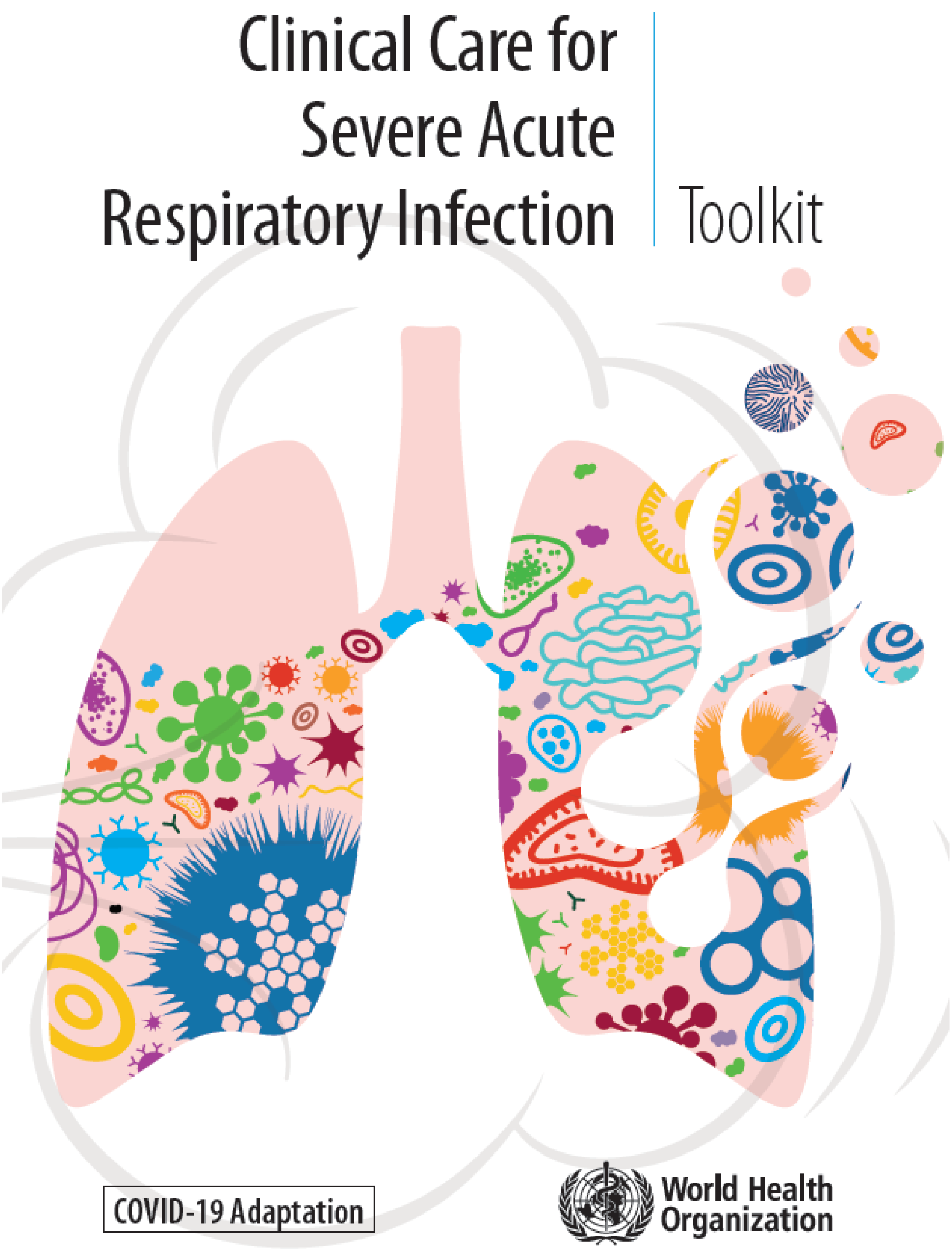
- What if we can not measure hypoxia main markers ?
  - No blood gaz analysis (Pao2/FiO2 ratio)
  - Only Pulse oxymeter (Oxygen saturation and not PaO2)
- What should we do if we don't have material support for oxygenation
  - Mechanical ventilation (Low Tv, High PEEP…)
  - ECMO, iNO….
  - Intensive care drugs (sedation, curare, noradrenaline)
  - Intensive care material



Intubation and Ventilation amid the COVID-19 Outbreak: Wuhan's Experience. Meng et al. Anesthesiology 2020

Guidelines for treatment of COVID19/ ARDS

- What are the WHO guidelines for Africa?
  - https://www.who.int/publications-detail/clinical-care-of-severe-acute-respiratory-infections-tool-kit
- 196 pages full of algorithm & checklist…. update April 10
- In my opinion… totally unadapted for most African hospitals where I have worked before



Guidelines for treatment of COVID19/ ARDS

Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected.

Interim guidance
13 March 2020

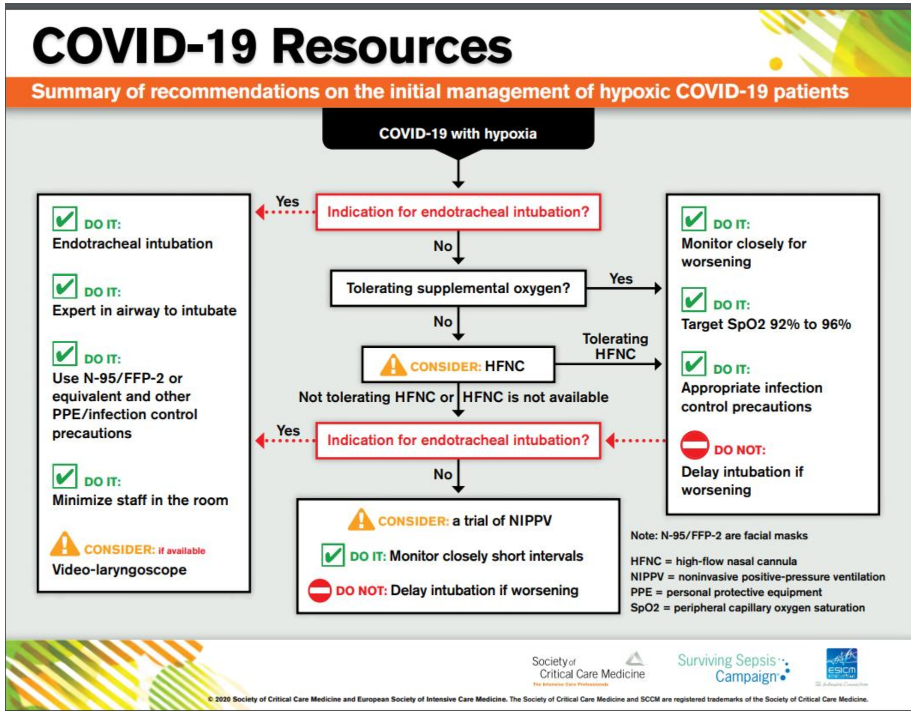
World Health Organization

EMERGENCY CARE OF COVID-19 IN ADULTS IN LOW RESOURCE SETTINGS

Key words:

- Endotracheal intubation
- Mechanical ventilation
    - PEEP (positive End expiratory Pressure)
- Support if SPO2 < 93%

AFEM
African Federation for Emergency Medicine
Fédération Africaine de Médecine d'Urgence

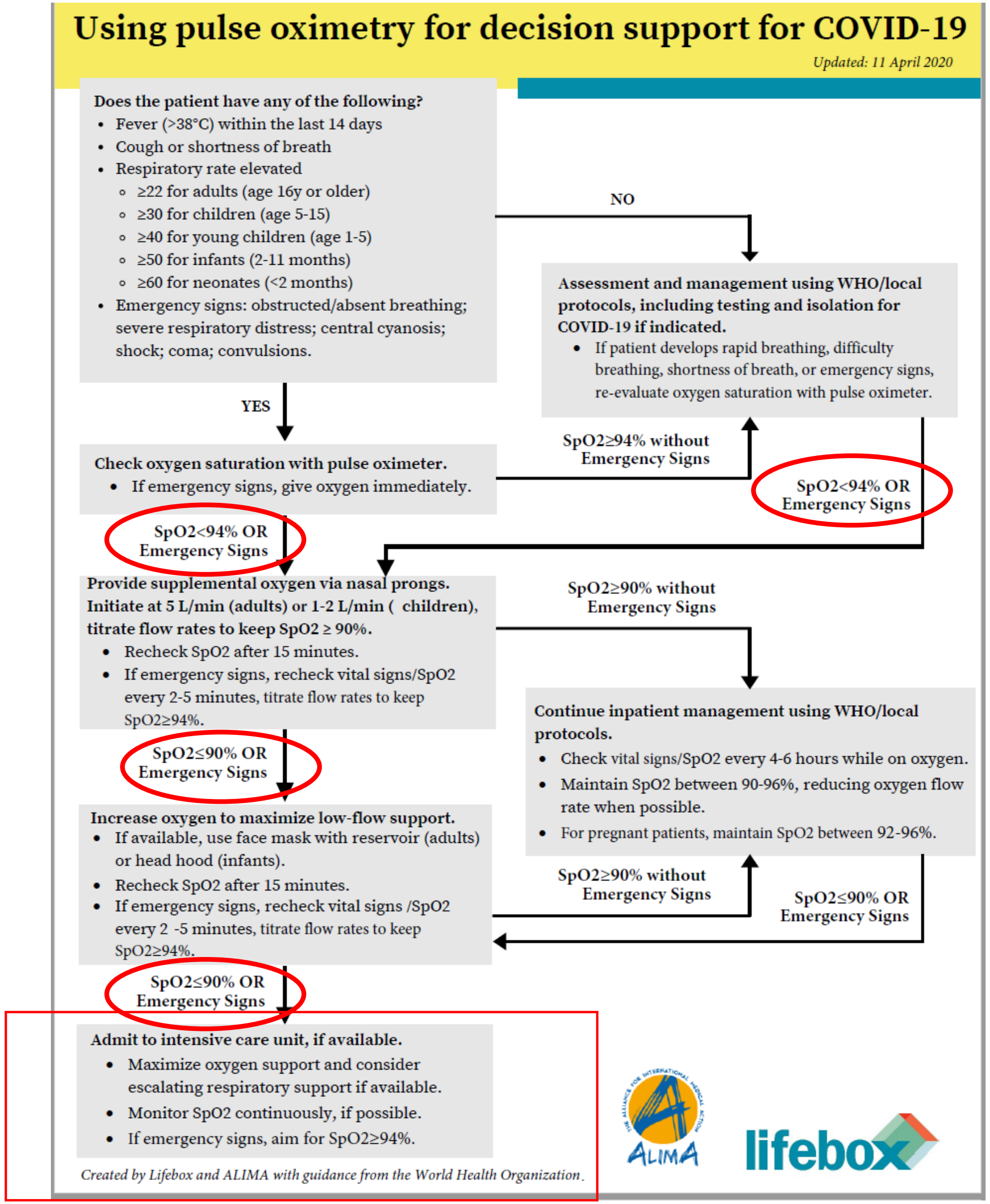


Guidelines for treatment of COVID19/ ARDS

Key words:

- Endotracheal intubation
- Mechanical ventilation
  - PEEP (positive End expiratory Pressure)
- Support if SPO2 < 93%

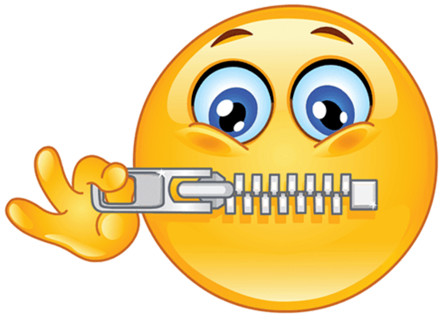
ESCALATING RESPIRATORY SUPPORT: Tacheal intubation / Mechanical Ventilation with special ventilatory mode and High PEEP? Intensive care Unit



Are these recommendations realistic in Low resource settings ?

- My opinion…

1. Intensive care copy/paste of Western guidelines



2. Do your best !! Good luck!!!!

3. Do your best based on published evidence BUT adapted to local resources

Do most of African hospitals have the minimal resources for treating Severe COVID19 ARDS?

ESCALATING RESPIRATORY SUPPORT: Tacheal intubation / Mechanical Ventilation with special ventilatory mode and High PEEP? Intensive care Unit

- Let's have a look at the litterature… **Answer is NO** [Dunser et al, Anesthesia, 2017] **Uganda;** [Junette Arlette Metogo Mbengono et al Hosp Pract Res. 2019 Dec;4(4):117-121] - **Cameroon**
- Let's have a look at our experience… **Answer is NO**
  - **Even no alternative to delay intubation such as**
    - **Hight Flow nasal Cannula HFNC**
    - **Non invasive ventilation**
    - **CPAP**

- **What do we have…**
  - **Oxygen (tank, concentrator)**
  - **Pulse Oxymeter**
  - **Willigness of doing well**
  - **Younger patients (mean age in Africa 19 years old)**
  - **Most COVID-19 patients admitted to hospitals have mild to moderate ARDS**

- **What can we do with these setups?**

Evidence in the literature for alternative approach?

- Question 1: Alternative to intubation and mechanical ventilation?
  - Yes probably in some cases
- Question 2: Is SaO2 > 93% is really necessary to survive ?

Evidence in the literature for alternative approach?

- Question 1: Alternative to intubation and mechanical ventilation?
  - Yes probably
- Question 2: Is SaO2 > 93% really necessary to survive ?
  - Not necessarily (examples: pictures 4556 meters) [Dumont et al, 2004 Clin Science; Dumont et al, 2005 Travel Med; Dumont et al, BMJ 2001]
  - Not so simple…. In the context of ARDS

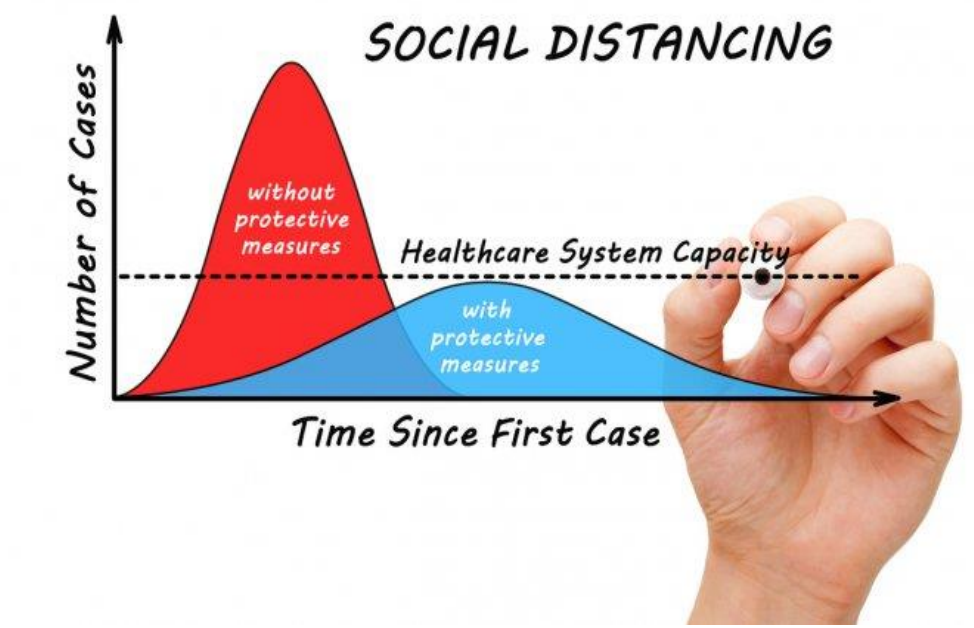
76%

Answer to question 1
Alternative to intubation and mechanical ventilation?
Evidence in the literature

- COVID pneumonia is "Not typical ARDS" [Gattinoni et al.,Intensive care 2020b]
- Any therapy or procedure that could prevent intubation and MV are welcome [Bendjelid - Crit Care Med , april 2020]
- COVID-19 Crisis: Ventilators Are Important – but They're Not Perfect Either [Health the Science Joshi et al 2020]
- Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province [Sun *et al. Ann. Intensive Care (2020)]*
- The surest way to increase Covid-19 mortality is liberal use of intubation and mechanical ventilation. [Tobin, 2020 Am J Respir Crit Care https://www.atsjournals.org/doi/pdf/10.1164/rccm.202004-1076ED
- COVID-19 - Trying Not to Intubate Early & Why ARDSnet may be the Wrong Ventilator Paradigm [Am Acad Emergency Med https://www.aaem.org/resources/publications/podcasts/critical-care-in-emergency-medicine/episode-19]
- 88.1% mortality rate among mechanically ventilated patients [Richardson et al. JAMA, 2020]

Alternative to intubation and mechanical ventilation? Reports in the media [Statnews, ABC, CNN,...]

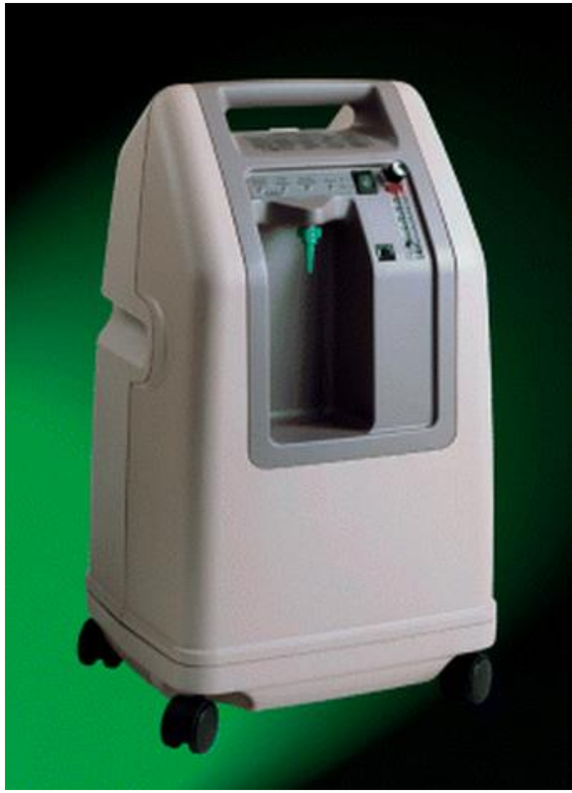
- Are doctors HARMING coronavirus patients by putting them on ventilators too early? Doctors warn that gadgets may be overused and could even damage the lungs of the infected
  - Almost two-thirds of coronavirus sufferers on ventilators in UK do not survive
  - Experts say ventilators are being implemented too soon and causing more harm
  - The machines, a last resort for patients, can aggravate inflammation in lungs Ventilators Cause Their Own Damage To Lungs. Is The Trauma Worth The Benefits For COVID-19 Patients?
- Are ventilators being overused on COVID-19 patients?



Is there any alternative to mechanical ventilation for COVID19 respiratory failure with low resources?

Reminder: No cure for ARDS

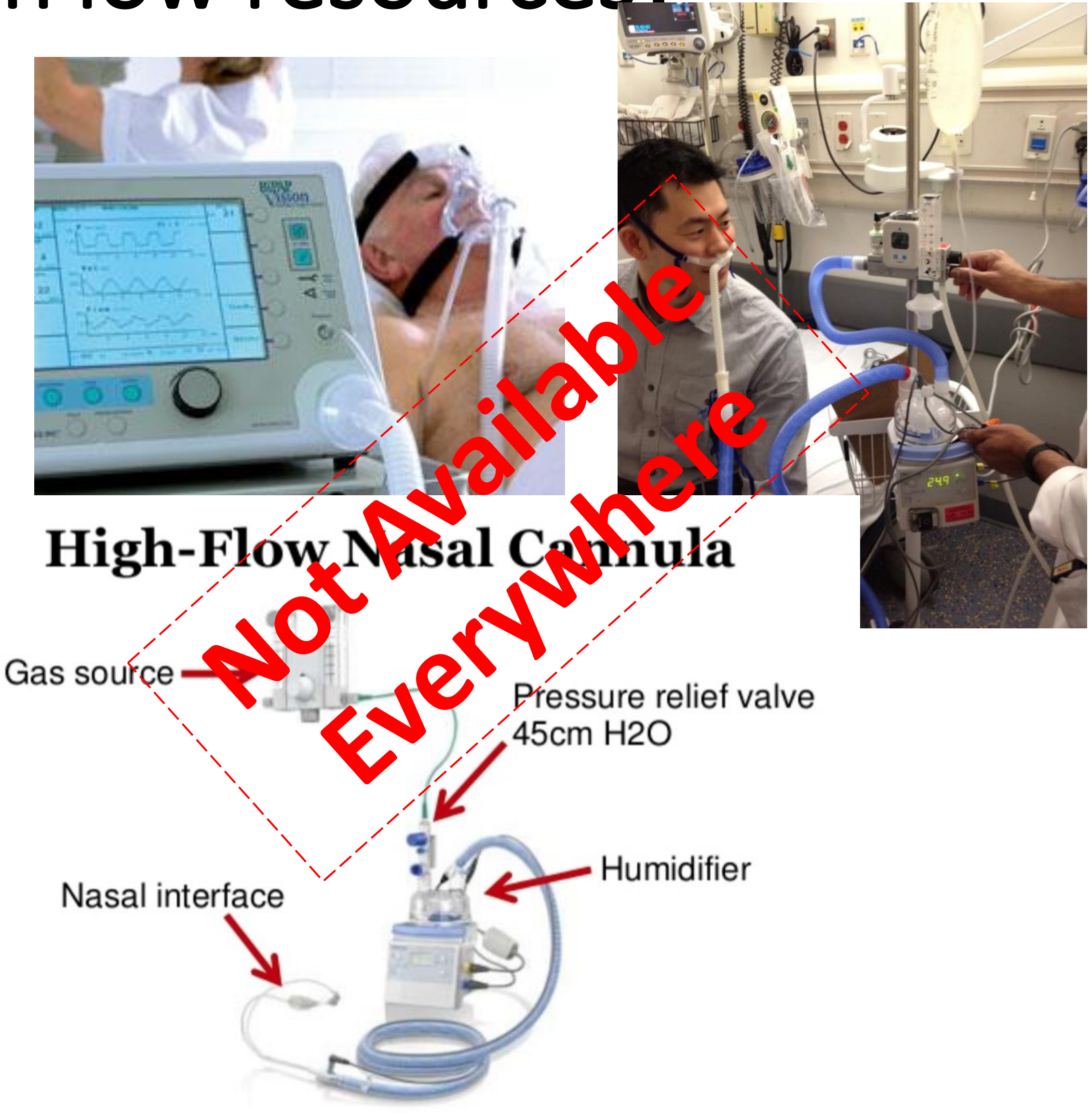
- Oxygen through facemask or nasal
  - Tank
  - Extractor (1-9 litres) – until 95%
- Spontaneous ventilation
- Non invasive ventilation, CPAP, HFNO
- Prone position in non-intubated patients in the setting of COVID-19
  - prone positioning in the non-intubated patient is likely safe and may be effective based on the above physiologic rationale (Ding et al., 2020; Sun et al., 2020)



Is there any alternative to mechanical ventilation for COVID19 respiratory failure with low resources?

Reminder: No cure for ARDS

- Oxygen
  - Tank
  - Extractor (1-9 litres) – until 95%
- Spontaneous ventilation
- Non invasive ventilation, CPAP, HFNO
- Prone position in non-intubated patients in the setting of COVID-19
  - prone positioning in the non-intubated patient is likely safe and may be effective based on the above physiologic rationale (Ding et al., 2020; Sun et al., 2020)



Is there any alternative to mechanical ventilation for COVID19 respiratory failure with low resources?

Reminder: No cure for ARDS

- Oxygen
  - Tank
  - Extractor (1-9 litres) – until 95%
- Spontaneous ventilation
- Prone position in non-intubated patients in the setting of COVID-19
  - prone positioning in the non-intubated patient is likely safe and may be effective based on the above physiologic rationale (Ding et al., 2020; Sun et al., 2020; Valter et al, 2003)

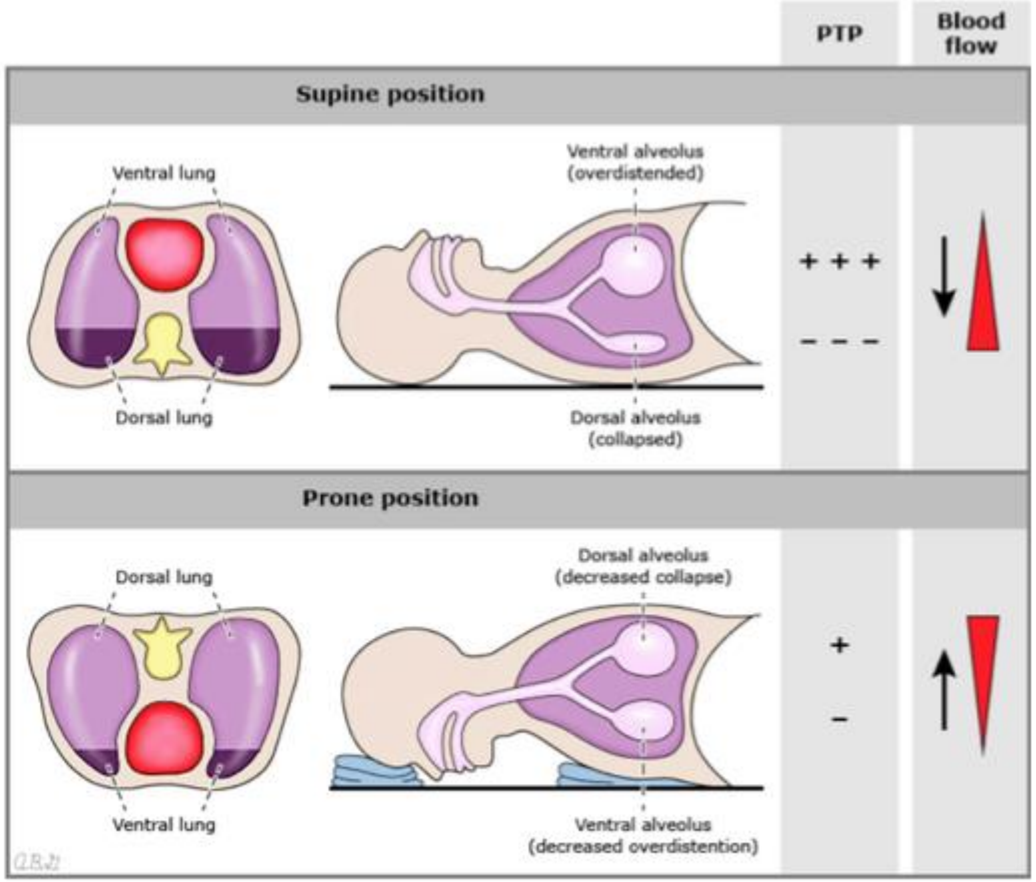
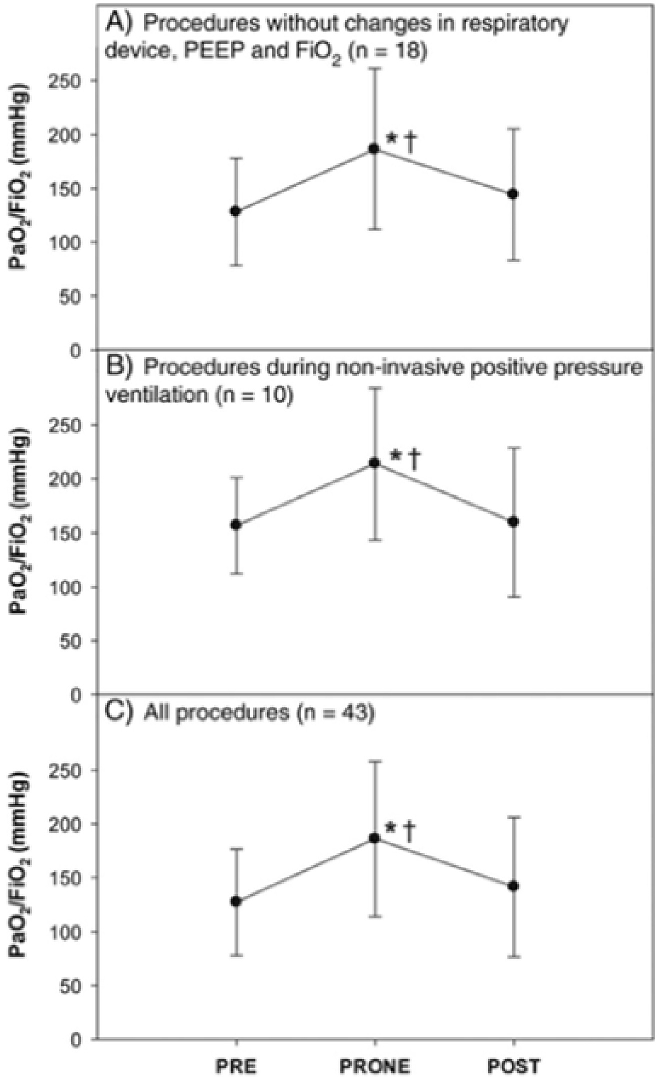


Figure 1: Regional decruitment, alveolar distension/collapse, transpulmonary pressure and blood flow in the supine and prone position. PTP= transpulmonary pressure. Image from A. Malhotra, UptoDate (Malhotra, 2019).

Prone positioning improves oxygenation in spontaneously breathing non-intubated patients with hypoxemic acute respiratory failure: New tool to avoid endotracheal intubation? (Scaravilli et al. 2015) https://emcrit.org/wp-content/uploads/2020/04/2020-04-12-Guidance-for-conscious-proning.pdf

- Proning was performed for a median of 3 hours and a maximum of 8 hours.
  - Improved secretion clearance (gravity works in your favor)
  - Recruitment of posterior lung regions which often become atelectatic
  - Improved ventilation / perfusion matching
- PP was feasible and improved oxygenation in non-intubated, spontaneously breathing patients with Acute Respiratory Failure.



Early Self proning in Awake, Non-intubated Patients in the Emergency Department: A Single ED's Experience during the COVID-19 Pandemic

(Caputo et al, 2020 /Academic Emerg Med) https://onlinelibrary.wiley.com/doi/abs/10.1111/acem.13994

- Fifty patients.
- Median SaO_2 at triage was 80% (IQR 69 to 85).
- After application of supplemental oxygen was given to patients on room air it was 84% (IQR 75 to 90).
- After 5 minutes of proning was added SaO_2 improved to 94% (IQR 90 to 95).
- 24% failed to improve or maintain their oxygen saturations >90% and required endotracheal intubation within 24 hours of arrival to the ED.

Prone position during spontaneous breathing may be an alternative to intubation (Banford et al,2020 ICS Guidance for Prone Positioning of the Conscious COVID Patient 2020 Intensive care society)

https://emcrit.org/wp-content/uploads/2020/04/2020-04-12-Guidance-for-conscious-proning.pdf

Massachusetts General Hospital Prone Positioning for Non-Intubated Patients Guideline

https://www.massgeneral.org/assets/MGH/pdf/news/coronavirus/prone-positioning-protocol-for-non-intubated-patients.pdf

- Limitations:
  - Pregnancy
  - Obesity
  - Intolerance

- Equipment
  - Pillow
  - Supplemental oxygen, as needed
  - Foam Dressings to protect pressure points
  - Continuous O2 monitor

Instructions for patients with cough or trouble breathing:

Instrucciones para pacientes con tos o dificultad para respirar:

Please try to not spend a lot of time lying flat on your back! Laying on your stomach and in different positions will help your body to get air into all areas of your lung.

¡Por favor, trate de no estar mucho tiempo acostado sobre su espalda (boca arriba)! Acostarse sobre su estómago (boca abajo), y en diferentes posiciones, le ayudará a su cuerpo a que le llegue aire a todas las áreas de sus pulmones.

Your healthcare team recommends trying to change your position every 30 minutes to 2 hours and even sitting up is better than laying on your back. **If you are able to, please try this:**

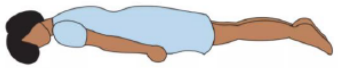
El grupo de sus cuidadores de salud le recomienda tratar de cambiar de posición entre cada 30 minutos y 2 horas, y aún permanecer sentado es mejor que estar acostado de espalda. **Si puede, por favor, intente esto:**

1. 30 minutes – 2 hours: lying on your belly
   30 minutos – 2 horas: acostado sobre su estómago (boca abajo)
2. 30 minutes – 2 hours: lying on your right side
   30 minutos – 2 horas: acostado sobre su lado derecho
3. 30 minutes – 2 hours: sitting up
   30 minutos – 2 horas: sentado
4. 30 minutes – 2 hours: lying on your left side; then back to position #1.
   30 minutos – 2 horas: acostado sobre su lado izquierdo; y luego vuelva a la posición # 1

PHOTOS BELOW TO DEMONSTRATE THIS:

LAS FOTOS DEBAJO DEMUESTRAN ESTO:

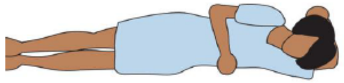
1. 30 minutes – 2 hours: laying on your belly
1. 30 minutos – 2 horas: acostado sobre su estómago (boca abajo)



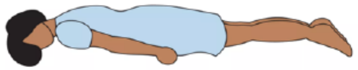
2. 30 minutes – 2 hours: laying on your right side
2. 30 minutos – 2 horas: acostado sobre su lado derecho

3. 30 minutes – 2 hours: sitting up
3. 30 minutos – 2 horas: sentado

4. 30 minutes – 2 hours: lying on your left side
4. 30 minutos – 2 horas: acostado sobre su lado izquierdo



Then back to Position 1. Lying on your belly!
Luego, vuelva a la posición 1. ¡Acostado sobre su estómago (boca abajo)!



Self Positioning Guide_Elmhurst Hospital_SB

Prone position during spontaneous breathing may be an alternative to intubation (Banford et al,2020 ICS Guidance for Prone Positioning of the Conscious COVID Patient 2020 Intensive care society)

https://emcrit.org/wp-content/uploads/2020/04/2020-04-12-Guidance-for-conscious-proning.pdf

Massachusetts General Hospital Prone Positioning for Non-Intubated Patients Guideline

https://www.massgeneral.org/assets/MGH/pdf/news/coronavirus/prone-positioning-protocol-for-non-intubated-patients.pdf

- Limitations:
  - Pregnancy
  - Obesity
  - Intolerance

- Equipment
  - Pillow
  - Supplemental oxygen, as needed
  - Foam Dressings to protect pressure points
  - Continuous O2 monitor

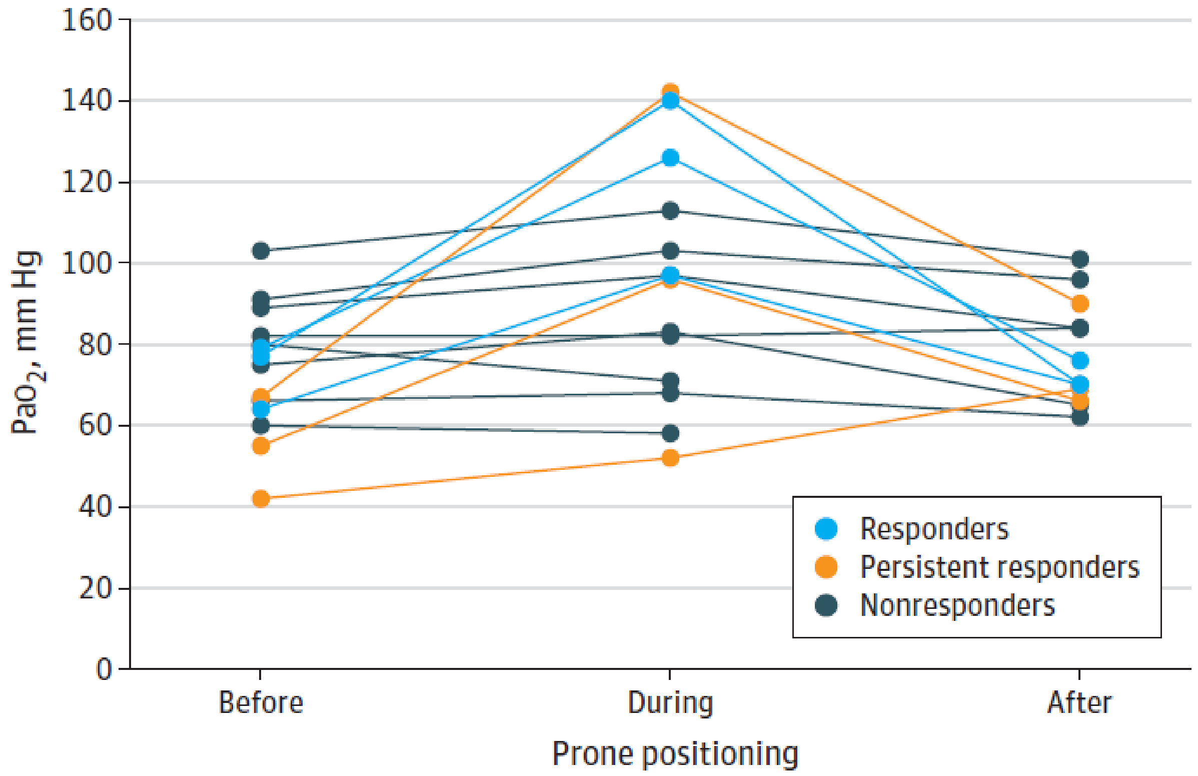
Patient self-proning with high-flow nasal cannula improves oxygenation in COVID-19 pneumonia [Slessarev et al, Can J Anesth 2020]

Case report – man 68 years old – severe ARDS P/F < 100 – HPNO - significant Improvement by self proning 16-18h/day – discharge after 4 day

FIGURE A) Anterior-posterior chest radiograph two days after intensive care unit (ICU) admission showing bilateral lung opacities. B) Patient self-proning while wearing high-flow nasal cannula. C) Changes in oxygenation expressed as arterial partial pressure of oxygen to fractional concentration of inspired oxygen (P:F) ratio versus time from ICU admission. Initiation of self-proning sessions is indicated by red arrows. Following the last self-prone session, the P:F ratio failed to improve. The patient was subsequently un-proned, which did not improve oxygenation. The care team then realized that the patient had developed nasal congestion (due to blood clots) in his posterior nasal passages. Once these were cleared, his oxygenation once again improved, and he was discharged from the ICU to a dedicated COVID-19 ward.

Use of Prone Positioning in Non intubated Patients with COVID-19 and Hypoxemic Acute Respiratory Failure [El Barrar *JAMA*. Published online May 15]

- 25 patients (66 Y //10,2)
- Mean Pao2 = 72 mmHg (14,2)
  - Supine: = 91 (27,3)
  - 4 did not tolerate PP > 1 h
  - 5 tolerate 1-3 h
  - 15 more than 3 hours
- At 10 days
  - 20 % need intubation
  - 80 % recover
- Conclusions:
  - Good responder, persistent and non responder
  - Limits (small sample, short term follow up, biais selection)



Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province [Sun *et al. Ann. Intensive Care (2020) 10:33]*

- Jiangsu 631 Novel Coronavirus pneumonia patients (1-96 years old)
- 3 points which showed valid evidence in reversing the disease and preventing tracheal intubation rate were:
- 10 % critical case (n=63) only 1% (n=6) need intubation

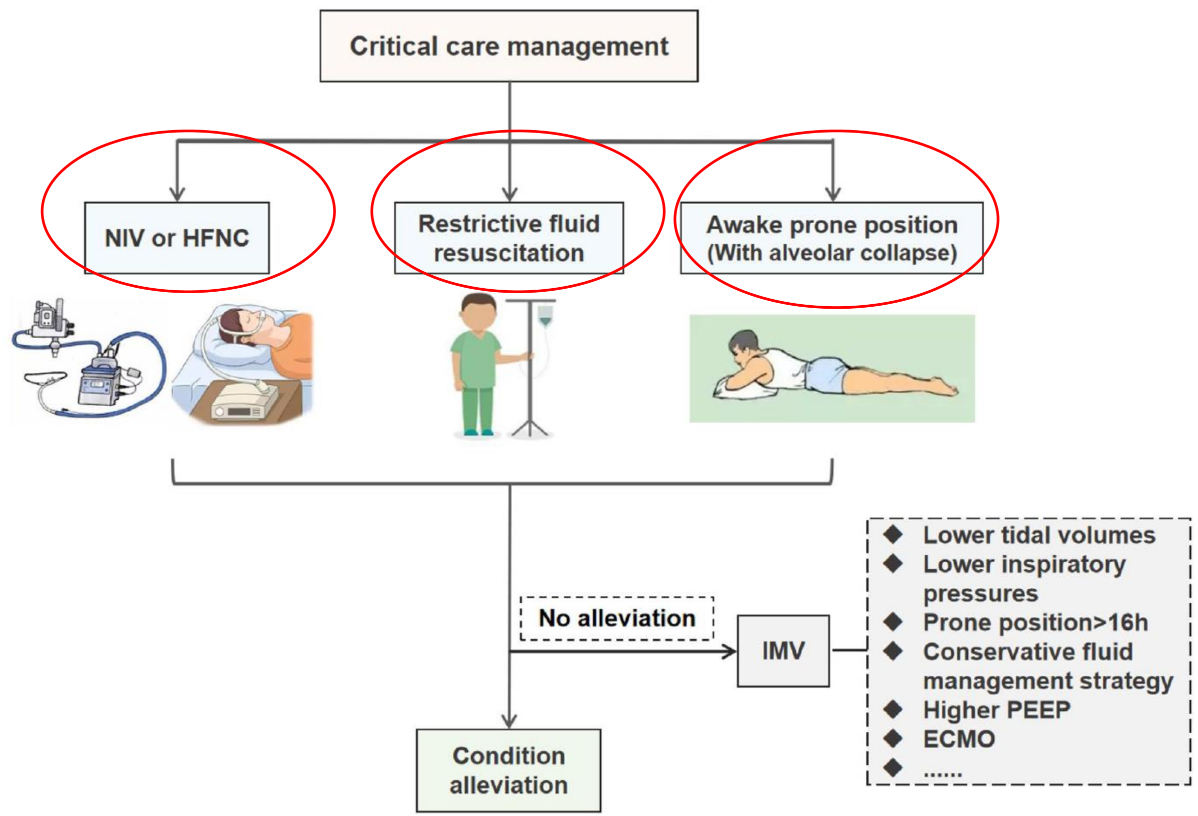
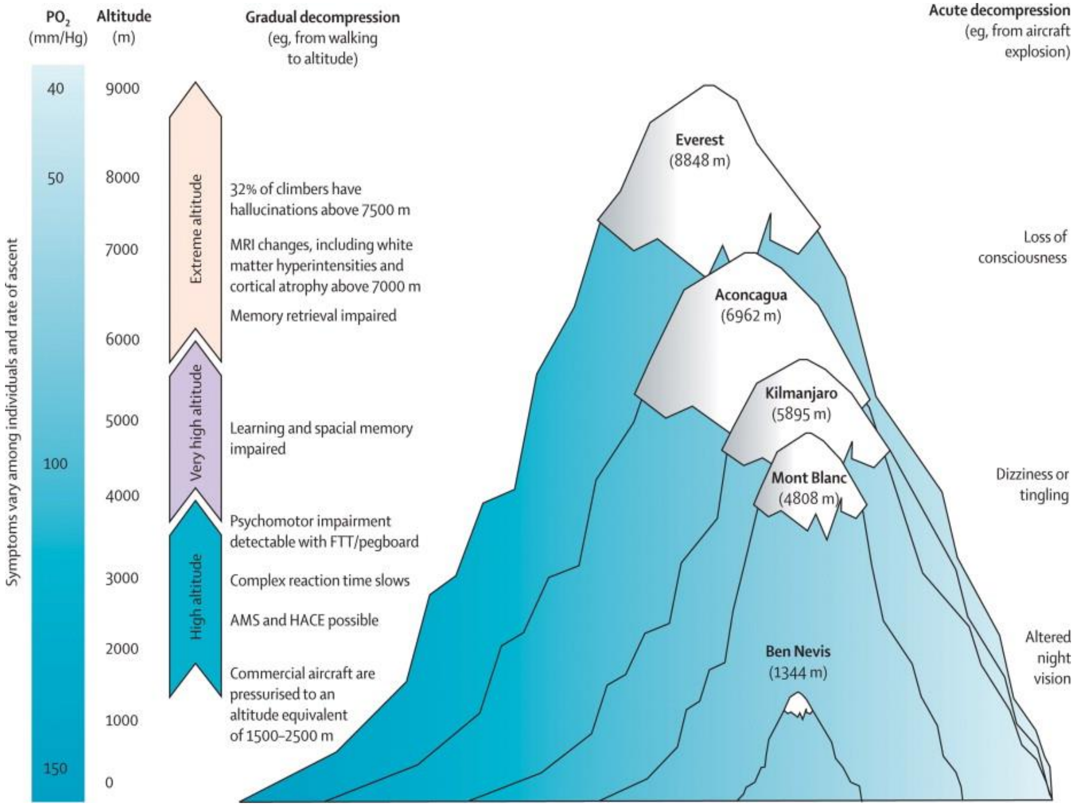


Fig. 2 Early intervention for patients with critical condition

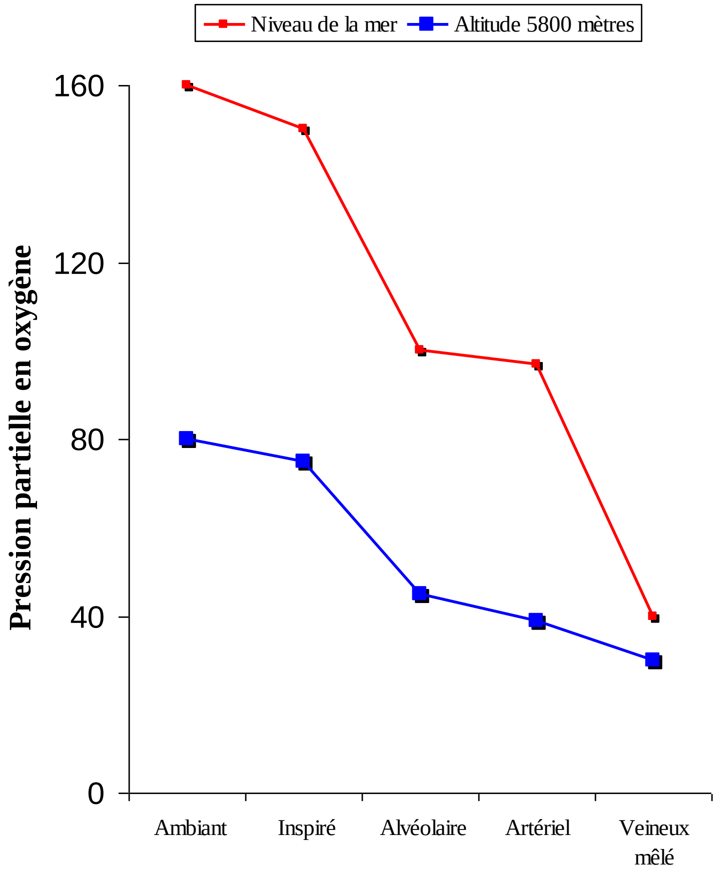
Answer to question 2
Is SAO2 > 93% is really necessary to survive ?
Another cause of hypoxemia : Low inspired oxygen content… high altitude!

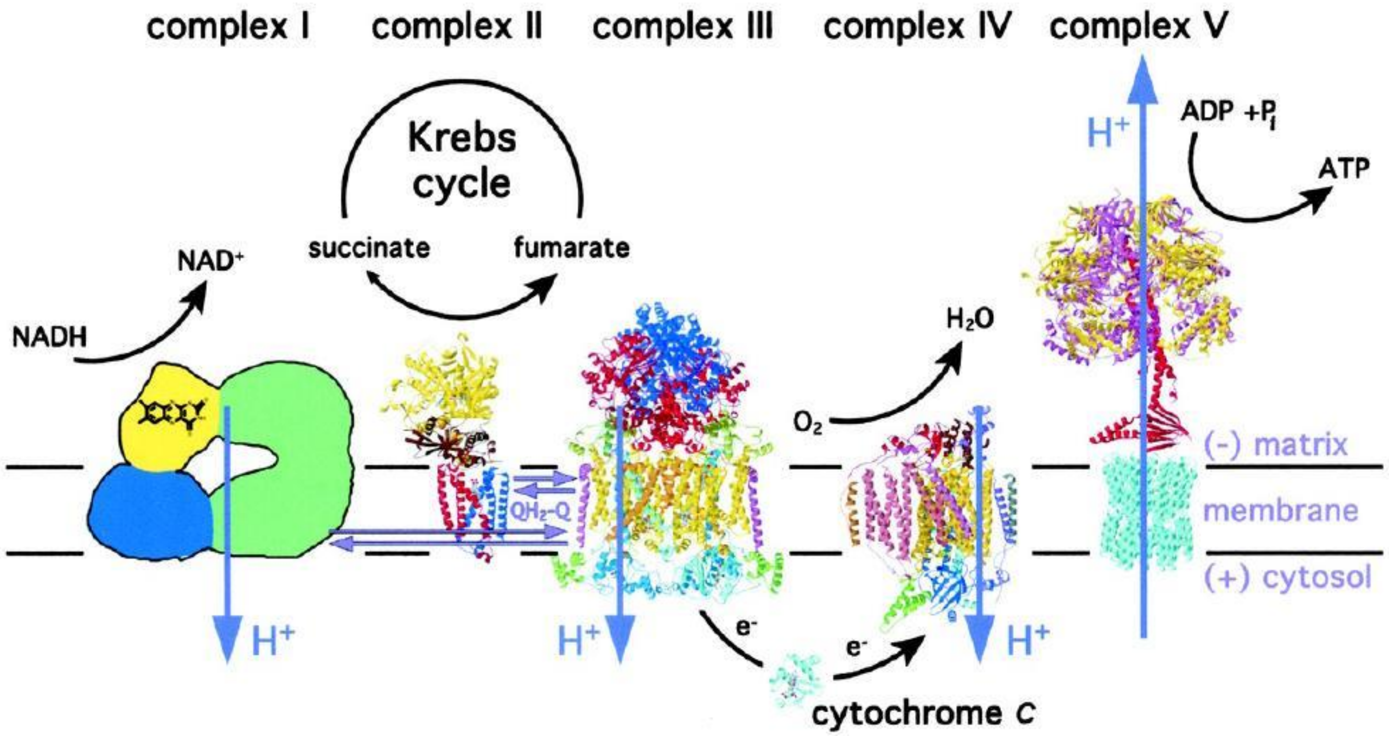
- Kilimajaro 5895 meters above sea level



PaO2 100 mmHg / FiO2 21 % at P_{atm} 760 mmHg = PaO2/FiO2 = 475
PaO2 50 mmHg / FiO2 21% at P_{atm} 380 mmHg = Pao2/FiO2= 475
Hypoxemia but no trouble in gaz exchange

Oxygen inspired by lung goes into the mitochondrial membrane to produce energy through the krebs cycle



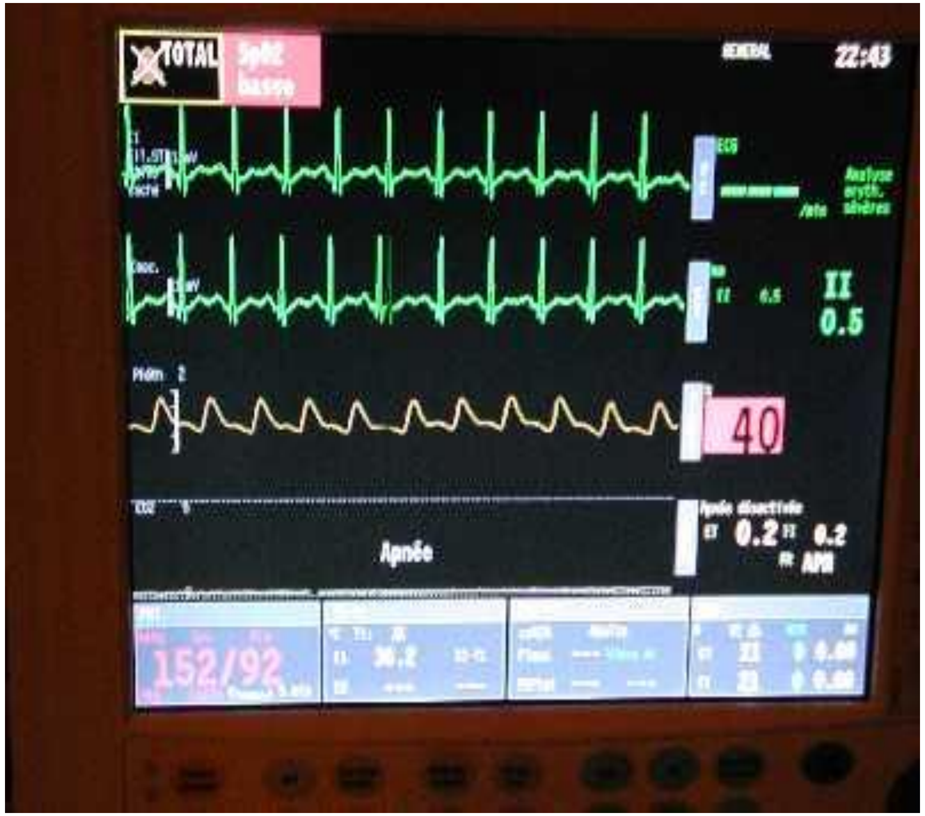


Hypoxemia at Kilimajaro Summit

- Hypobaric hypoxemia
- SaO2 around 70%
- Humans tolerate hypobaric hypoxemia very well
    - Complex mechanisms of compensation & Acclimatization
- Example Everest: PaO_2 : 25-30 // $PaCO_2$: 7 mmHg

Tolerance to severe hypoxia

- Kinsella & Walsh. Inhaled nitric oxide in premature neonates with severe hypoxaemic respiratory failure: a randomised controlled trial. Lancet. 1999: 1061-5.
    - Premature babies
- Gray FD & Horner GJ. Survival following extreme hypoxemia. JAMA. 1970:1815-7.
    - 22 patients PaO2<20 mmHg (7.5 mmHg)
    - 13 complete recovery (y compris celui avec PaO_2 7.5 mmHg, 2 comateux + rigidité cérébrale)
- West. HIGH ALTITUDE MEDICINE & BIOLOGY 2003: Survival following severe acute hypoxia and cold
    - Travelling in gears 56 personnes (47 vols)/12 survivants
- Lindohlm et al. J Applied Physiol 2010: The physiology and pathophysiology of human breath-hold diving
    - Divers



Tolerance to severe hypoxia

[Dumont et al, 2012]

Lessons learned from the Kilimanjaro Summit that may be use for the covid19

- Hypoxemia does not lead necessarily to hypoxia and lactate acidosis
- **Hypoxemia and hypoxia may be well tolerated**
- **Hypoxemia & Hypoxia (in absence of ischemia & Anemia) may recover well**
- **Is SpO2 around 75-80% a problem ?**
  - **No…in healthy for short term periods!**
  - **Covid 19 ARDS patients**
    - Hypobaric hypoxia is not ARDS hypoxia (no concomitent disease)
    - No formal guidelines exist regarding the optimal oxygenation target in ARDS [Oxygen saturation targets in critical care Nickson 2019]

Can we accept and tolerate some severe level hypoxemia?

NO

- In adults with COVID-19, [Alhazzani et al, 2020 Intensiv care Med]
  - we ***suggest*** starting supplemental oxygen if the peripheral oxygen saturation (SpO2) is < 92%
  - we ***recommend*** starting supplemental oxygen if SpO2 is < 90%.
- Time spent below normal saturation values (SpO2 <90%, <85%, and <80%) correlated with decreased cognitive performance. [Hopkins et al, 1999 Am J Crit Care]
  - 100% that completed neuropsychological testing were cognitively impaired at hospital discharge.
  - 30% that completed neuropsychological testing were cognitively impaired at 1 year.
- It is unclear if hypoxaemia is directly responsible for cognitive impairment or it is simply an association with hypoxaemia a marker of more severe disease [Ramona et al, Am J Respir Crit Care Med 1999]

Can we accept and tolerate some hypoxemia?

YES

- Sometimes, tolerating lower arterial oxygen saturations is appropriates [Tobin, 2020 Am J Respir Crit Care https://www.atsjournals.org/doi/pdf/10.1164/rccm.202004-1076ED

- Evidence of end-organ damage is difficult to demonstrate in patients with PaO2 above 40 mmHg (equivalent to oxygen saturation of approximately 75%) Relation DO2/extraction. Laghi F, Tobin MJ. Indications for mechanical ventilation. In: Tobin MJ (ed). Principles and Practice of Mechanical Ventilation, Third edition. McGraw-Hill Inc., New York, 2012, p129-162

- Tobin argues that organ dysfunction is unlikely unless oxygen delivery falls to as low as 25% of normal (Tobin, 2020), which may not occur until SpO2 falls below 80% depending on the patient's cardiac output and oxygen extractionuch as when the patient is undistressed and has normal mentation

Take home messages

- Alternatives to intubation & mechanical ventilations in severe COVID19 respiratory distress
  - **Oxygen & prone position spontaneous ventilation**
    - **Fluid restriction** [Keddissi et al, Can J Respir Ther 2019]
- Humans may tolerate hypoxia much more than expected
  - **In absence of resources… the threshold of 92-93% as a lower limit may be decrease**
- COVID19 is not only about respiratory distress ! (coagulation, renal, neurological, dermatological… troubles)
- Protect yourself… safety first

Keywords of the guidelines

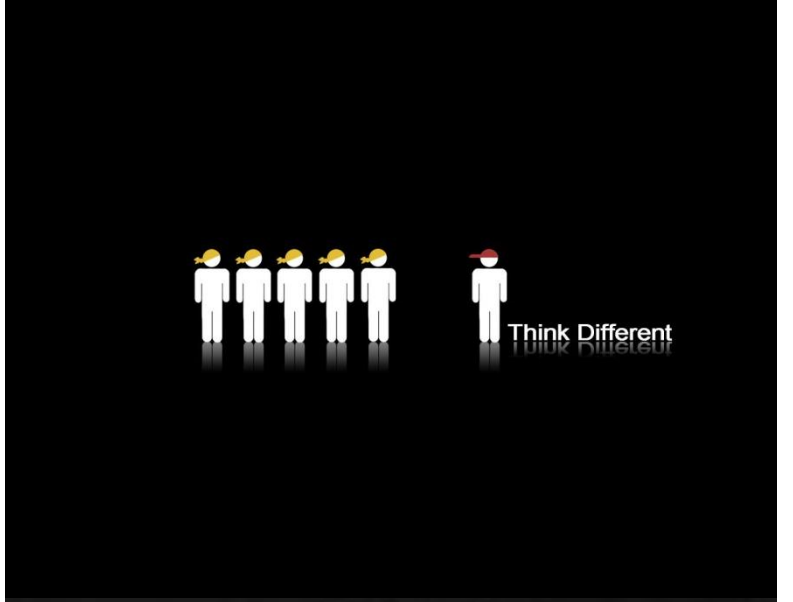
- Endotracheal intubation
- Mechanical ventilation
  - PEEP (positive End expiratory Pressure)
- Support if SPO2 < 93%

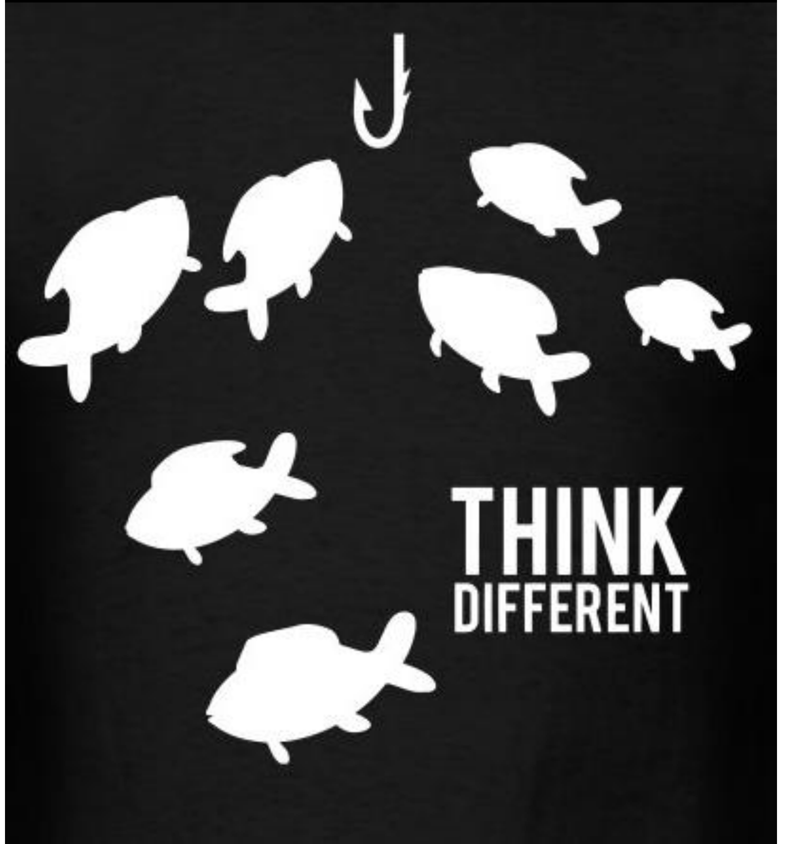
Conclusions

- With limited resources… Think different !!!

- COVID19 patients with respiratory distress in low resource environments may have a better chance to survive than expected when mechanical ventilation was supposed to be the only option for oxygen support

- Oxygenation support
  - Oxygen
  - Prone position
  - SpO_2 target lower than 92%





Thank you !!!!

2ND CHANCE