HOW TO VENTILATE COVID-19 PATIENTS ?

freely based on talk by Luigi Camporota during ESICM webinar
on Apr 2 2020 moderated by Prof. Claude Guerin
graphics by MV Antonini @FOAMecmo

A model to approach ventilation in COVID-19 patients reflecting the phase of the disease induced by SARS-CoV-2 Coronavirus. How do these patients present from an hypoxemia perspective? Hypoxemia is mainly 3 fold: dysregulation of pulmonary perfusion, really important; pulmonary micro-thrombosis (it's role becoming more and more relevant), & frank pulmonary edema ("ARDS like"). COVID-19 patients could present with similar P/F ratio, but with completely different CXR appearance or CT scan patterns (resembling or not ARDS, and with different distribution of normal/consolidated lung).

1 HYPOXEMIA

- ★ dysregulation of pulmonary perfusion with
- ★ + pulmonary micro-thrombosis creating difficulty in lung perfusion/hypoxemia & dead space (increased CO2)

low Elastance
low V/Q matching
low recruitability, so a limited "PEEP response"

named as = **PHENOTYPE L**

L = low everything

- ★ pulmonary edema - collapse ARDS-like with

high lung compliance, & compared to the other type
higher recruitability
higher R→L shunt
higher "PEEP response"

= **PHENOTYPE H**

H = high everything

(Gattinoni et al. ICM 2020 in press)

Early categorizing these patients according to the 2 phenotypes could be really important, as therapeutic approach, or at least management, could be quite different. Moreover, consider that patients may progress from phenotype L to phenotype H, due to disease progression, but also due to early management. SARS-CoV-2 has an important effect on ACE2 receptor, impacting on pulmonary perfusion, with differential effects on ANGII receptors: profound vasodilation prevails at the beginning, and on later on inflammation, vasoconstriction and fibrosis.

COVID-19 ≠ ARDS

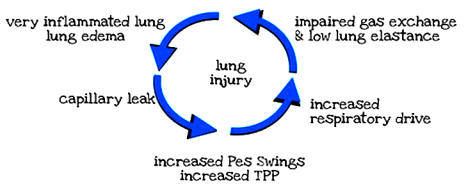
Comparing COVID-19 pneumonia to the conventional ARDS definition. It is clear that COVID-19 dos not fits all the criteria of Berlin definition: does not fit timing very well, with some late presentations in these patients; about chest imaging, at least for phenotype L (majority of patients at presentation). Oxygenation criteria remains relevant. COVID-19 pneumonitis may not similar or equal to ARDS.

2 RESPIRATORY DRIVE

Respiratory drive could have different sources, hypoxemia drives increase in VT, therefore increasing swing in esophageal and pleural pressures, impacting on lung stress/strain. The other important point is the pulmonary edema, leading to elastin WoB, and increased RR. Also consider the metabolic drive: Some of these patients have incredibly high inflammatory/febrile states and O_2 consumption/demand is increased, leading to respiratory drive. Also is becoming clear a neurotropism for SARS-CoV-2, particularly around midbrain, influencing respiratory/cardiovascular control (with some patient at the extreme presenting with sudden unexplained cardiac arrest). Subjective dispnea may be less pronounced, with patients not fully perceiving WoB. FiO_2 is an important first measure; improve V/Q matching; prone positioning may work really well. On the other side, for the elastic WoB mechanical support & maybe pharmacological support may be needed to control RR so stress/strain of the lung.

- ★ hypoxemia — tidal volumes, Δ Pes = stress-strain → FiO_2, improve V/Q
- ★ neurotropism of SARS-CoV-2 (ACE2) — cardio-respiratory centres, delirium, cognition, anosmia
- ★ pulmonary edema — elastic WOB, respiratory Rate → mechanical support, control of RR
- ★ metabolic drive

This can lead to a perpetuating vicious circle, where:



modified Brochard/Pesenti AJRCCM

WHAT'S NEXT ?

what to do next? we have a series of options: NIV, HFNO, CPAP... intubation?? and some clinical/organizational considerations need to be made

- infection control: big issue.. in some hospitals, HFNO not allowed in COVID-19 positive patient because of the potential risk for spreading the infection
- adequate support: what kind of support does the patient actually require?
  - work of breathing
  - failure rate: how likely will patient fail?
  - degree of hypoxaemia
  - tolerance to the interface
  - control of TransPulmonary Pressure
- duration of the disease: This is not a disease likely to be easily reversible in few days, it is less responsive to short term positive pressure MV vs ie cardiogenic pulmonary edema.
- resources:
  - It is really resources demanding:
  - ICU beds
  - Staffing
  - availability of ventilators
  - oxygen: HFNO/CPAP may use incredibly high quantities

Use of CPAP may be associated with decreased CO (Dantzker et al Chest 1980), and as CO goes down, then the shunt fraction goes down, with an apparent increase in P/F ratio, exclusively related to a change in shunt fraction. In COVID-19 population, moreover, use of NIV may lead to delayed intubation. CPAP or NIV may decrease the work of breathing, but WoB need to be monitored (use of esophageal pressure is the gold standard): if excessive, this dictates immediate intubation. CPAP alone may not be very effective/efficient in decreasing elastic WoB, despite the fact it may improve P/F ratio. Keep in mind with some devices may not be easy measure VTE : if >9-9.5 ml/kg, this may be associated to NIV failure and increased mortality.

ASSESSMENT

Based on the 2 different initial phenotypes treatment of respiratory failure (mainly hypoxemic) may be really different.
First stage of management of respiratory failure is non-invasive assessment of "Shunt fraction"/severity of hypoxemia

Assess very early WOB! patient may have very aggressive/fulminant disease. If WOB is low, use NIV/O2 may be prolonged but time limited & with strict monitoring. If SpO2 does not increase (ie above 95%) on oxygen, shunt fraction is likely elevated, with moderate-severe hypoxemia, which may not be easily reversed with O2 therapy alone.

O_2 therapy (15 lt) with target SpO_2 90-94%
- if FiO2 > 0.4 and no ceiling of escalation → work of breathing: low / high
- ceiling of escalation → palliative care

INTUBATION

targets on MV:
SpO_2 90-94%
PaO_2 ≥ 8 KPa
$PaCO_2$ < 6 or pH >7.30
P_{PLAT} ≤ 28 cmH_2O

intubation + MV (bleed MEriT)
volume control ventilation to measure driving P
V_T 8 ml/Kg PBW (not super-low tidals)
PEEP 8 cmH_2O
RR - initially to $EtCO_2$ 4-5 KPa

is driving pressure < 15 cmH_2O?
- no → reduce V_T to 6 ml/Kg PBW
- if not shocked at presentation, low dose vasoconstrictors, minimize fluids
- yes → keep V_T 8 ml/Kg PBW

targets on MV:
SpO_2 90-94%
PaO_2 ≥ 8 KPa
$PaCO_2$ < 6 or pH >7.30
P_{PLAT} ≤ 30 cmH_2O
ΔP ≤ 15 cmH_2O

SpO2 ≤ 90% with FiO_2 > 0.7
→ NMBA
uptitrate PEEP in 2 cmH_2O steps up to 15 cmH_2O if required
(but characterizing phenotype needed before optimizing MV

SpO2 ≤ 90% with FiO_2 > 0.7

obtain echo as soon as possible

IDENTIFY PHENOTYPES

compliance ≥ 40ml/cmH_2O
- no → consider switch to APRV to improve recruitment and improve alveolar stability; PEEP/FiO_2; RM (40 x 10-15")
- aim to combine if targets not achieved
- yes → near normal compliance: first strategy is prone positioning, with same MV settings

ARDS-Like Phenotype Phenotype H
High Elastance
PEEP responsive
Prone Responsive

COVID-19 pneumonitis Phenotype L
Low elastance
-Prone responsive
iNO - Iloprost (biological rationale)
pulmonary vascular reactivity Test

FAILURE & ESCALATION

if refractory hypoxemia (> 6h, earlier if life threatening
ECMO candidate *
- no → review targets & strategy
- yes → VV-ECMO

* 4 QUESTIONS...

pt selection:
- 4 questions to consider thinking about ECLS particularly in a pandemics:
- is the pathology reversible (maybe not the one hyperinflammation or MOF)?
- Is the patient able to recover? frailty, comorbilities, ability to sustain prolonged ECMO/rehab particularly in a limited resources setting

timing/indications:
- is the gas exchange so severe that is life-threatening? (= patient selection
- Is mechanical ventilation injurious?

HYPERACUTE DISEASE

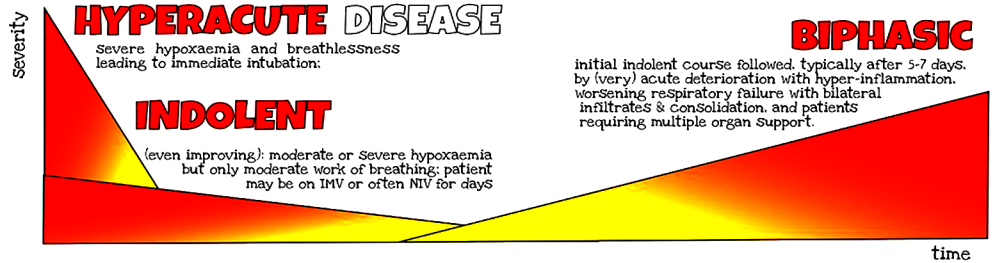
Severe hypoxaemia and breathlessness leading to immediate intubation;

INDOLENT

(even improving): moderate or severe hypoxaemia but only moderate work of breathing; patient may be on IMV or often NIV for days

BIPHASIC

initial indolent course followed, typically after 5-7 days, by (very) acute deterioration with hyper-inflammation, worsening respiratory failure with bilateral infiltrates & consolidation, and patients requiring multiple organ support.



Early recognition of hyper-acute disease: need for immediate intubation and high risk of cardiovascular events, some related to the myocarditis, some centrally mediated (effect of the virus in midbrain-central control)
-Short and judicious use of CPAP/NIV for hemodynamically stable patients with moderate hypoxaemia; low respiratory drive and low inflammatory phenotype. Beware of biphasic course of the disease in some patients, who may fail late.
-Early differentiation of L Phenotype (preserved compliance, dysregulated pulmonary perfusion). Need to balance PEEP with perfusion. Do not use high PEEP or PEEP/FiO2 scales. This is not ARDS!

Work licensed under Creative Commons Attribution NonCommercial-NoDerivatives 4.0 International License.
http://creativecommons.org/licenses/by-nc-nd/4.0/

graphics by MV Antonini @FOAMecmo
CCN/CCP, MS - 1st ICU University Hospital of Parma, Italy