treatment

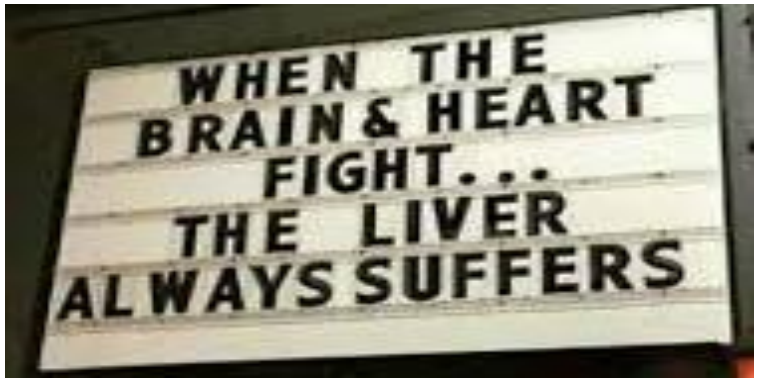
- Predisposing factor
- Fluid and hemodynamic
- nutrition
- Mechanical ventilation
- Rescue therapies

What Causes ARDS?

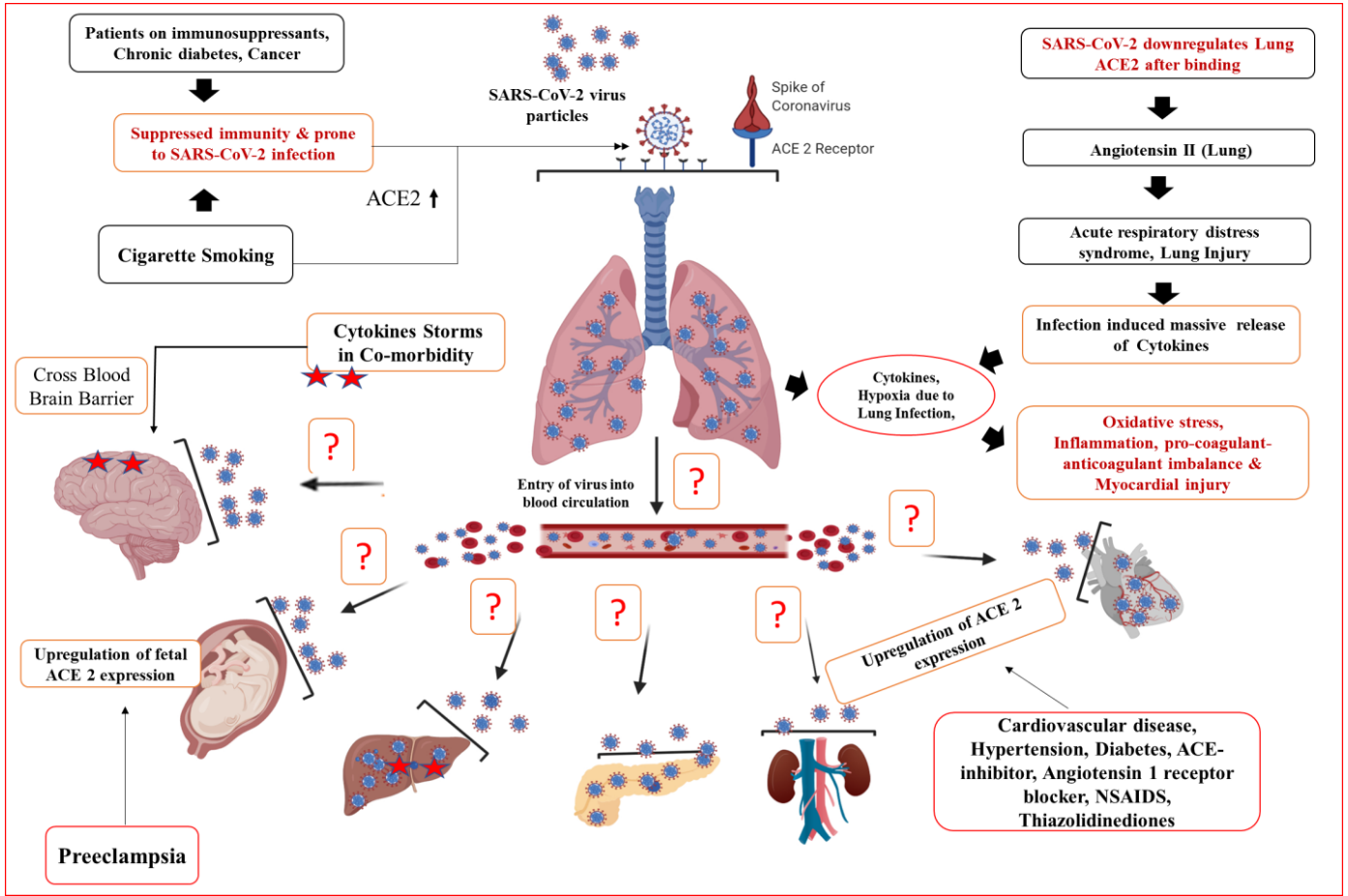
- Sepsis
- Inhaling harmful substances
- Pneumonia
- Trauma to the head, chest or other areas of the body
- Blood transfusions
- Pancreatitis
- Near drowning

treatment

- Supranormal oxygen delivery?
- Liberal fluid strategy?
- Multi system organ failure!
- Conservative fluid strategy
- CVP<4 if no shock
- Zero net fluid balance



ARDS Most common cause of death is not pulmonary



ARDS management

- intelligent use of sedatives
- hemodynamic management
- nutritional support
- control of blood glucose levels
- evaluation and treatment of nosocomial pneumonia
- prophylaxis against deep venous thrombosis (DVT)
- prophylaxis against gastrointestinal (GI) bleeding
- neuromuscular blockade

Nutrition in ARDS

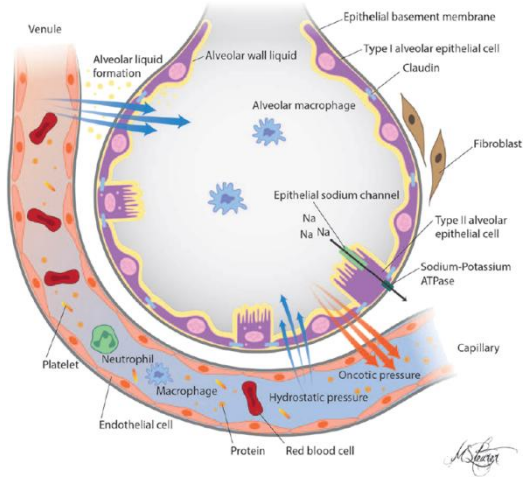
- Adequate micro and macro nutrition
- Enteral is preferred
- immunomodulatory
- Omega 3 ???
- high fat low carbohydrate
- Full calorie vs Trophic?

Non ARDS indications of Glucocorticoids

- non-ARDS-related indications for systemic glucocorticoid therapy
- ARDS has been precipitated by a steroid-responsive process (eg, acute eosinophilic pneumonia)
- ARDS who have refractory sepsis or community-acquired pneumonia if they meet indications

ARDS indications of Glucocorticoids

- early moderate to severe ARDS fail standard therapies
- (within 14 days of onset)
- persistent or refractory moderate to severe ARDS ([PaO /FiO] <200) despite initial management with standard therapies including low tidal volume ventilation.



Glucocorticoids

- less severe ARDS
- Patients late in the disease course

(persistent ARDS beyond 14 days)

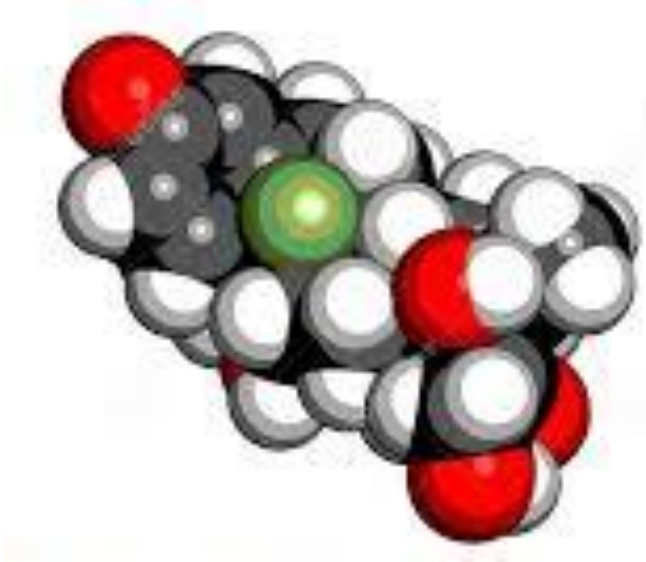
- certain viral infections(ARDS secondary to influenza)

Glucocorticoids in ARDS

How strong is the risk of complications from steroids?	How strong in the indication to use steroids?			
		Very Strong (*eg,* P/F ratio < 200 despite optimal ventilator management, septic shock, COVID-19 with > 7 days since symptoms onset)	←←←←←←	**Not Very Strong** (*eg,* P/F ratio 200-300, influenza, non-infectious etiologies such as trauma, rapidly improving P/F)
	Low	**Give Steroids.**	Suggest Steroids	Consider steroids on case-by-case basis.
	←←←	Suggest steroids	Consider steroids on case-by-case basis.	Suggest against steroids
	High	Consider steroids on case-by-case basis.	Suggest against steroids	**Do not give steroids.**

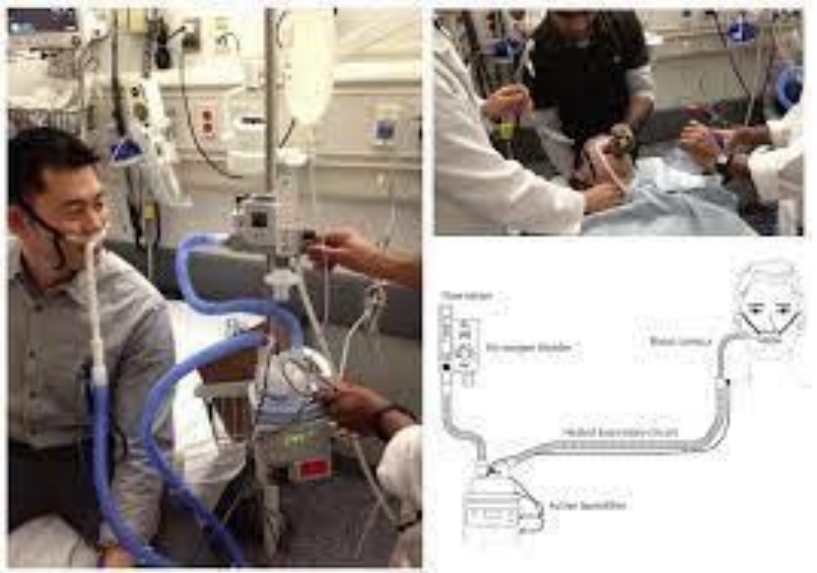
glucocorticoid therapy in ARDS

- Methylprednisolone 1 mg/kg per day for 21 to 28 days followed by a taper [41,42].●
- Dexamethasone 20 mg IV once daily for five days, then 10 mg once daily for five days

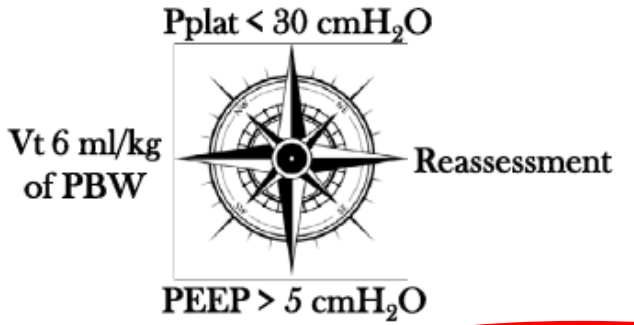


hypoxemia

- Use of high fractions of inspired oxygen (FiO2)
- Decrease oxygen consumption
- Improve oxygen delivery
- Manipulate mechanical ventilatory support



Early management of ARDS in 2019



P/F < 80 — Discuss VV-ECMO

P/F < 150 — Neuromuscular blockers
Prone positioning

P/F < 200 — High level of PEEP
if improves oxygenation

Tidal volume about 6 ml/kg of PBW
Plateau pressure < 30 cmH_2O
PEEP > 5 cmH_2O
Check for hypercapnia

Confirmed ARDS

Initiation of invasive mechanical ventilation with sedation in ICU

Tidal volume (Vt) about 6 ml/kg of PBW in the absence of severe metabolic acidosis

Systematic screening for ARDS diagnosis criteria

Reassessment of ventilator settings and of the management strategy at least every 24h

ARDS severity

Veno-venous ECMO
- ❑ In case of refractory hypoxemia or when protective ventilation can not be applied
- ❑ To be discussed with experienced ECMO centres

Neuromuscular blockers: continuous intravenous infusion
- ❑ Early initiation (within the first 48h of ARDS diagnosis)

Prone positioning methods :
- ❑ Applied for >16h a day, for several consecutive days

Moderate or severe ARDS -> High PEEP test (> 12 cmH_2O)
Use high levels if:
- ❑ Oxygenation improvement
- ❑ Without hemodynamic impairment or significant decrease in lung compliance
- ❑ Maintain Pplat < 30 cmH_2O, continuous monitoring

ARDS diagnosis criteria
- ❑ $PaO_2/FiO_2 \leq 300$ mmHg
- ❑ PEEP ≥ 5 cmH_2O
- ❑ Bilateral opacities on chest imaging
- ❑ Not fully explained by cardiac failure or fluid overload
- ❑ Within a week of a known clinical insult

Might be applied
- ➢ Inhaled Nitric Oxide (iNO), when severe hypoxemia remains despite prone positioning and before considering VV-ECMO
- ➢ Partial ventilation support after early phase to generate tidal volume about 6 ml/kg and less than 8 ml/kg

No recommendation could be made
- ➢ $ECCO_2R$
- ➢ Driving pressure
- ➢ Partial ventilation support at the early phase

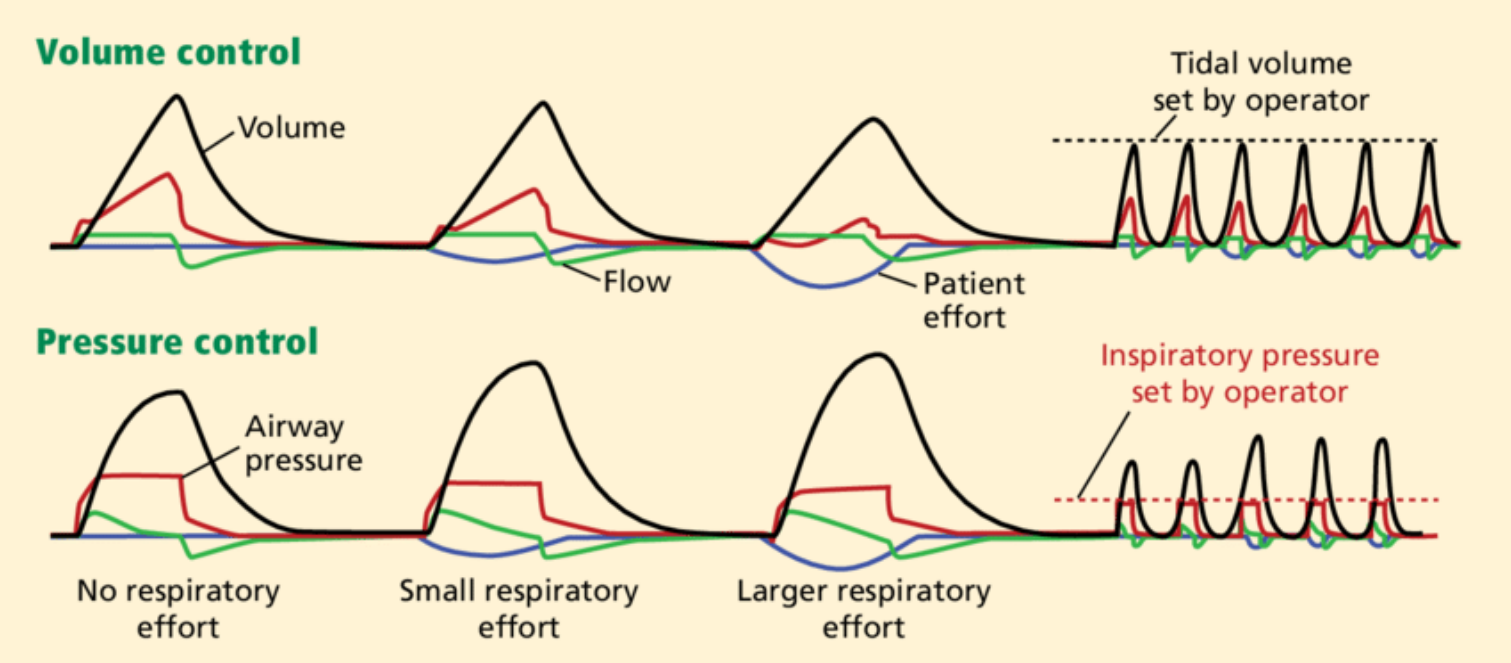
Should probably not be done
- ➢ Systematic recruitment maneuvers

Should not be done
- ➢ HFOV

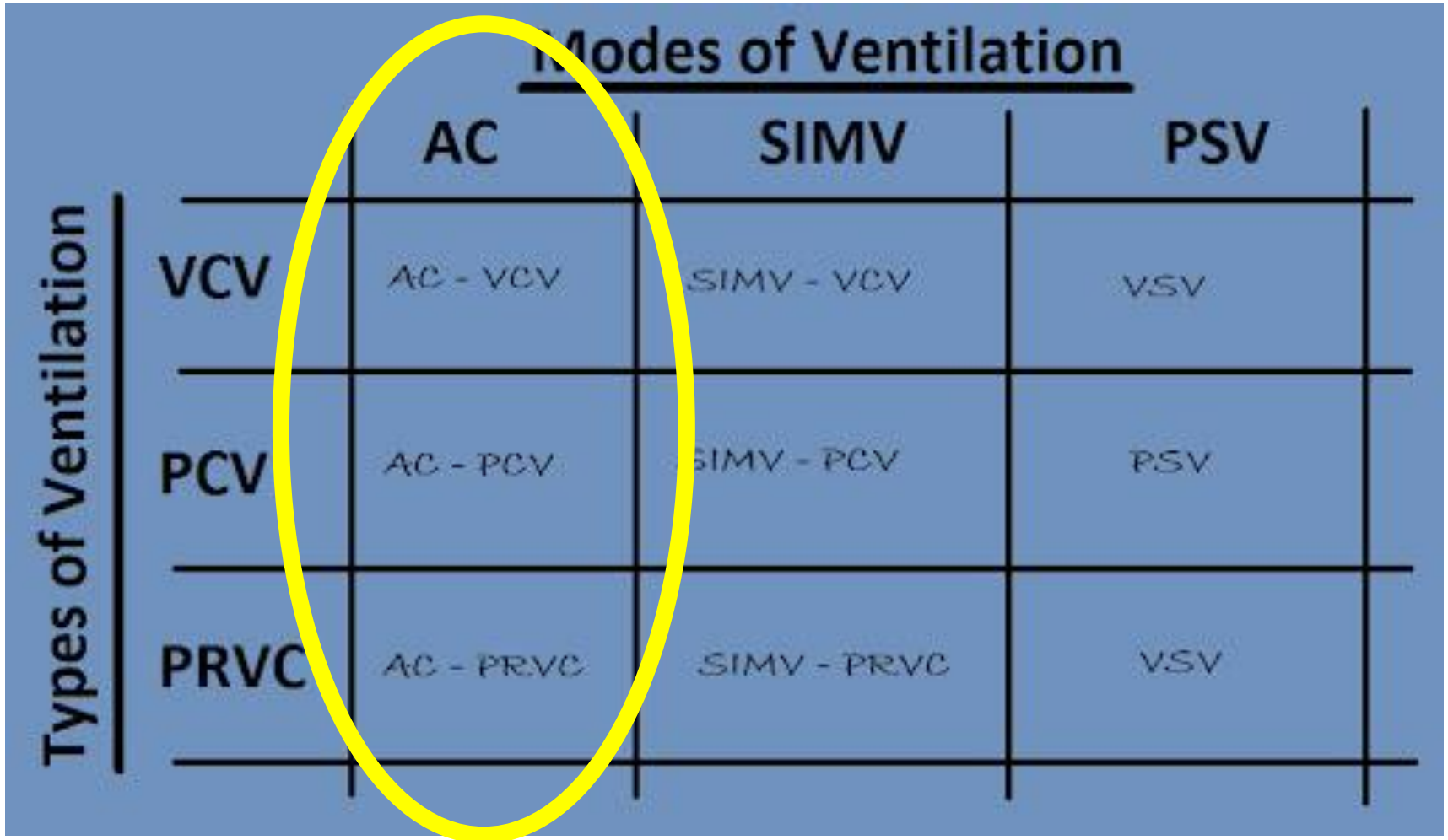
Mechanical ventilation in ARDS

Volume- versus pressure-limited mode

- In most patients with ARDS
- a volume-limited mode will produce a stable tidal volume
- a pressure-limited mode will deliver a stable airway pressure



Assist control vs SIMV



VENTILATOR SETUP AND ADJUSTMENT

- Calculate predicted body weight (PBW)
- **Males** = 50 + 2.3 [height (inches) - 60]
- **Females** = 45.5 + 2.3 [height (inches) -60]
- Select any ventilator mode
- Set ventilator settings to achieve initial V^T = 6 ml/kg PBW
- Reduce V^T by 1 ml/kg at intervals ≤ 2 hours until V^T = 4ml/kg PBW.
- Set initial rate to approximate baseline minute ventilation (not > 35 bpm).
- Adjust V^T and RR to achieve pH and plateau pressure goals below.

OXYGENATION GOAL: PaO_2 55-80 mmHg or SpO_2 88-95%

Use a minimum PEEP of 5 cm H_2O. Consider use of incremental FiO_2/PEEP combinations such as shown below (not required) to achieve goal.

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

Permissive hypercapnea

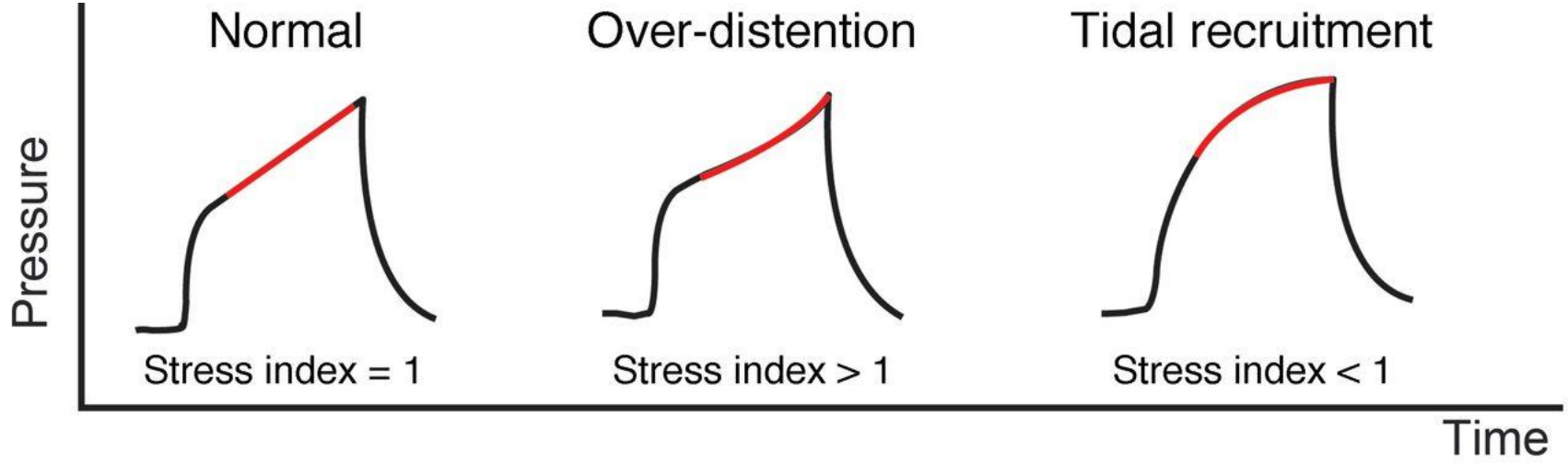
PaCO2 → PAP → RR 25 and 30 cycles/min

- Too high a rate → dynamic hyperinflation
- A PaCO2 below 50 mmHg
- instrumental dead space

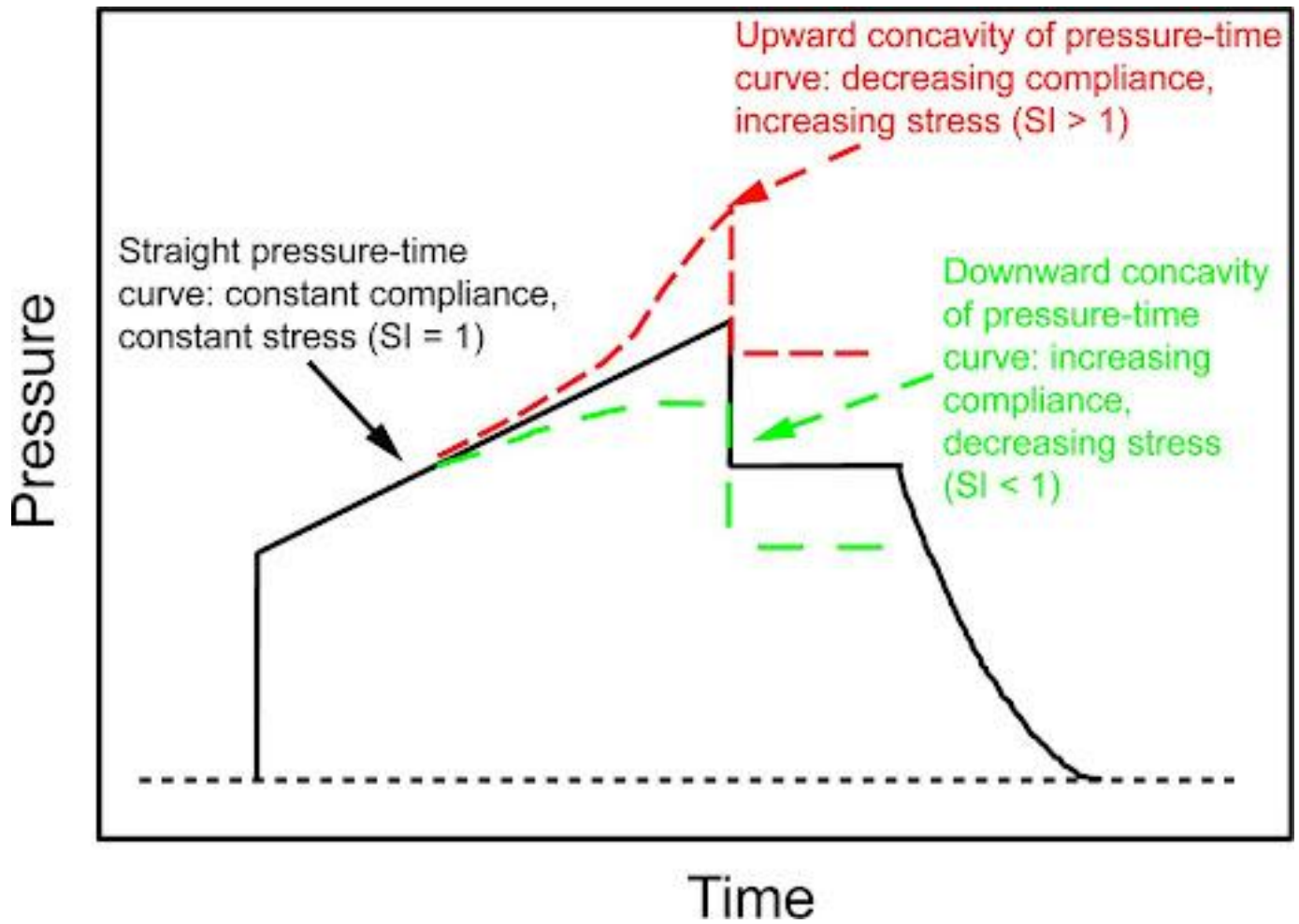

Hey not always the same buddy
STOP

Stress Index

- pressure-time curve during constant flow-volume control ventilation
- constant compliance,
  stress index = 1 ➡ adequate alveolar recruitment
- progressive decrease in compliance, upward concavity,
  stress index > 1 ➡ over-distention decrease the PEEP, V_T, or both
- progressive increase in compliance, downward concavity,
  stress index < 1 ➡ increase PEEP

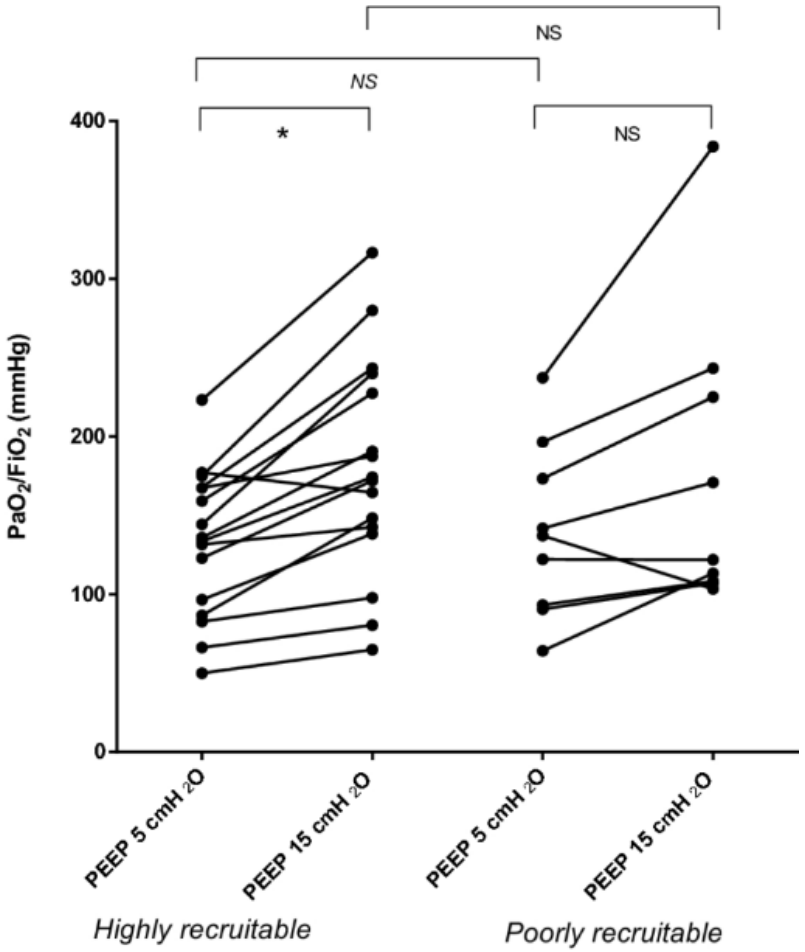


Stress index



Recruitment-to-Inflation (R/I) ratio

- abrupt release of PEEP from 15 to 5 cmH2O increases the expired volume.
- compliance at low PEEP multiplied by PEEP change
- estimates the volume recruited by PEEP
- A high R/I ratio means high potential for recruitment
- R/I ratio ➡ change in SpO2 low and high PEEP



RESEARCH Open Access

Recruitability and effect of PEEP in SARS-Cov-2-associated acute respiratory distress syndrome

François M. Beloncle[1*], Bertrand Pavlovsky[1], Christophe Desprez[1], Nicolas Fage[1], Pierre-Yves Olivier[1], Pierre Asfar[1], Jean-Christophe Richard[1,2] and Alain Mercat[1]

Abstract

Background: A large proportion of patients with a SARS-Cov-2-associated respiratory failure develop an acute respiratory distress syndrome (ARDS). It has been recently suggested that SARS-Cov-2-associated ARDS may differ from usual non-SARS-Cov-2-associated ARDS by higher respiratory system compliance (C_{RS}), lower potential for recruitment with positive end-expiratory pressure (PEEP) contrasting with severe shunt fraction. The purpose of the study was to systematically assess respiratory mechanics and recruitability in SARS-Cov-2-associated ARDS.

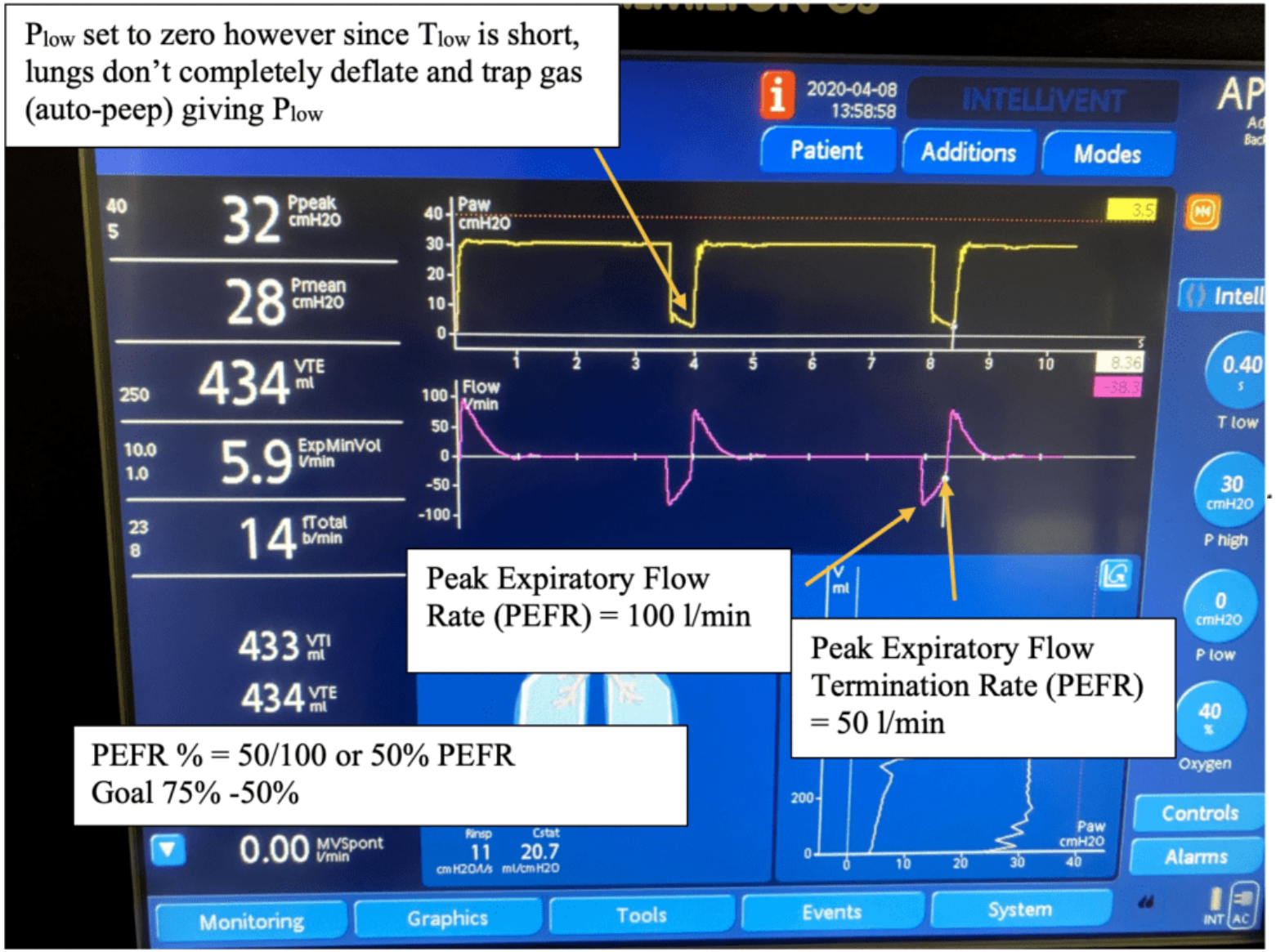
Methods: Gas exchanges, C_{RS} and hemodynamics were assessed at 2 levels of PEEP (15 cmH_2O and 5 cmH_2O) within 36 h (day1) and from 4 to 6 days (day 5) after intubation. The recruited volume was computed as the difference between the volume expired from PEEP 15 to 5 cmH_2O and the volume predicted by compliance at PEEP 5 cmH_2O (or above airway opening pressure). The recruitment-to-inflation (R/I) ratio (i.e. the ratio between the recruited lung compliance and C_{RS} at PEEP 5 cmH_2O) was used to assess lung recruitability. A R/I ratio value higher than or equal to 0.5 was used to define highly recruitable patients.

Results: The R/I ratio was calculated in 25 of the 26 enrolled patients at day 1 and in 15 patients at day 5. At day 1, 16 (64%) were considered as highly recruitable (R/I ratio median [interquartile range] 0.7 [0.55–0.94]) and 9 (36%) were considered as poorly recruitable (R/I ratio 0.41 [0.31–0.48]). The PaO_2/FiO_2 ratio at PEEP 15 cmH_2O was higher compared to PEEP 5 cmH_2O only in highly recruitable patients (173 [139–236] vs 135 [89–167] mmHg; $p < 0.01$). Neither PaO_2/FiO_2 or C_{RS} measured at PEEP 15 cmH_2O or at PEEP 5 cmH_2O nor changes in PaO_2/FiO_2 or C_{RS} in response to PEEP changes allowed to identify highly or poorly recruitable patients.

Conclusion: In this series of 25 patients with SARS-Cov-2 associated ARDS, 64% were considered as highly recruitable and only 36% as poorly recruitable based on the R/I ratio performed on the day of intubation. This observation suggests that a systematic R/I ratio assessment may help to guide initial PEEP titration to limit harmful effect of unnecessary high PEEP in the context of Covid-19 crisis.

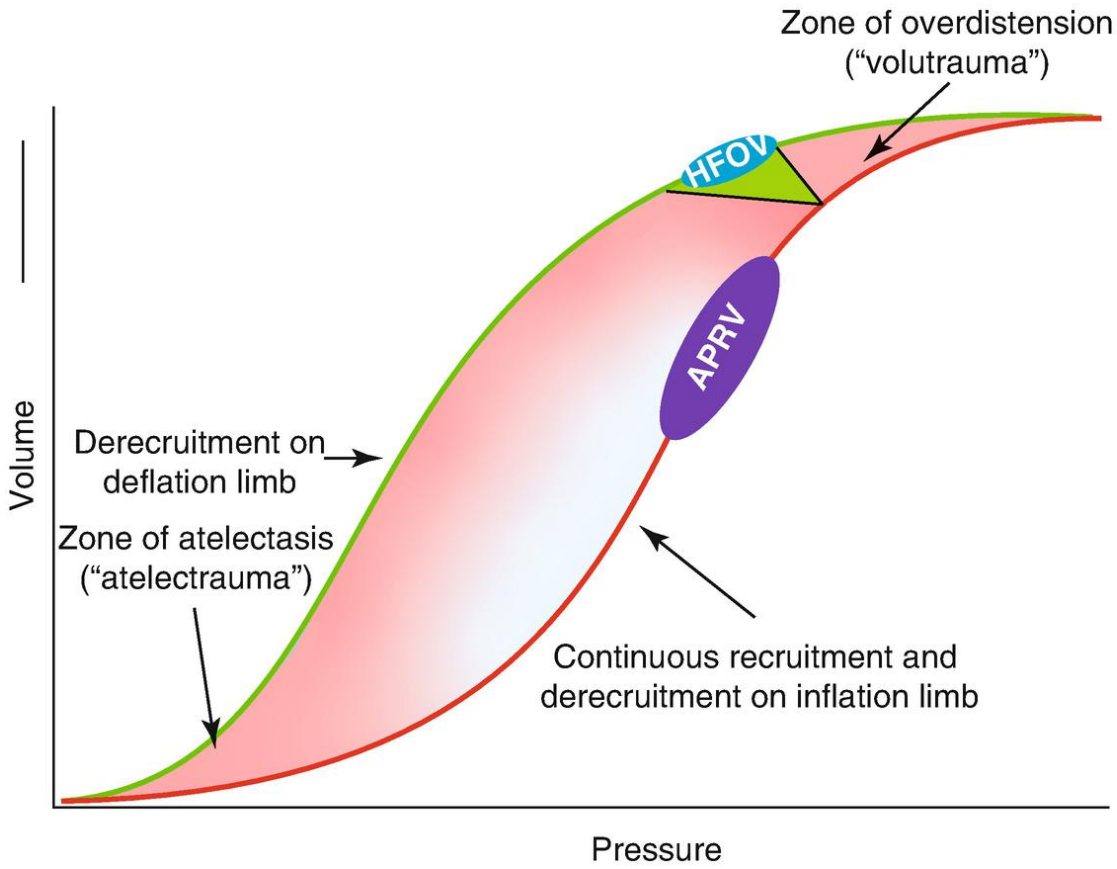
Keywords: Covid-19, SARS-Cov-2, Acute respiratory distress syndrome, Respiratory failure, Mechanical ventilation, Respiratory mechanics, Recruitability, Positive end-expiratory pressure

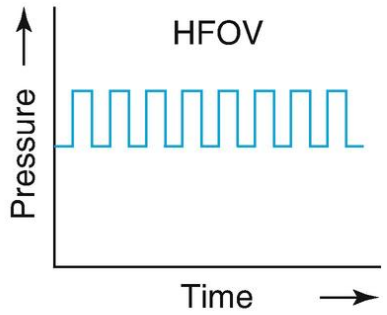
APRV

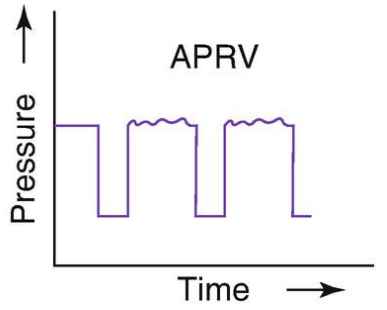


Ventilator Company	Mode
Dräger®	APRV
Servo-i®	Bi-Vent
Puritan Bennett™ 840	Bi-Level
Hamilton	DuoPAP+

APRV

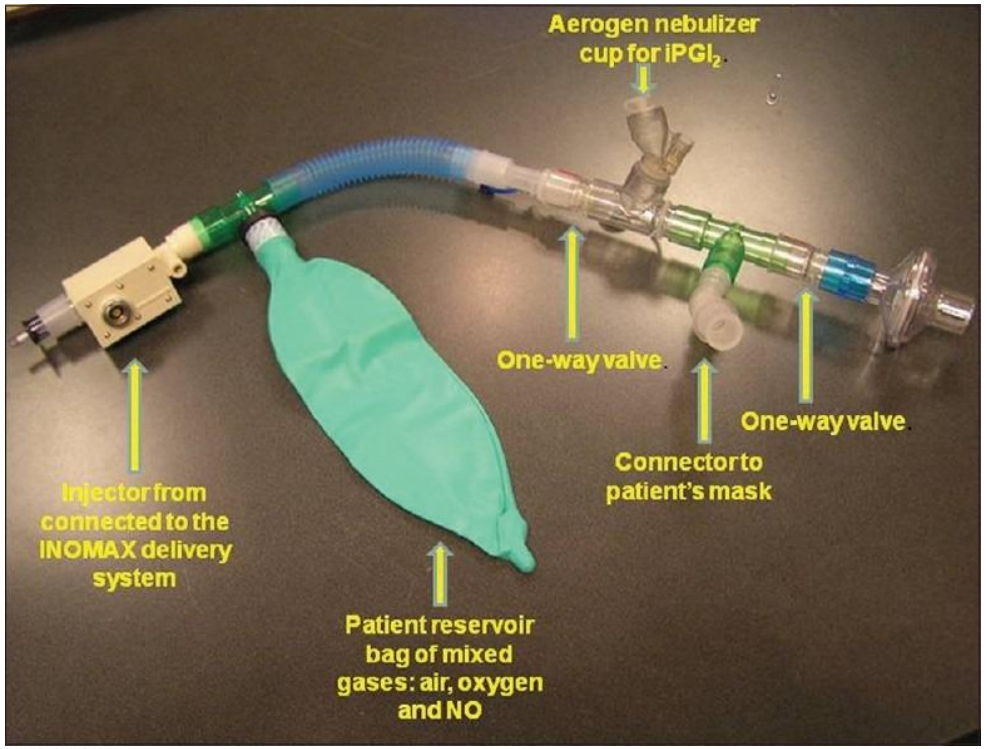

Zone of overdistension
("volutrauma")
HFOV
APRV
Derecruitment on
deflation limb
Zone of atelectasis
("atelectrauma")
Continuous recruitment and
derecruitment on inflation limb
Volume
Pressure

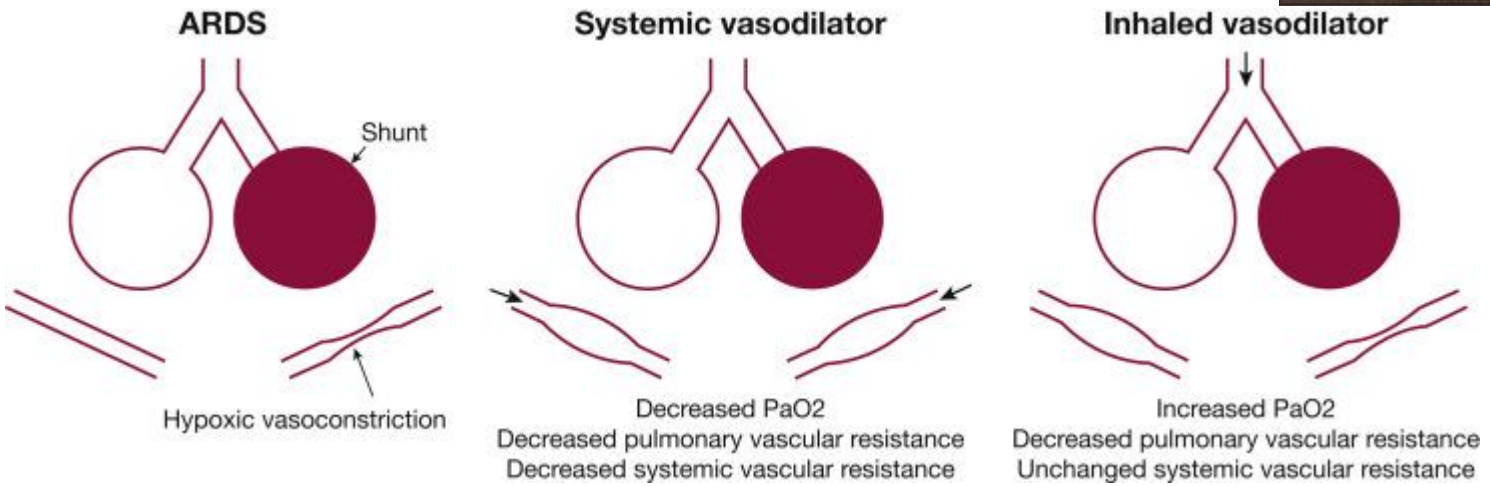

HFOV
Pressure
Time


APRV
Pressure
Time

Inhaled vasodilators

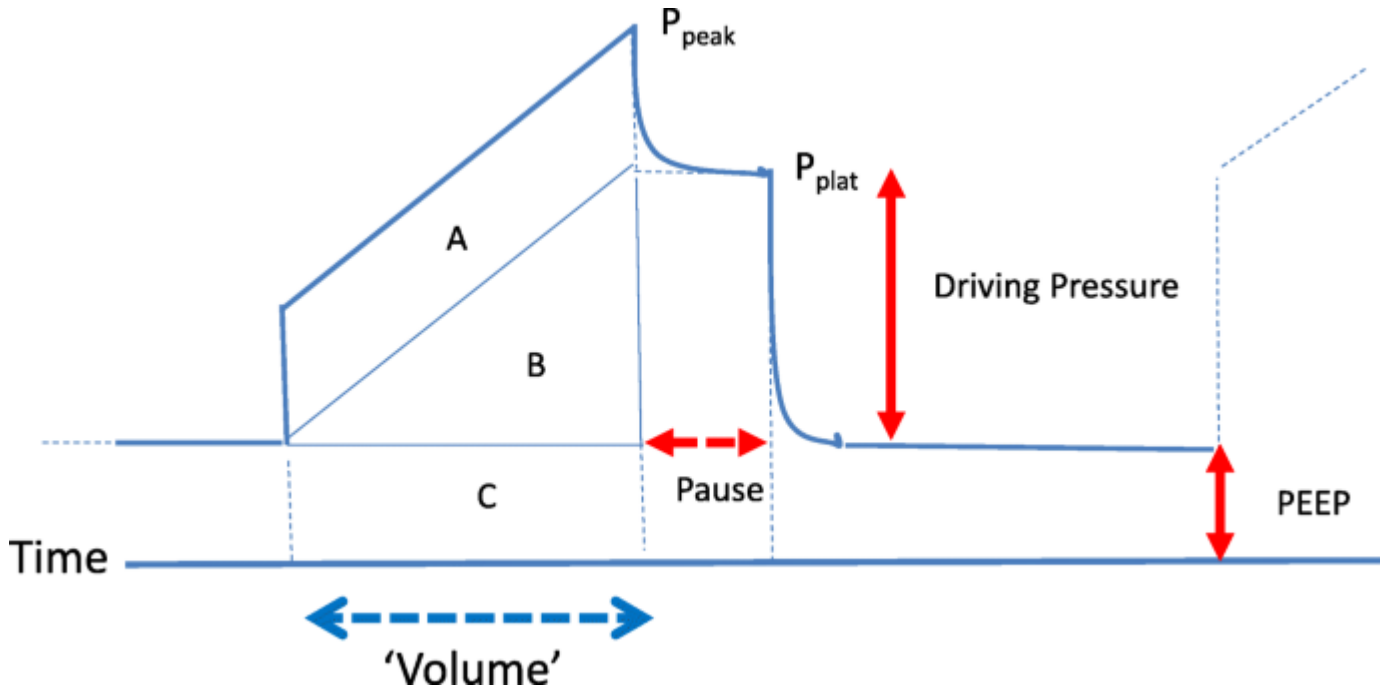
- Nitric oxide
- Prostacyclin
- prostaglandin E1





Driving pressure in ARDS

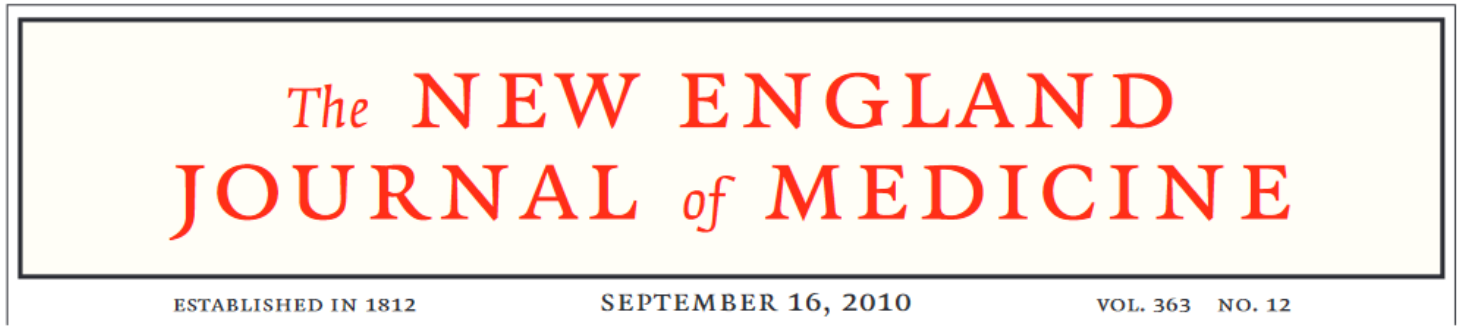
- Driving pressure is calculated as the difference between plateau pressure and total PEEP



Limiting driving pressure

- Muscle relaxant
- Prone position
- Decreasing instrumental dead space
- Co2 removal
- Veno venus ECMO

NMBA



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Neuromuscular Blockers in Early Acute Respiratory Distress Syndrome

Laurent Papazian, M.D., Ph.D., Jean-Marie Forel, M.D., Arnaud Gacouin, M.D., Christine Penot-Ragon, Pharm.D., Gilles Perrin, M.D., Anderson Loundou, Ph.D., Samir Jaber, M.D., Ph.D., Jean-Michel Arnal, M.D., Didier Perez, M.D., Jean-Marie Seghboyan, M.D., Jean-Michel Constantin, M.D., Ph.D., Pierre Courant, M.D., Jean-Yves Lefrant, M.D., Ph.D., Claude Guérin, M.D., Ph.D., Gwenaël Prat, M.D., Sophie Morange, M.D., and Antoine Roch, M.D., Ph.D., for the ACURASYS Study Investigators*

- ConclusionsIn patients with severe ARDS, early administration of a neuromuscular blocking agent improved the adjusted 90-day survival and increased the time off the ventilator without increasing muscle weakness

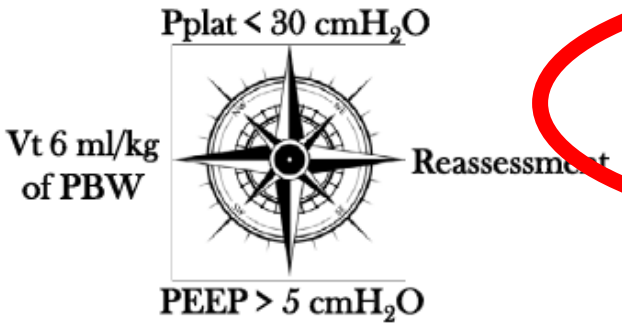
NMBA

Early Neuromuscular Blockade in the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute PETAL Clinical Trials Network*

- Among patients with moderate-to-severe ARDS who were treated with a strategy involving a high PEEP, there was no significant difference in mortality at 90 days between patients who received an early and continuous cisatracurium infusion and those who were treated with a usual-care approach with lighter sedation targets.

Early management of ARDS in 2019



P/F < 80 — Discuss VV-ECMO

P/F < 150 — Neuromuscular blockers
Prone positioning

P/F < 200 — High level of PEEP
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Tidal volume about 6 ml/kg of PBW
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Confirmed ARDS

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- ❑ In case of refractory hypoxemia or when protective ventilation can not be applied
- ❑ To be discussed with experienced ECMO centres

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Prone positioning methods :
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Moderate or severe ARDS -> High PEEP test (> 12 cmH_2O)
Use high levels if:
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Might be applied
- ➢ Inhaled Nitric Oxide (iNO), when severe hypoxemia remains despite prone positioning and before considering VV-ECMO
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