Driving the ECMO road to Lung protection

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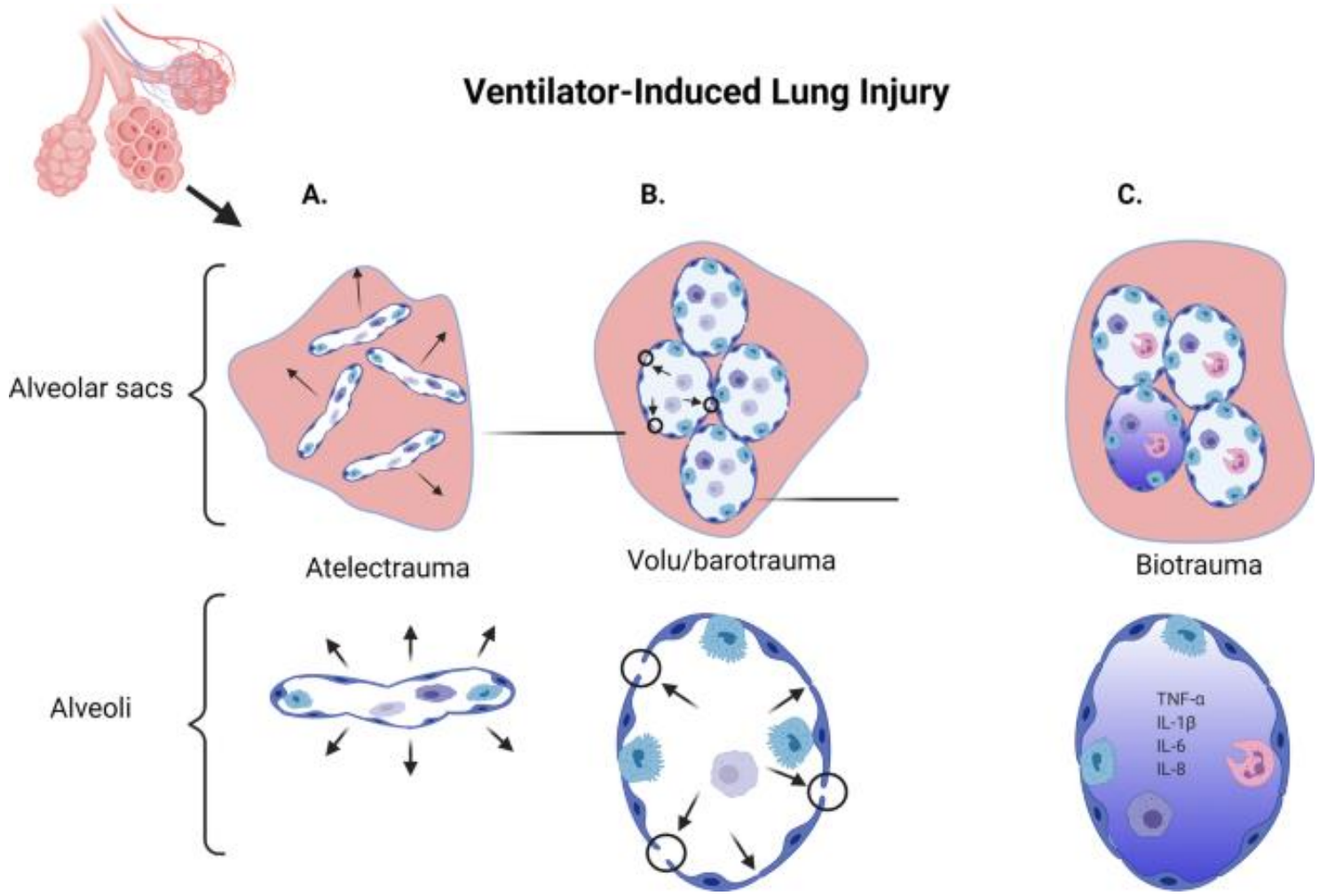
No disclosures

Roadmap

- What is Driving Pressure?
- How to optimize Driving Pressure?
- Mechanical ventilation in ECMO

Increased strain on the lung leads to Ventilator induced lung injury



Lung protective ventilation decreases stress on the lung

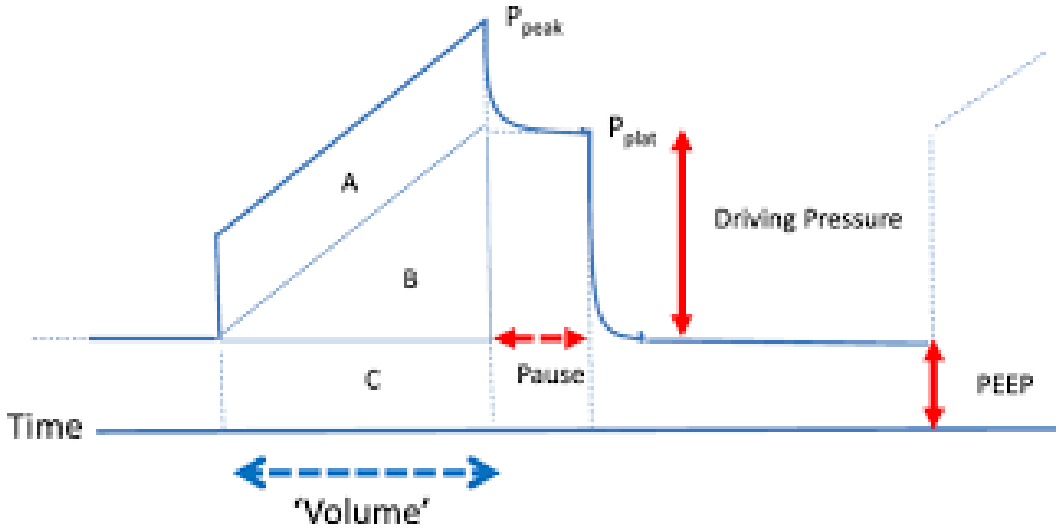
- Low tidal volume - to limit overdistention
- Low plateau pressure – limit barotrauma
- High PEEP - to prevent injury from low lung volume (atelectrauma)

Driving pressure is the distending pressure above PEEP to provide a tidal volume

$$\Delta P = V_T / C_{RS}$$

$$C_{RS} = V_T / P_{plat} - PEEP$$

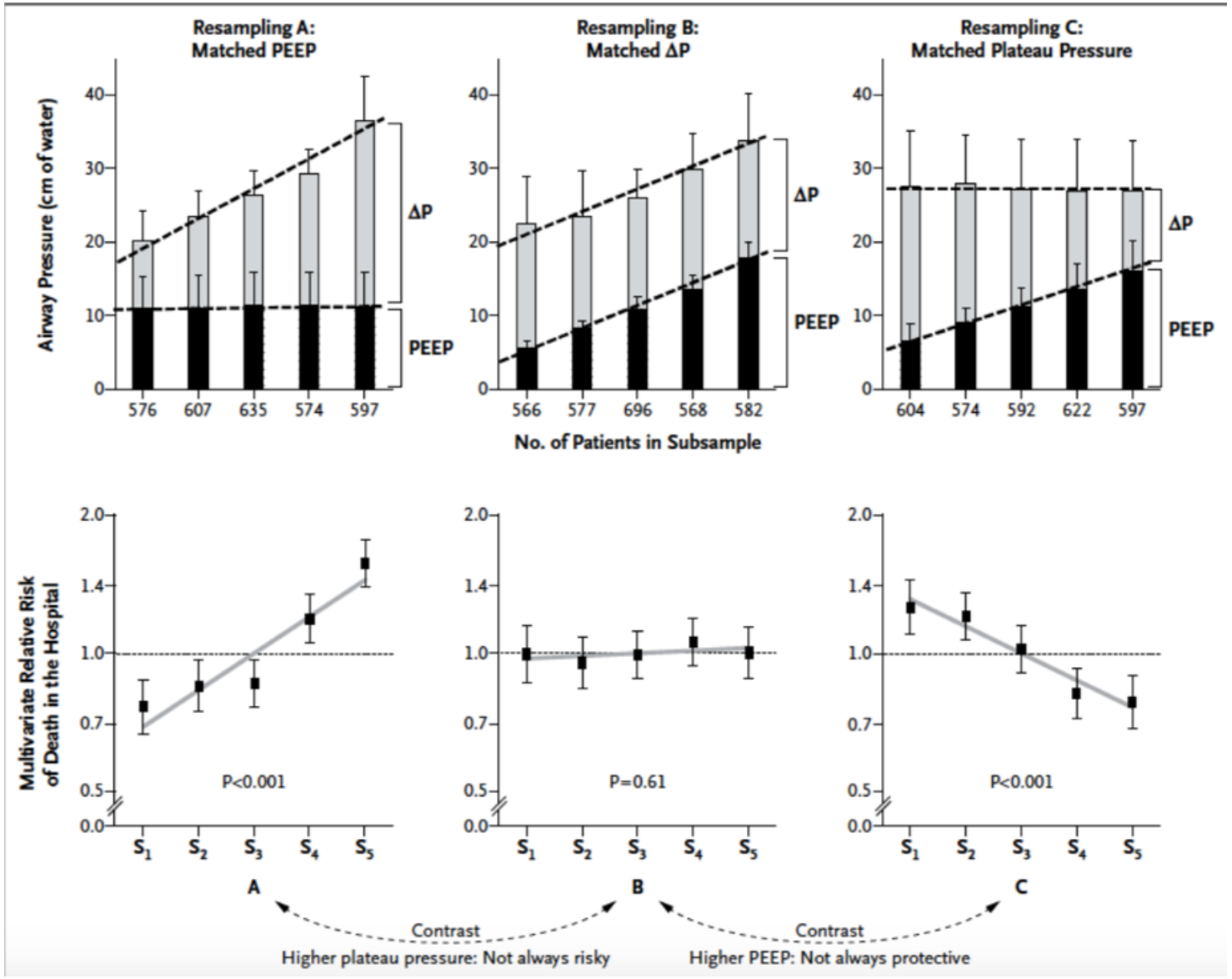
$$\Delta P = P_{plat} - PEEP$$



Time	Pplat (cm H_2O)	PEEP (cm H_2O)	Vt (mL)	DRIVING PRESSURE
T0	28	5	450	23
T1	28	10	450	18

Driving pressure (ΔP) was a better predictor of mortality than Compliance or V_T

3,562 patients from 9 major previously reported ARDS trials



Amato et al, NEJM 2015

How to Optimize Driving pressure

Decrease VT

Optimize PEEP

How to set an optimal PEEP

PEEP is increased in increments

- PEEP tables
- Compliance
- Pressure volume loops
- Driving pressure
- Stress Index
- Transpulmonary pressures
- Electrical impedence tomography

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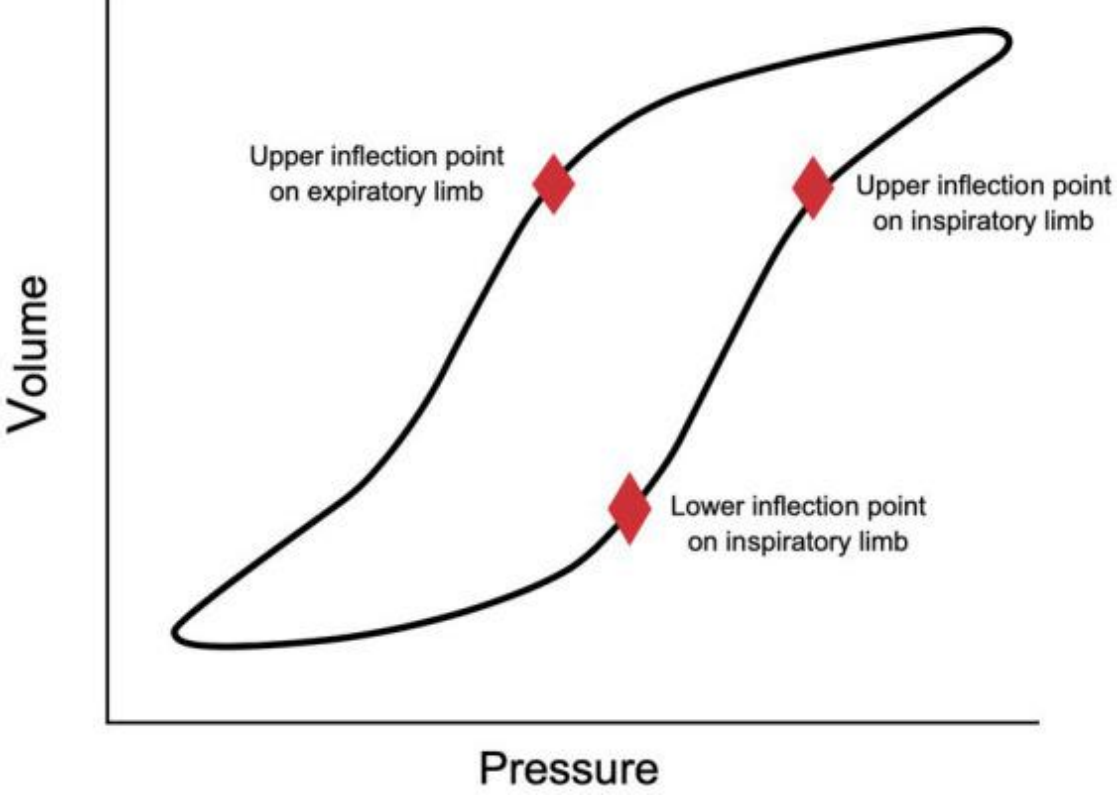

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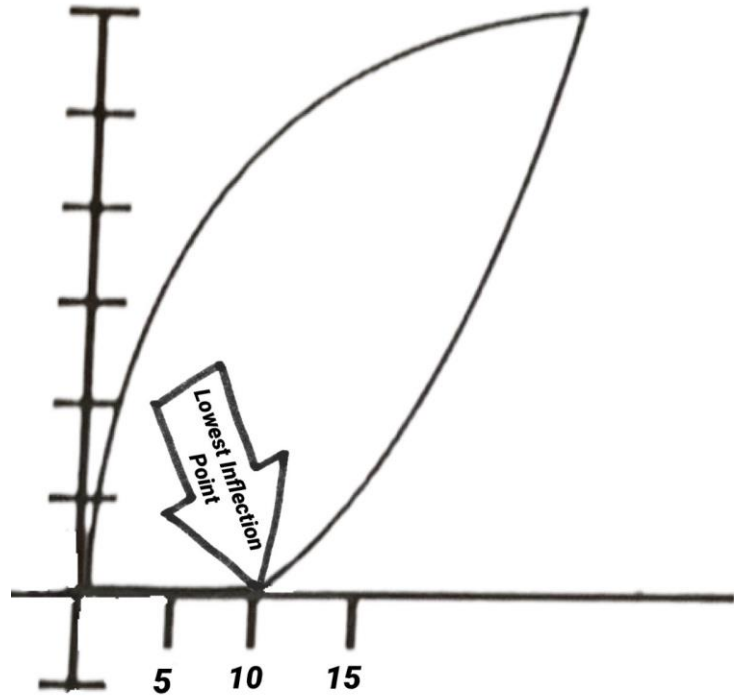

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SI > 1, decreasing compliance- **Overdistension**
SI < 1 increasing compliance- **alveolar recruitment**

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PEEP requires individualization

- Alveolar recruitability
- Pleural pressures
- Hemodynamics- can decrease cardiac output by
  - Increasing intrathoracic pressure → Dec venous return
  - Increased RV afterload

Camporota et al. Critical Care med 2019

Lung protective ventilation in ARDS

- Low tidal volume
- Low plateau pressure
- High PEEP
- Driving Pressure<15

Think of Extracorporeal life support (ECLS)

- Refractory hypoxemia or hypercapnia with lung protective ventilation

ECMO is a supportive life saving therapy

- VV ECMO – for refractory hypoxemia or hypercapnia
- VA ECMO – for both cardiac and respiratory support

The overall goal of mechanical ventilation under ECMO is to rest the lung by using **ultra-protective ventilation**

- Low (and even very low) tidal volume- *Typically 4 mL/kg PBW and adjusted for the goal of plateau pressure (24 cmH2O)*
- Low respiratory rate

What about PEEP and driving pressure in ECMO ?

Lung. 2020 Jul 23;198(5):785–792. doi: 10.1007/s00408-020-00381-y

Don’t Drive Blind: Driving Pressure to Optimize Ventilator Management in ECMO

Ena Gupta [1,2,✉], Bharat Awsare [1], Hitoshi Hiroshi [3], Nicholas Cavarocchi [3], Michael Baram [1]

192 patients including both VA and VV ECMO

Higher DP 24 h after ECMO was associated with an **increase in 30-day mortality** (OR 1.15, $p \leq 0.001$)

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70 patients with **DP measured before and after ECMO**

DECREASE IN DP

INCREASE IN DP

Ena Gupta et al. LUNG 2020

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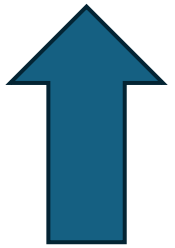

	DECREASE IN DP	INCREASE IN DP	
PEEP before cannulation	9.3 (± 4.3)	13.1 (± 5.4)	<0.01
PEEP 24h after ECMO	6.8 (± 1.7)	7.0 (± 2.1)	0.63
Change in PEEP	**-2.5 (± 3.4)**	**- 6 (± 4.8)**	**<0.01**
Compliance before cannulation	31.5 (± 19.1)	29 (± 11.3)	0.58
Compliance 24 h after ECMO	32.2 (± 14.2)	22.6 (± 9)	<0.01
Change in compliance	**0.51 (± 10.5)**	**- 7.7 (± 10.8)**	**0.01**

	DECRESAE IN DP	INCREASE IN DP	
Days on ECMO (days)	**9 ± 5**	**13 ± 8**	0.022
Length of stay after ECMO (days)	37 ± 37	30 ± 19	0.528
Died on ECMO	10 (30%)	10 (31%)	0.958
30-day mortality	11 (34%)	13 (42%)	0.537
Home	3 (9.4)	2 (6.4)	
Long-term acute care facility	3 (9.4)	2 (6.4)	
Rehabilitation facility	11 (34.4)	13 (42)	

CONCLUSION

- A significant proportion of the patients had an increase in driving pressure and decrease in compliance after initiation of ECMO despite ultraprotective ventilation.

- This may be due to inadequate recruitment while on ECMO.

- Those with increase in driving pressure had a longer length of stay on ECMO.

- Elevated driving pressure after ECMO initiation was associated with increased adjusted 30-day mortality among both VA- and VV-ECMO

Table 1. Overview of the recent studies investigating the impact of mechanical ventilator settings during ECMO on outcomes in patients with ARDS.

Studies	Study Design	Main Results	
Pham et al., 2013 [18] (n = 123)	Retrospective observational study	ICU mortality: 35.8% Higher plateau pressure on the first day under ECMO was independently associated with ICU mortality (OR 1.33, $p < 0.01$)	High Plateau P= Higher mortality
Schmidt et al., 2015 [20] (n = 168)	Retrospective study	ICU mortality: 29% Higher PEEP during the first 3 days of ECMO was independently associated with lower mortality (OR 0.75, $p = 0.0006$)	High PEEP = Lower mortality
Marhong et al., 2015 [16] (n = 2042)	Systematic review	Median (IQR) overall mortality: 41% (31–51%) Mortality was lower in patients receiving lower intensity of applied ventilation during ECMO. Combined tidal volume $\leq$ 4 mL/kg PBW and plateau pressure $\leq$ 26 cmH_2O during ECMO had lowest mortality	Combined TV<4 and PP<26 had lower mortality
Modrykamien et al., 2016 [19] (n = 64)	Retrospective observational study	Hospital mortality: 46.9% Increased plateau pressure was independently associated with decreased odds of hospital survival (OR 0.79, $p = 0.007$)	High Plateau P = dec odds of survival
Neto et al., 2016 [21] (n = 545)	Individual patient data meta-analysis of observational studies	In-hospital mortality: 35.2% Driving pressure was the only ventilatory parameter during ECMO that was independently associated with in-hospital mortality (adjusted HR 1.06, $p < 0.001$)	Driving pressure associated with mortality
Kim et al., 2019 [29] (n = 56)	Retrospective study	Hospital mortality: 48.1% Lung compliance during ECMO was significantly associated with 6-month mortality (HR 0.943, $p = 0.009$)	
Schmidt et al., 2019 [26] (n = 350)	International prospective cohort study	Six-month mortality: 39% MV settings during the first 2 days of ECMO did not impact the prognosis	MV settings did not impact mortality
Chiu et al., 2021 [17] (n = 152)	Retrospective study	Hospital mortality: 53.3% MP during the first 3 days of ECMO was the only ventilatory variable independently associated with 90-day hospital mortality, and MP referenced to compliance had the greatest predictive value for mortality compared to MP alone (adjusted HR 2.289, $p = 0.010$)	Mechanical power associated with mortality

ECMO: extracorporeal membrane oxygenation; ARDS: acute respiratory distress syndrome; ICU: intensive care unit; OR: odds ratio; PEEP: positive end-expiratory pressure; IQR: interquartile range; PBW: predicted body weight; HR: hazard ratio; MV: mechanical ventilation; MP: mechanical power.

The overall goal of mechanical ventilation under ECMO is to rest the lung by using

- low (and even very low) tidal volume- *Typically 4 mL/kg PBW and adjusted for the goal of plateau pressure (24 cmH2O)*
- low respiratory rate
- Maintain sufficient PEEP

Table 2. Suggested Initial Mechanical Ventilation Targets during ECLS for Acute Respiratory Distress Syndrome

Parameter	Target	Notes
Pplat*	≤24 cm H_2O; may choose to go lower if feasible	
Driving pressure*	≤14 cm H_2O	
V_T	Adjust for goal Pplat	Typically ≤4 ml/kg PBW, often much lower
Respiratory rate†	≤10 breaths/min	Typically only achieved when sedation, with or without NMBAs, is being used. Consider increased sweep flow to achieve, when appropriate
PEEP*	≥10 cm H_2O	*See* text for circumstances that may warrant particularly high levels of PEEP
F_{IO_2}*	0.3–0.5	Higher F_{IO_2} may be necessary if ECLS is inadequate for achieving acceptable levels of oxygenation

ECMONet expert opinions' consensus conference, 2018

SUMMARY

Mechanical ventilation matters in ECMO

PEEP Is PERSONALIZED

Keep DRIVING PRESSURE low