Lung and Diaphragm-Protective Ventilation

What, Why, and How?

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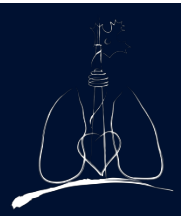


Disclosures

- Conflicts of Interest
  - Equipment from Timpel
  - Equipment and personal fees from Getinge

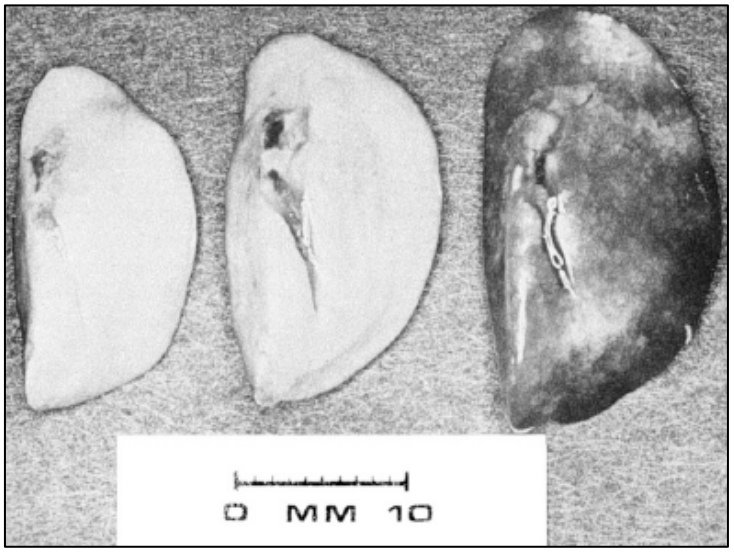
Modern Mechanical Ventilation Saves Lives

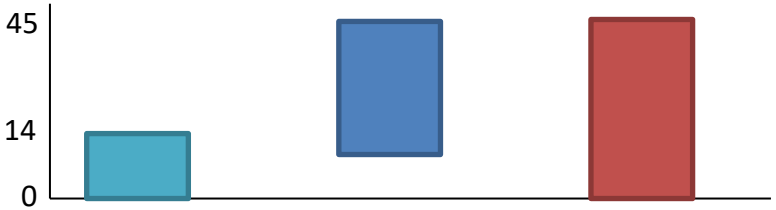
TABLE III—MORTALITY-RATES

Group	Period of admission	No. of cases	Died	Died within three days
I	July 24–Aug. 25	31	27 (*87*%)	19 (*70*%)
II	Aug. 26–Sept. 8	50	26 (*52*%)	7 (*27*%)
III	Sept. 8–Sept. 23	50	24 (*48*%)	8 (*33*%)
IV	Sept. 23–Oct. 5	50	19 (*38*%)	10 (*53*%)
V	Oct. 6–Oct. 21	50	13 (*26*%)	7 (*54*%)
VI	Oct. 21–Nov. 6	50	18 (*36*%)	10 (*55*%)
	Total II–VI	250	100 (*40*%)	42 (*42*%)

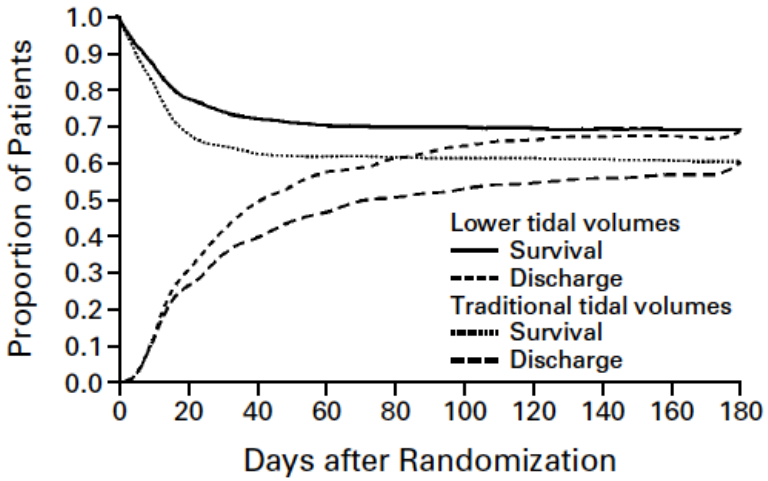
Lassen HCA *Lancet* 1953
West JB *JAP* 2005

Protective Mechanical Ventilation Saves Lives



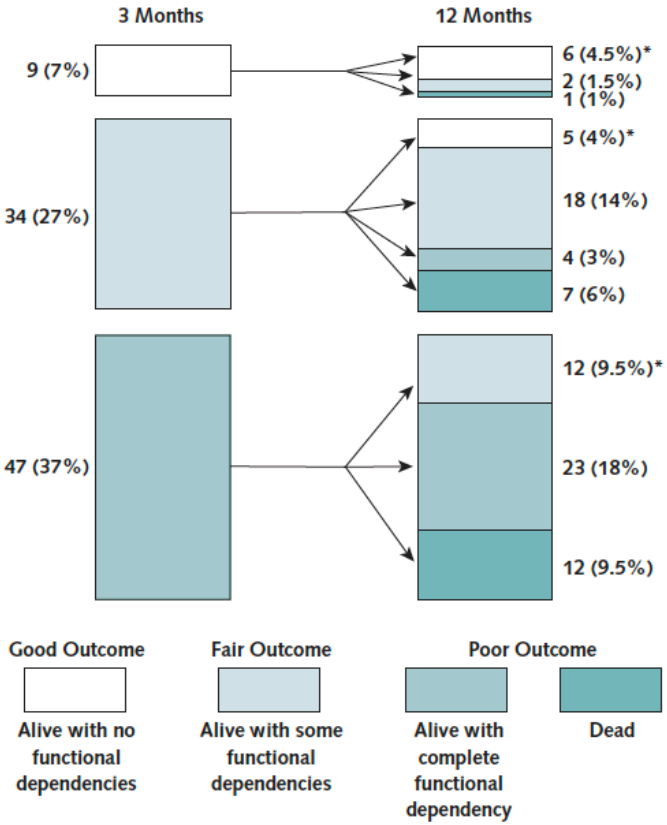


Webb & Tierney *ARRD* 1974



ARDSNet *NEJM* 2000

Prolonged Mechanical Ventilation Leads to Disability

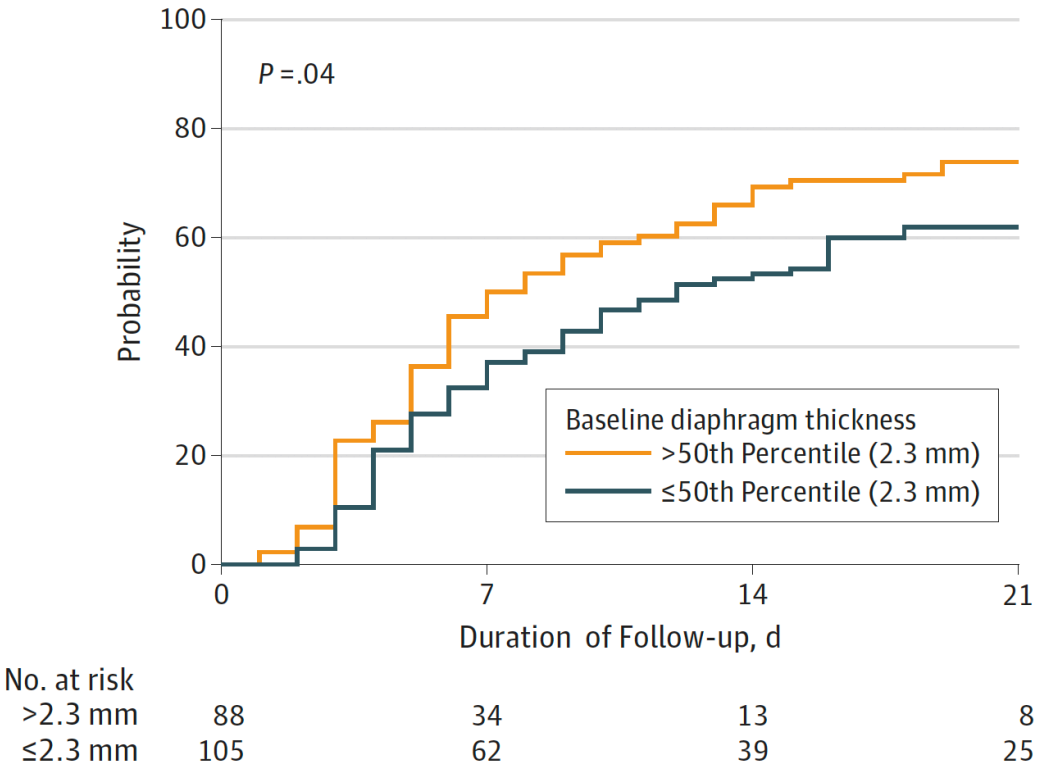


Unroe et al *Ann Intern Med* 2011

Parameter	Odds ratio [confidence interval]	*P* value
Disability		
History of anxiety/depression	1.65 [1.22, 2.23]	0.001
Separated or divorced	2.87 [1.35, 6.08]	0.006
Mechanical ventilation days	1.04 [1.01, 1.08]	0.03
Discharge to another facility (not home)	1.96 [1.01, 3.70]	0.04

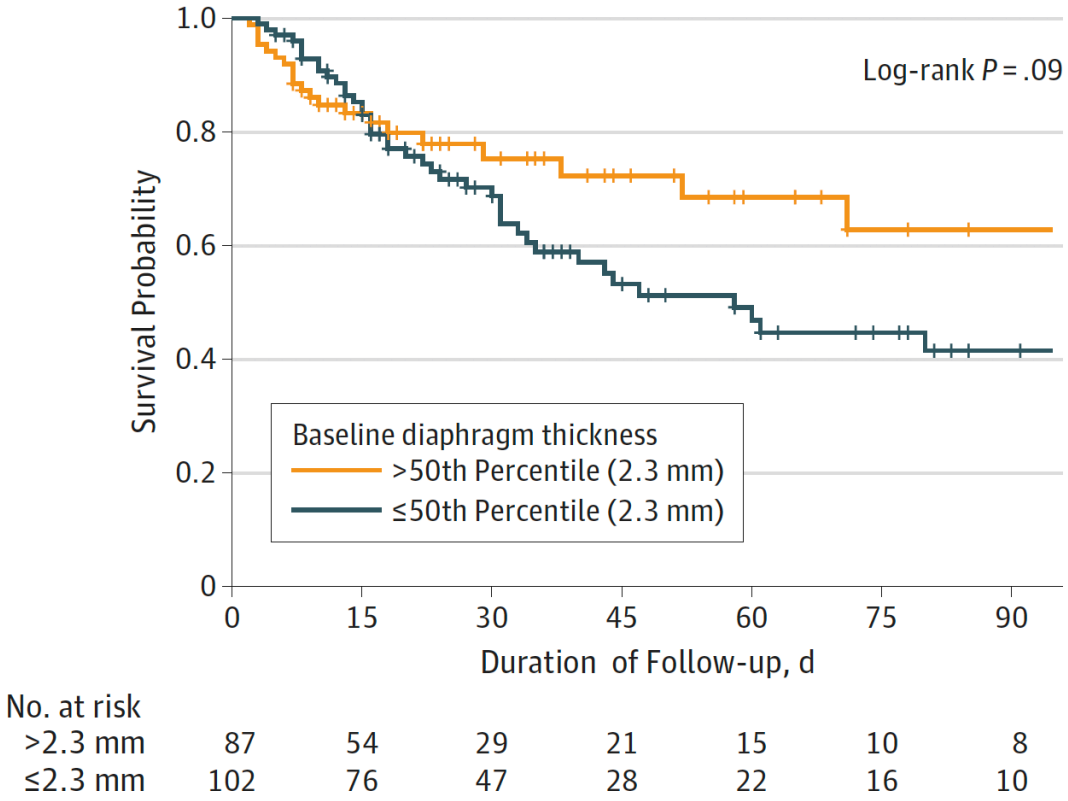
Hodgson et al *Intensive Care Med* 2017

The Diaphragm and ICU Outcomes



Sklar et al *JAMA Netw Open* 2020

The Diaphragm and ICU Outcomes



Sklar et al *JAMA Netw Open* 2020

Ventilator-Induced Diaphragm Dysfunction

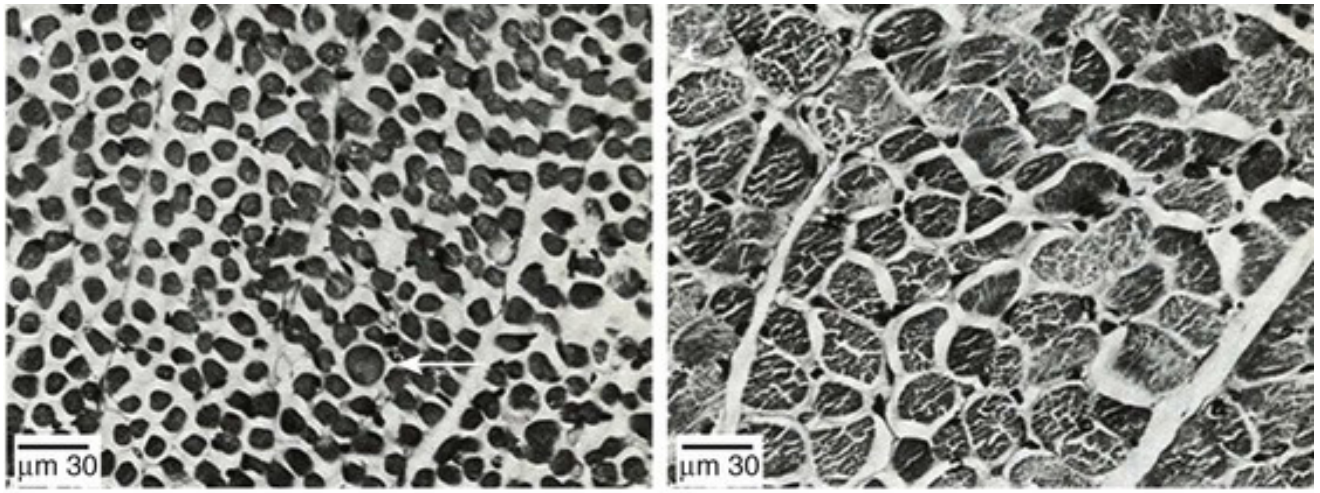
J Pediatr. 1988 Dec;113(6):1074-7.

Abnormalities of diaphragmatic muscle in neonates with ventilated lungs.

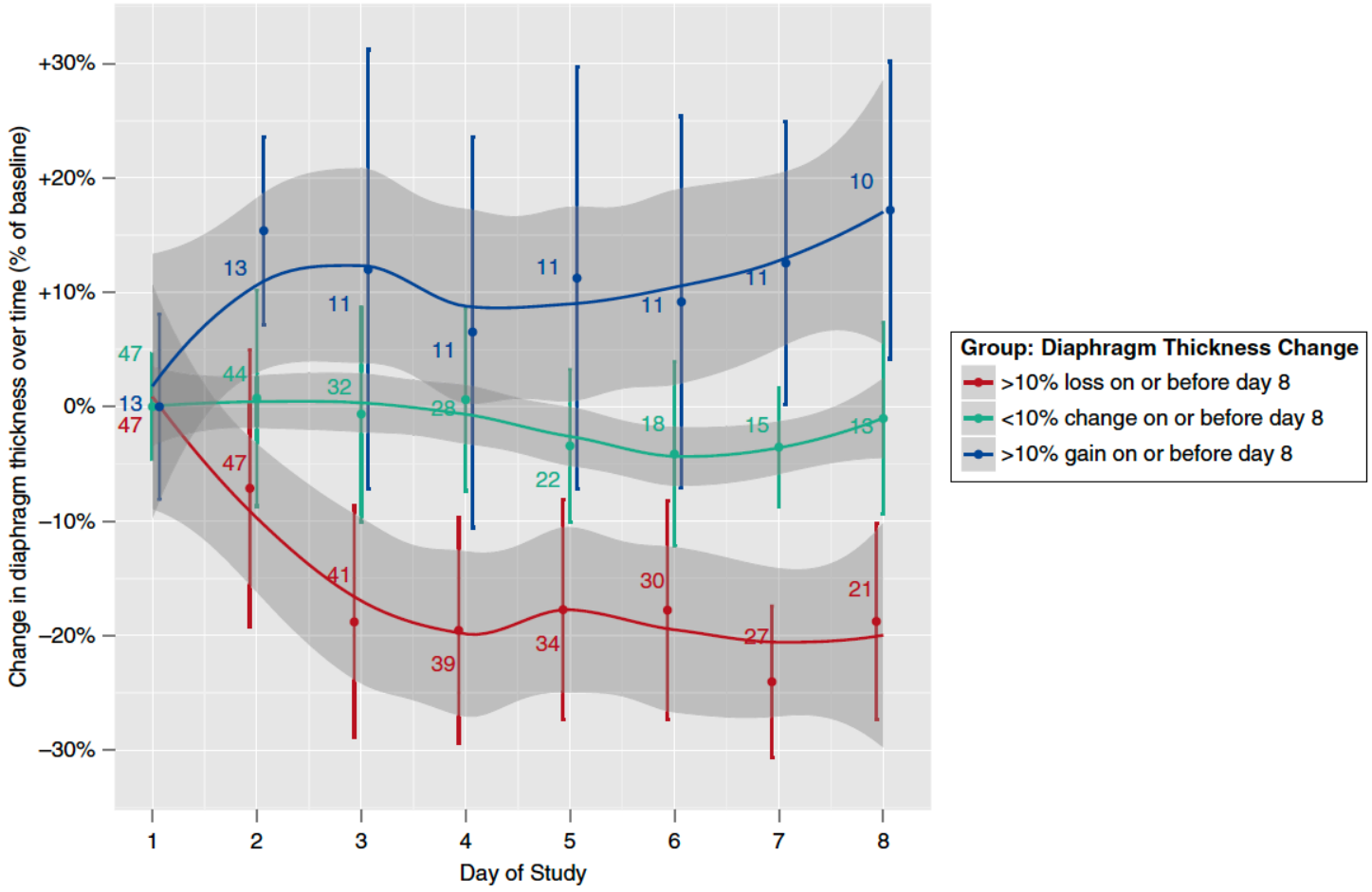
Knisely AS[1], Leal SM, Singer DB.

47 days of MV

3 days of MV

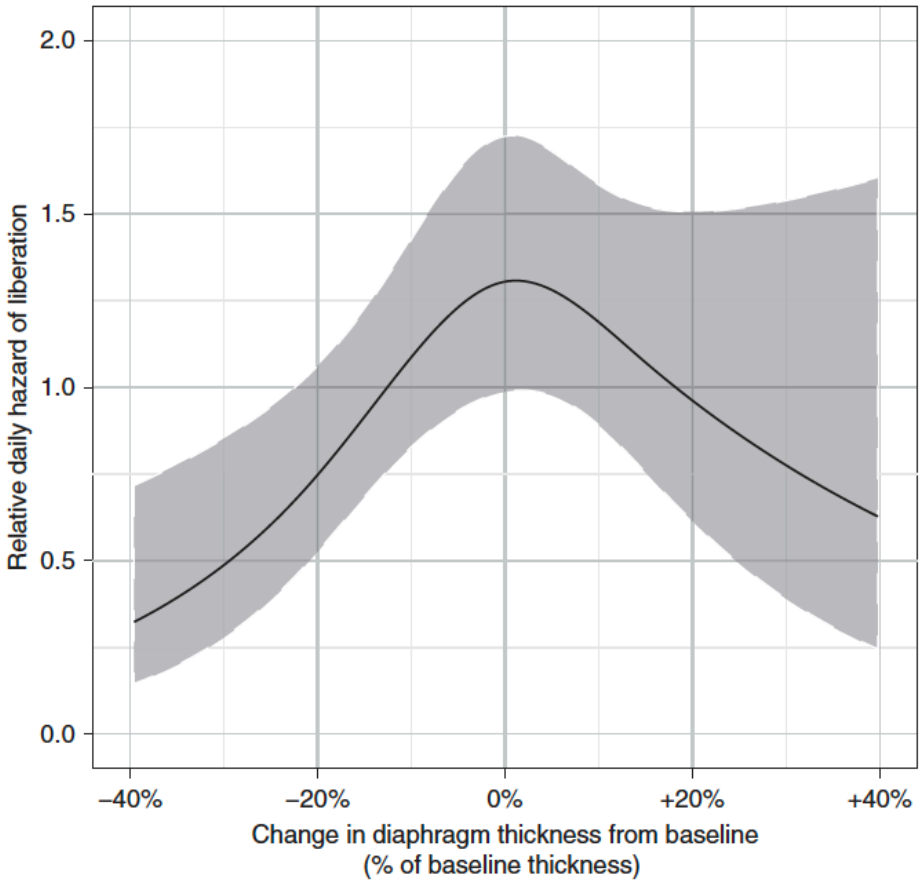


Diaphragm Myotrauma



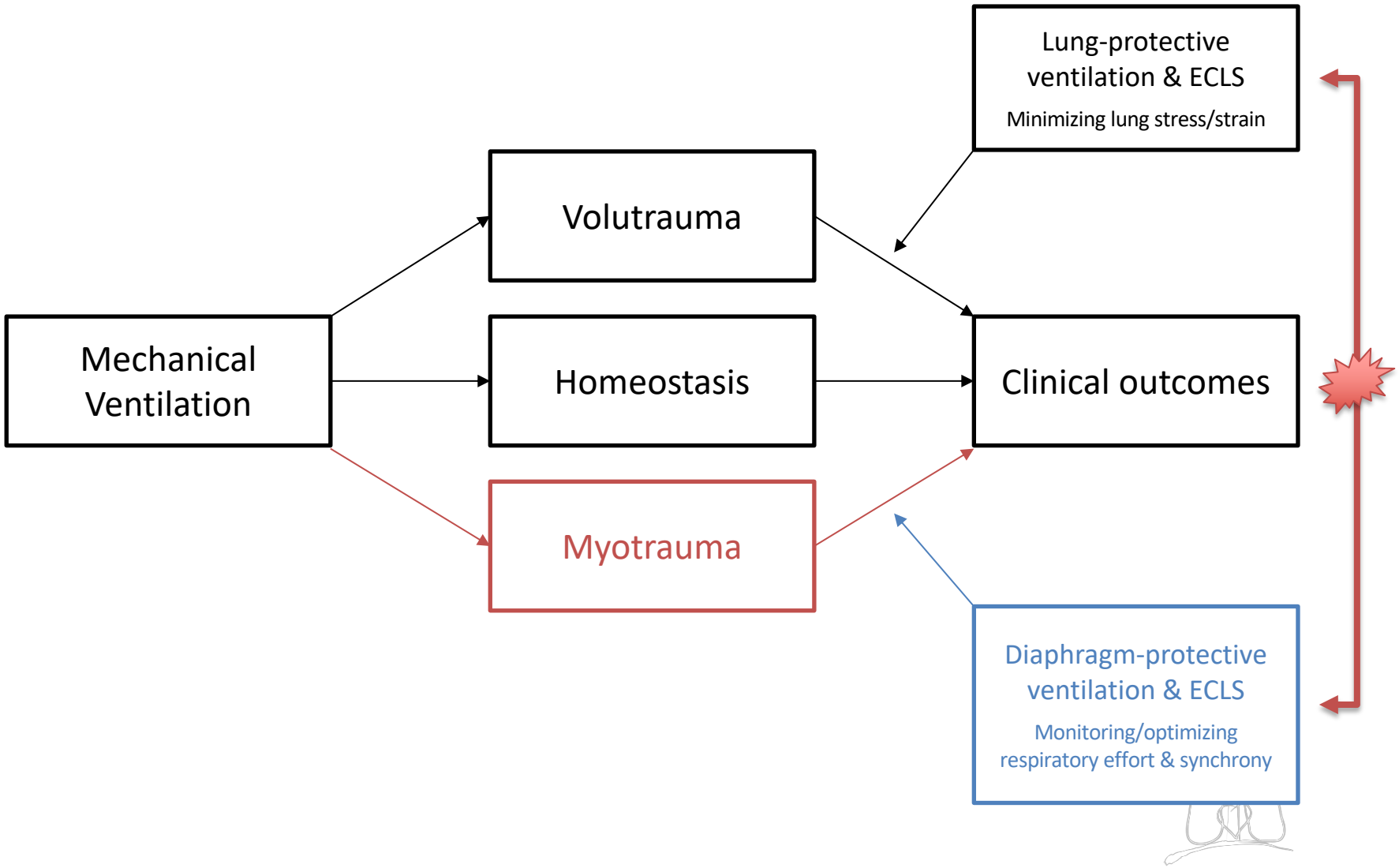
Goligher et al. *AJRCCM* 2015

Diaphragm Myotrauma Associated with Delayed Liberation from Ventilation



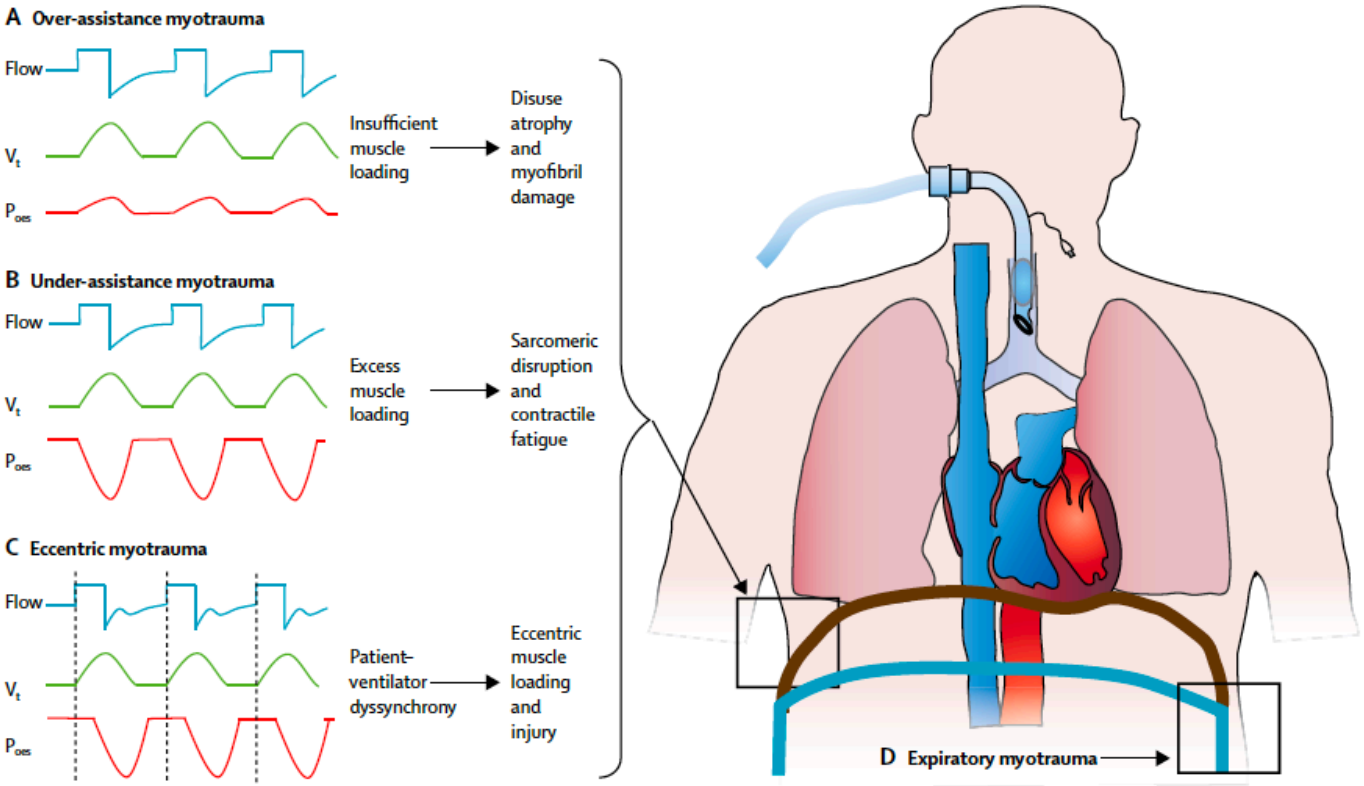
Goligher et al. *AJRCCM* 2018

Lung and Diaphragm-Protective Ventilation



Diaphragmatic myotrauma: a mediator of prolonged ventilation and poor patient outcomes in acute respiratory failure

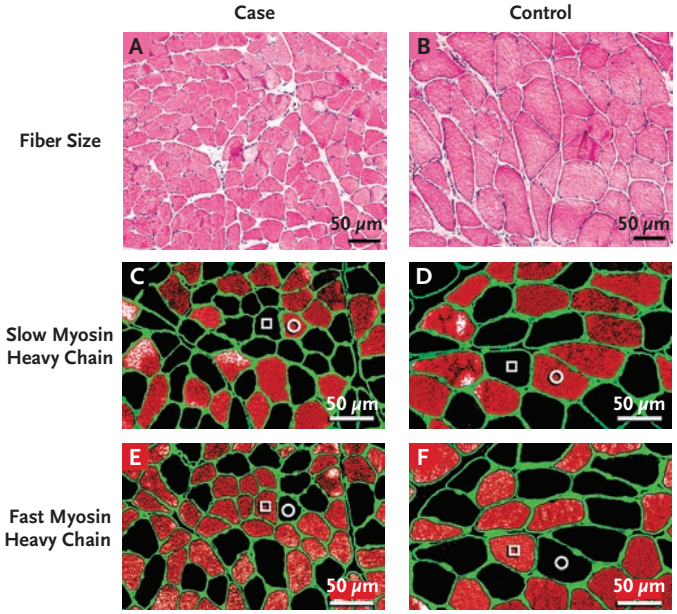
Ewan C Goligher, Laurent J Brochard, W Darlene Reid, Eddy Fan, Olli Saarela, Arthur S Slutsky, Brian P Kavanagh, Gordon D Rubenfeld, Niall D Ferguson



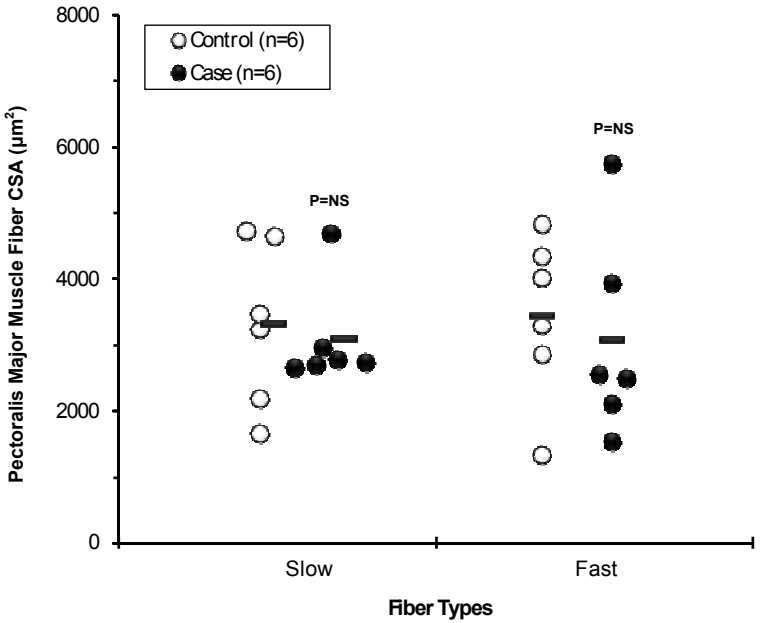
Goligher et al. *Lancet Respir Med* 2019

Over-assistance Myotrauma: Disuse Atrophy

Diaphragm

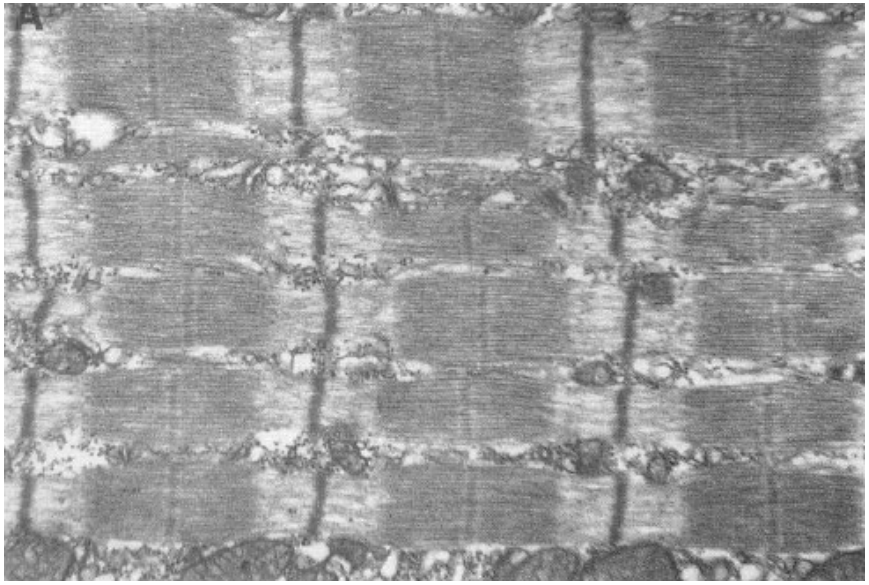


Pectoralis major



Levine et al *N Engl J Med* 2008

Under-Assistance Myotrauma: Load-Induced Injury



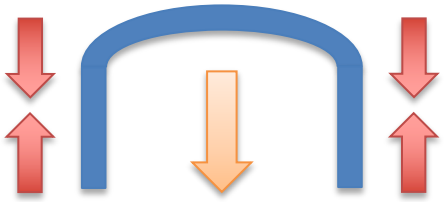
Control specimen

Resistive loading specimen

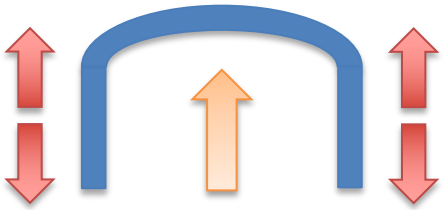
Reid et al. *J Appl Phys* 1994

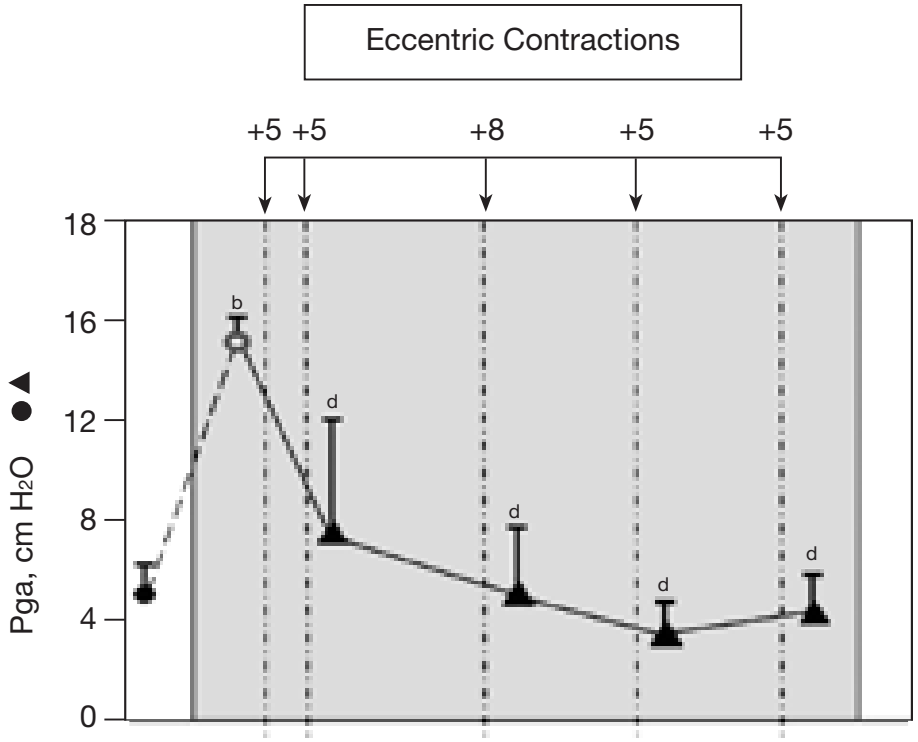
Eccentric Myotrauma

Concentric



Eccentric

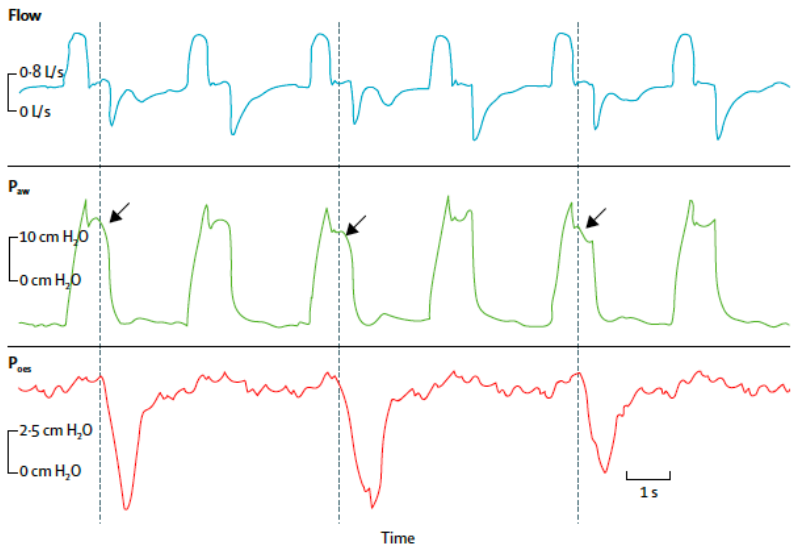




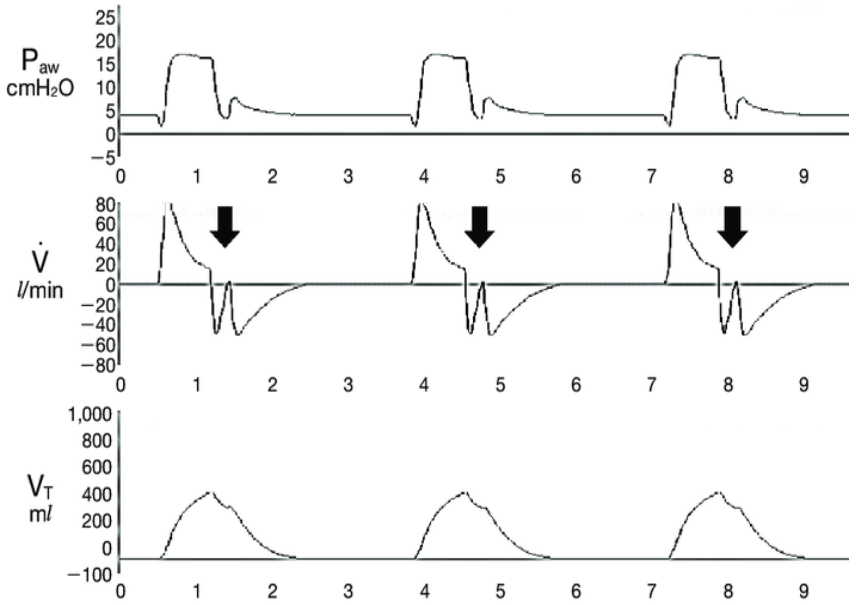
Gea et al. *Arch Bronchopneumol* 2009

Eccentric Myotrauma

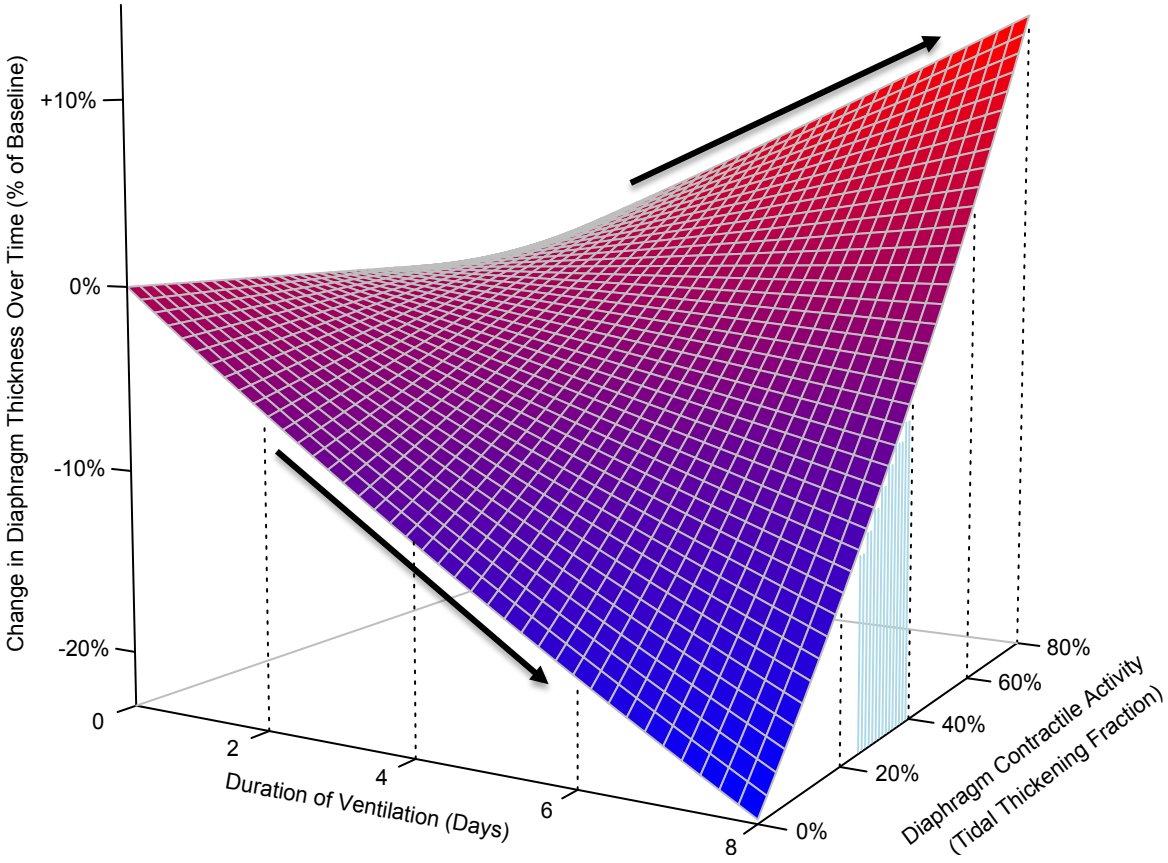
Reverse triggering



Premature cycling

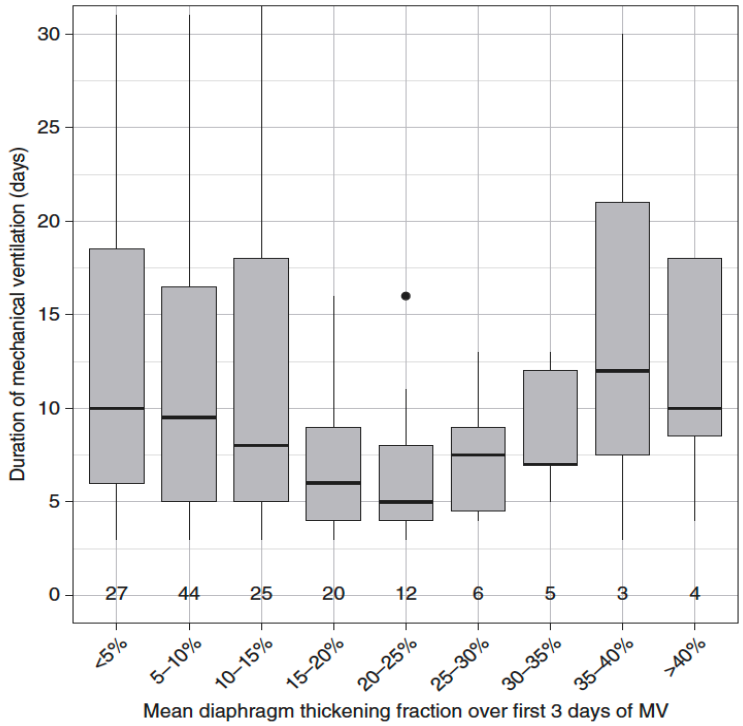


Myotrauma: Clinical Investigation



Goligher et al *AJRCCM* 2015

Inspiratory Effort and Outcome



Target window

Goligher et al *AJRCCM* 2018

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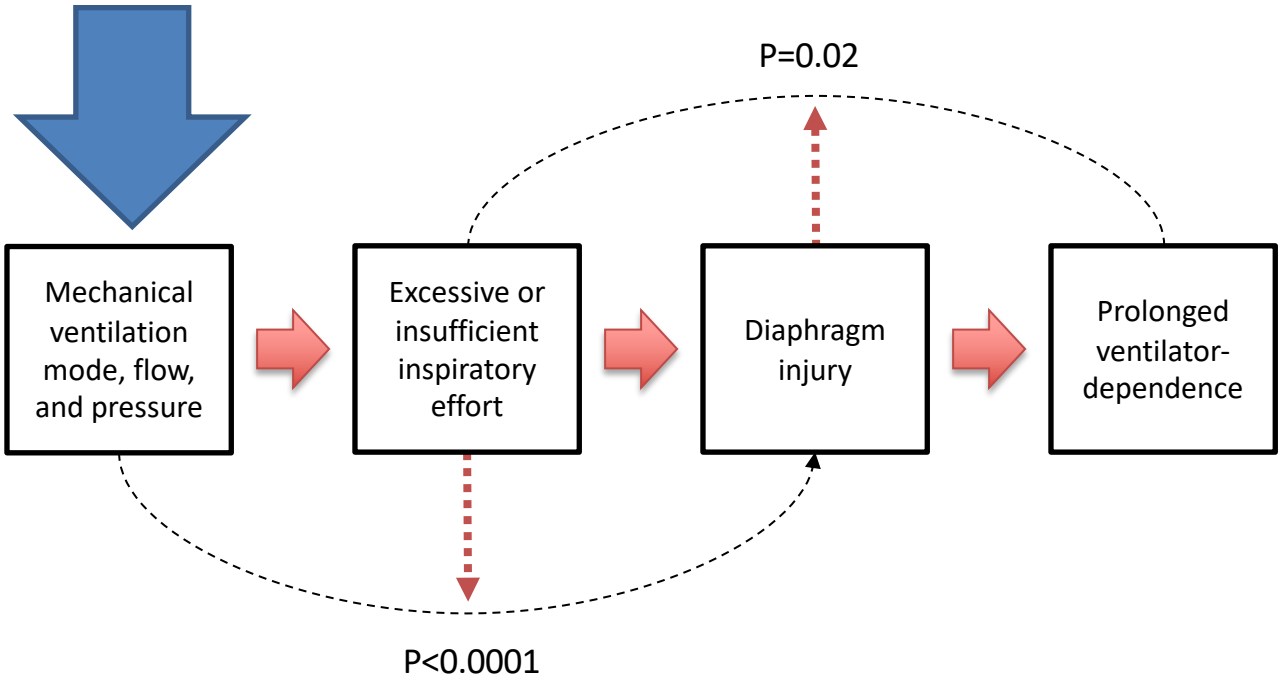
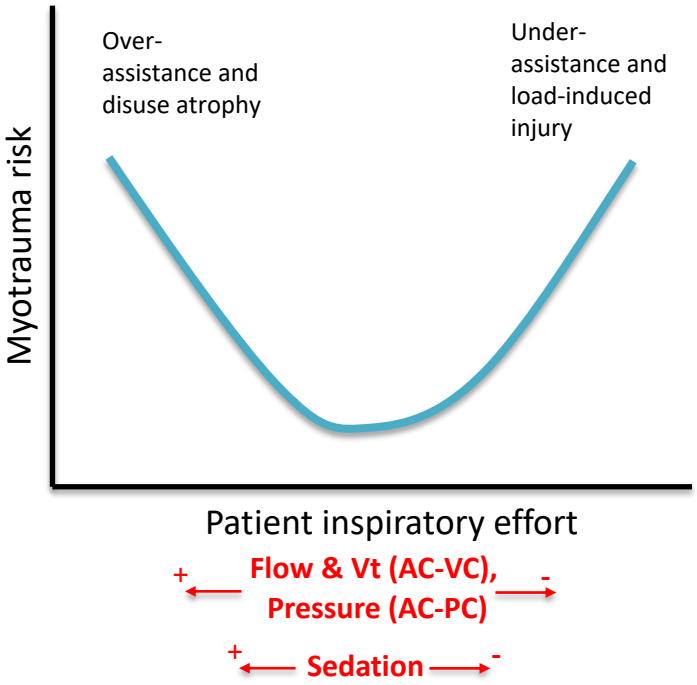


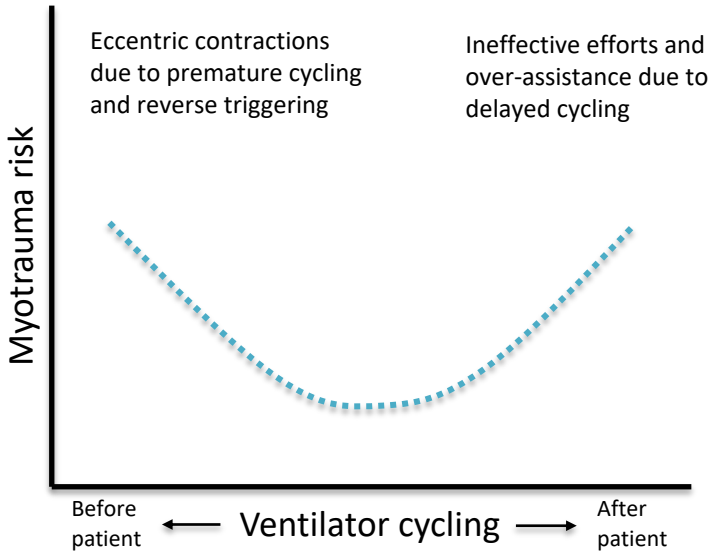
Goligher et al *Lancet Respir Med* 2019

Diaphragm-Protective Ventilation in 2019

Optimize respiratory effort



Optimize patient-ventilator synchrony



Goligher *Intensive Care Med* 2019

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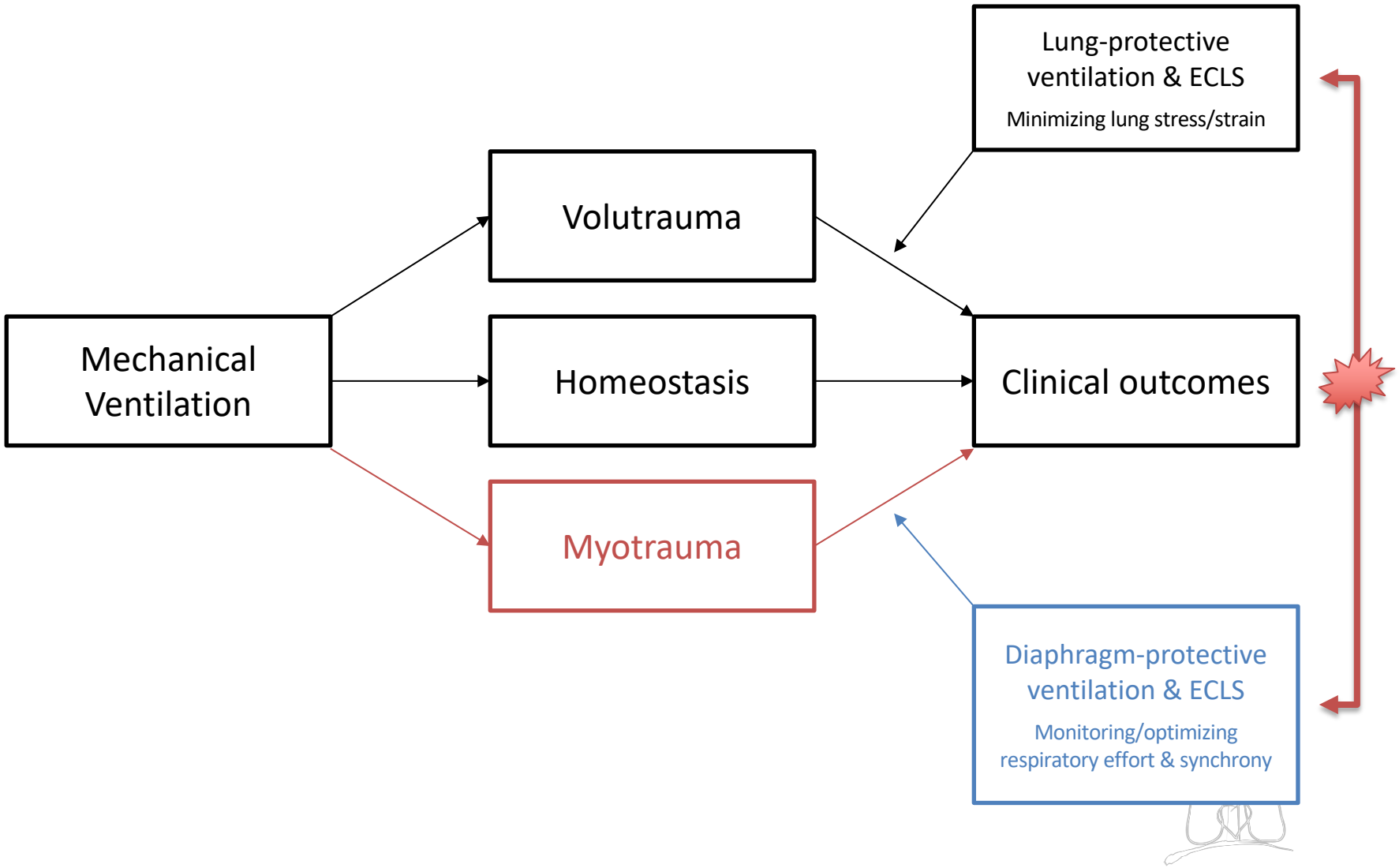
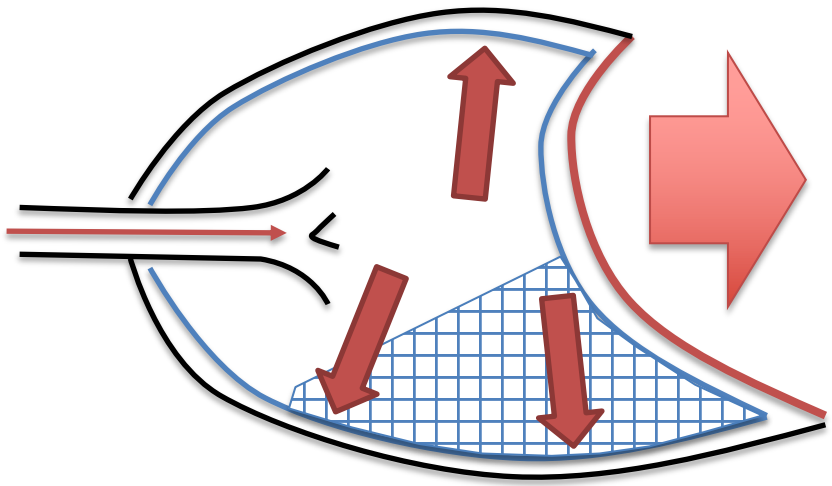
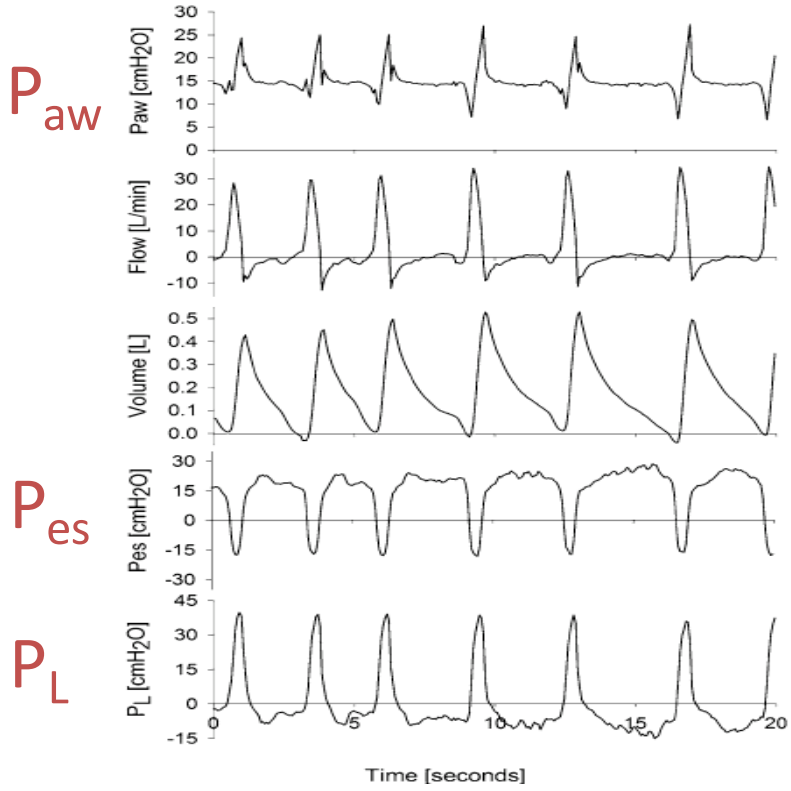


Excess Lung Stress

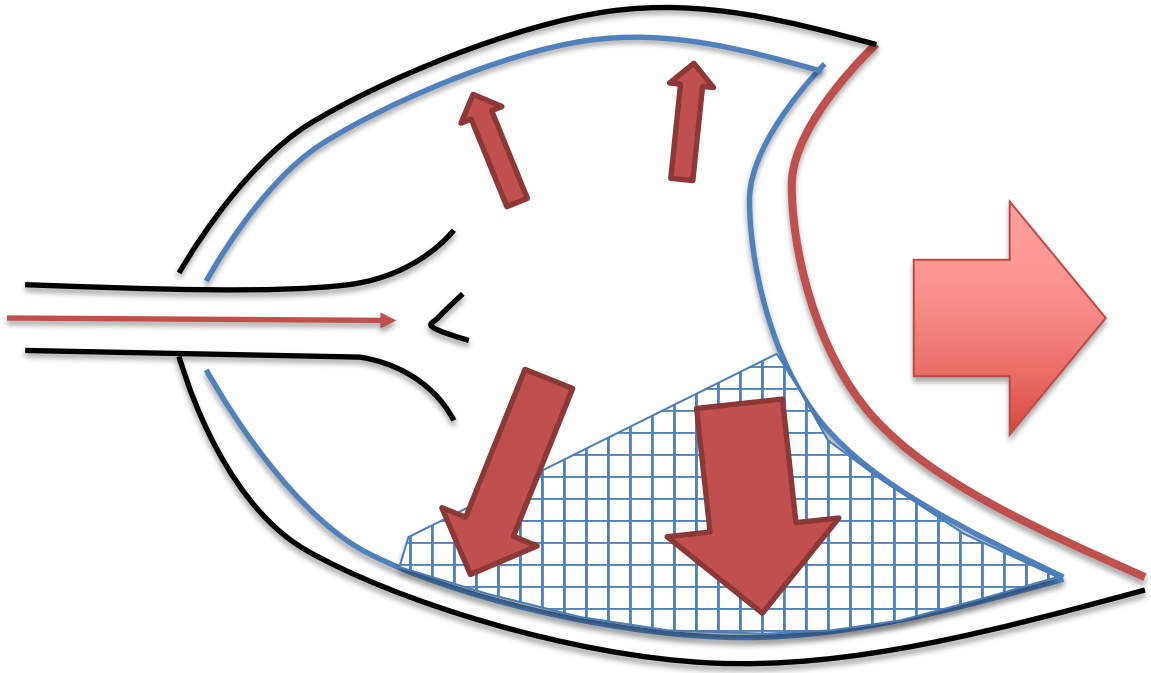


$$P_L = P_{airway} - P_{pleural}$$

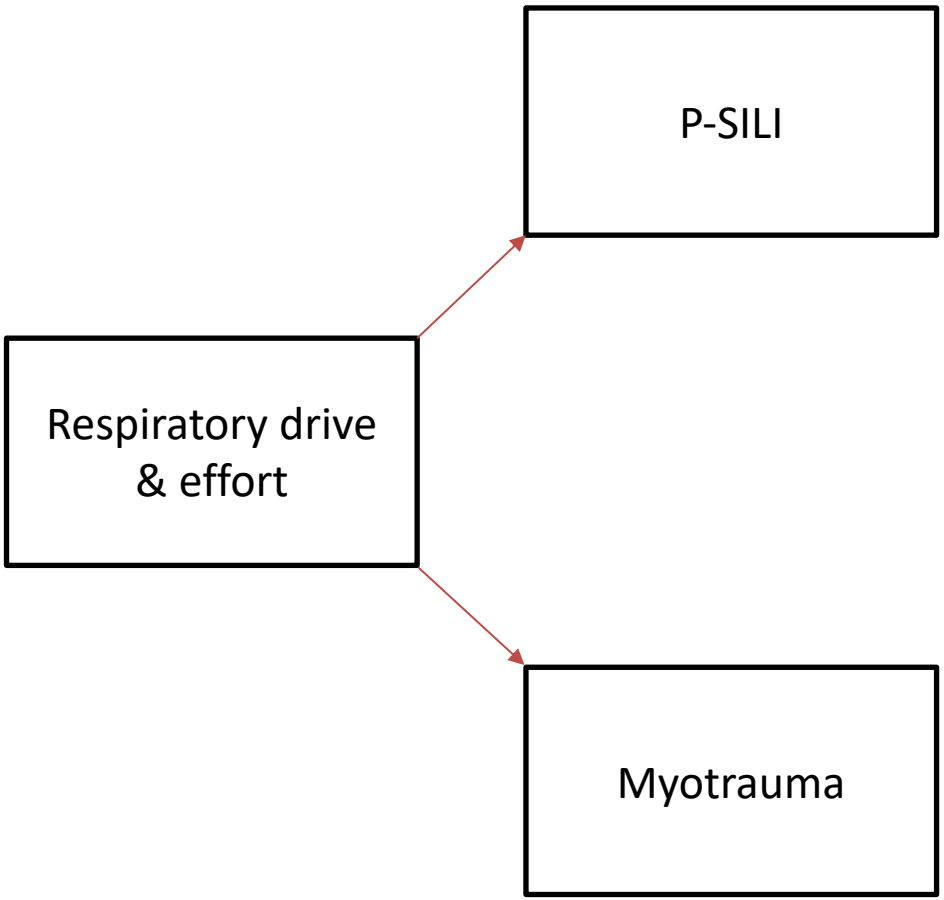


Mauri et al *Intensive Care Med* 2016

Inhomogeneous Lung Stress

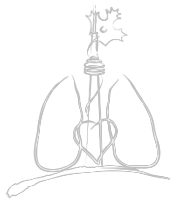


Challenge: Managing Respiratory Drive



LDPV: How

- Ventilation targets
- Monitoring
- Methods for controlling respiratory drive and effort



LDPV Goals

Position Statements

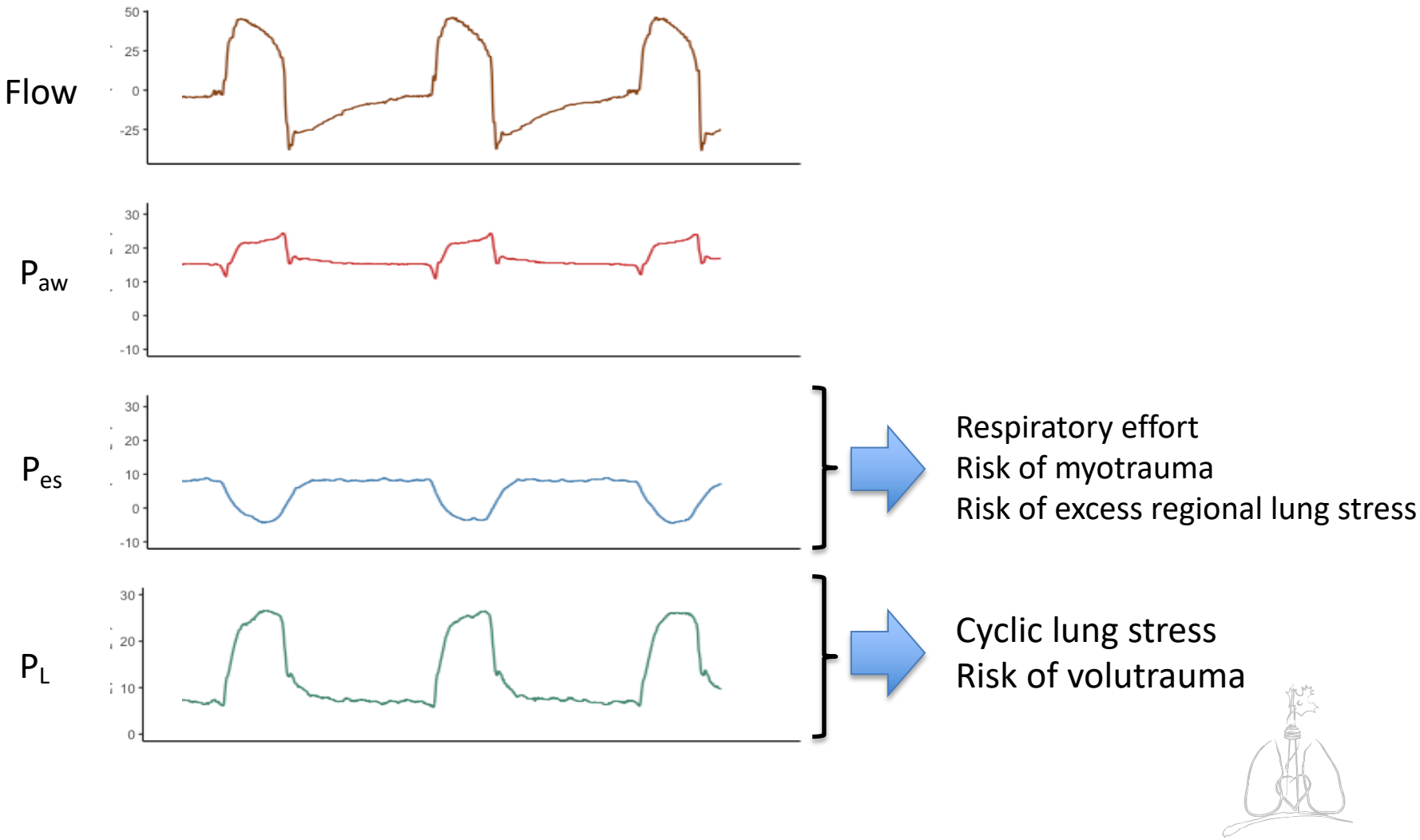
- No single universally applicable one-size-fits-all setting for optimal mechanical ventilation
- Protecting the lung should be prioritized over protecting the diaphragm
- Respiratory effort should be monitored routinely

LDPV Goals

Proposed LDPV Goals

- Limit cyclic lung stress
- Limit regional cyclic lung stress
- Maintain low-normal respiratory effort
- Avoid breath stacking dyssynchrony
- Aim for expiratory synchrony

Monitoring for LDPV Strategy



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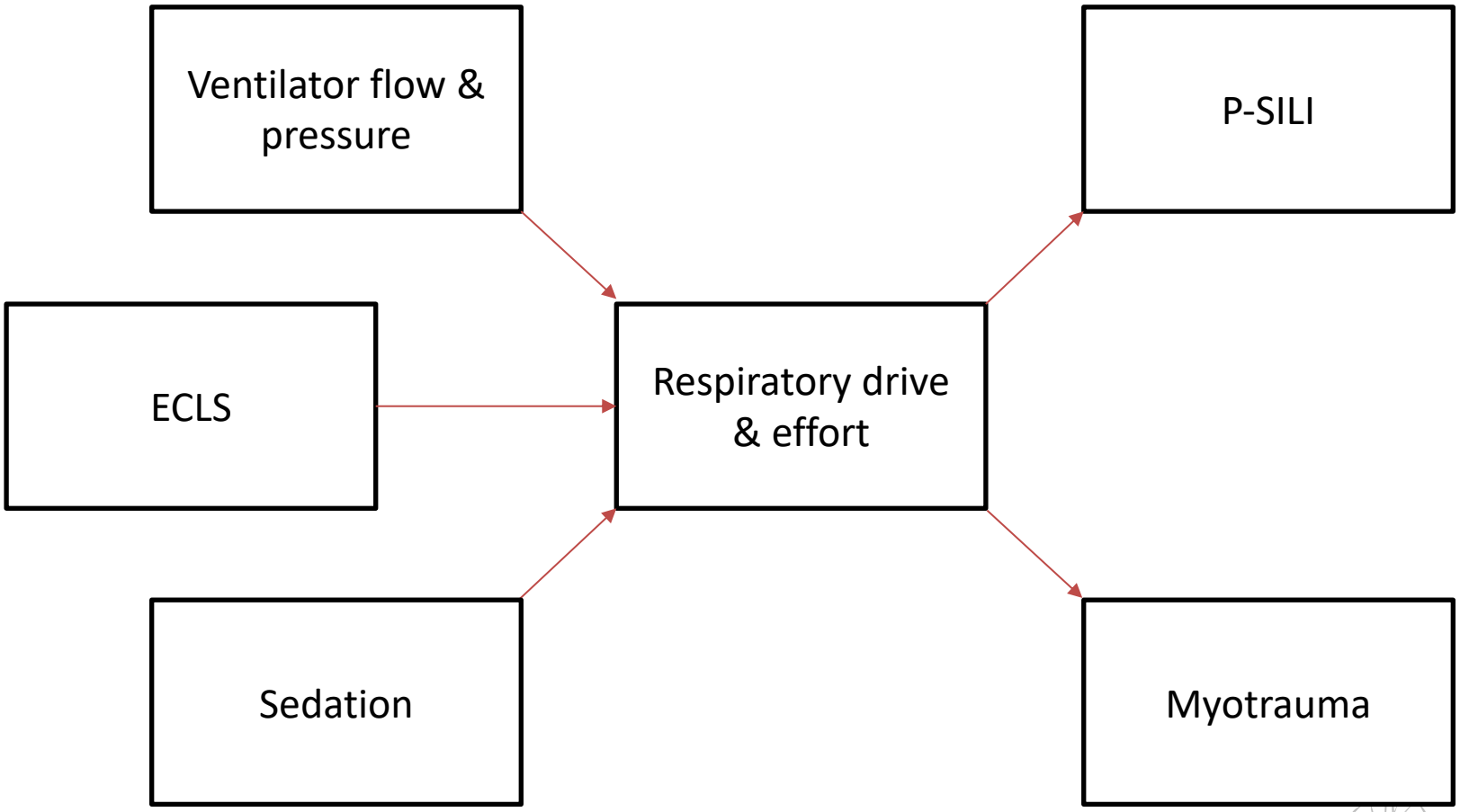

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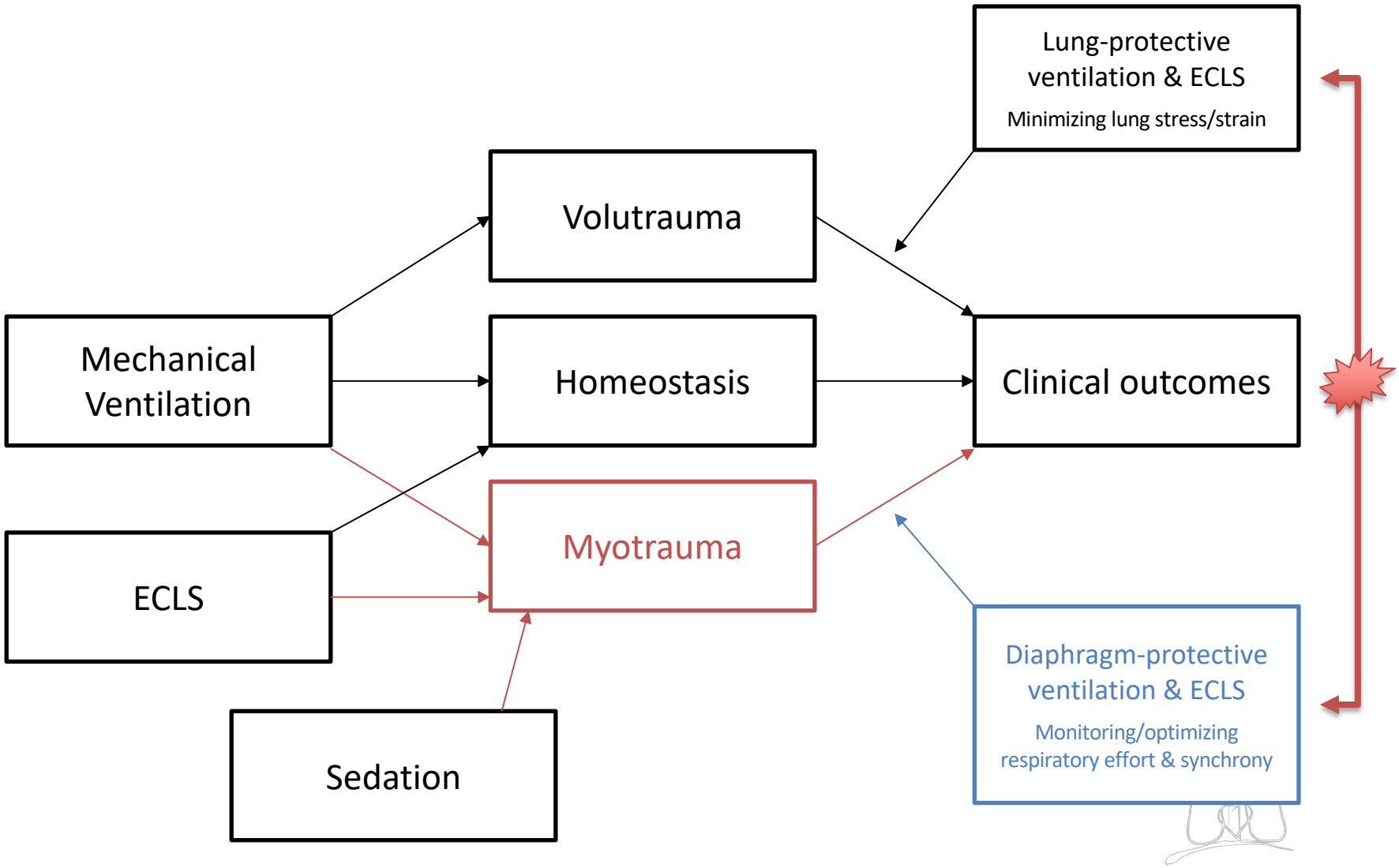

Questions?

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