Stimulation du diaphragme

CLÉMENT MEDRINAL
UNIVERSITÉ DE ROUEN
UR GRHVN 3830
SRLF 2025

No conflict of interest regarding this oral presentation

I declare the following COI:

Fullphysio academy
Asten Santé
SOS Oxygène
Air Liquide medical system

Réentrainement du diaphragme en réanimation?

NON!

CLÉMENT MEDRINAL
GROUPE HOSPITALIER DU HAVRE
SRLF 2024

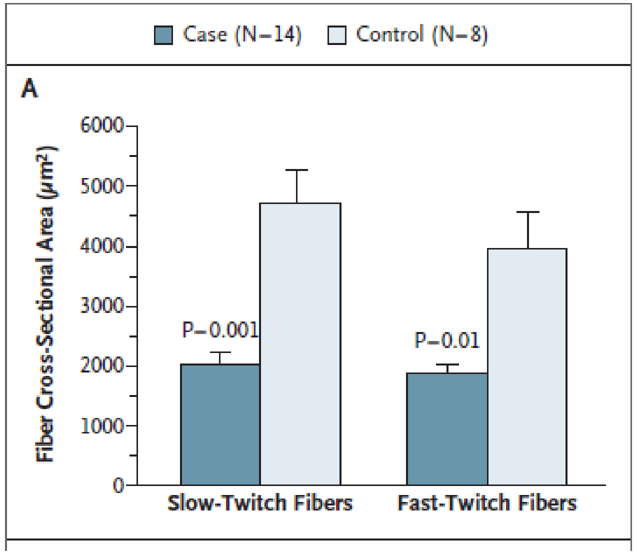
Critical illness weakness

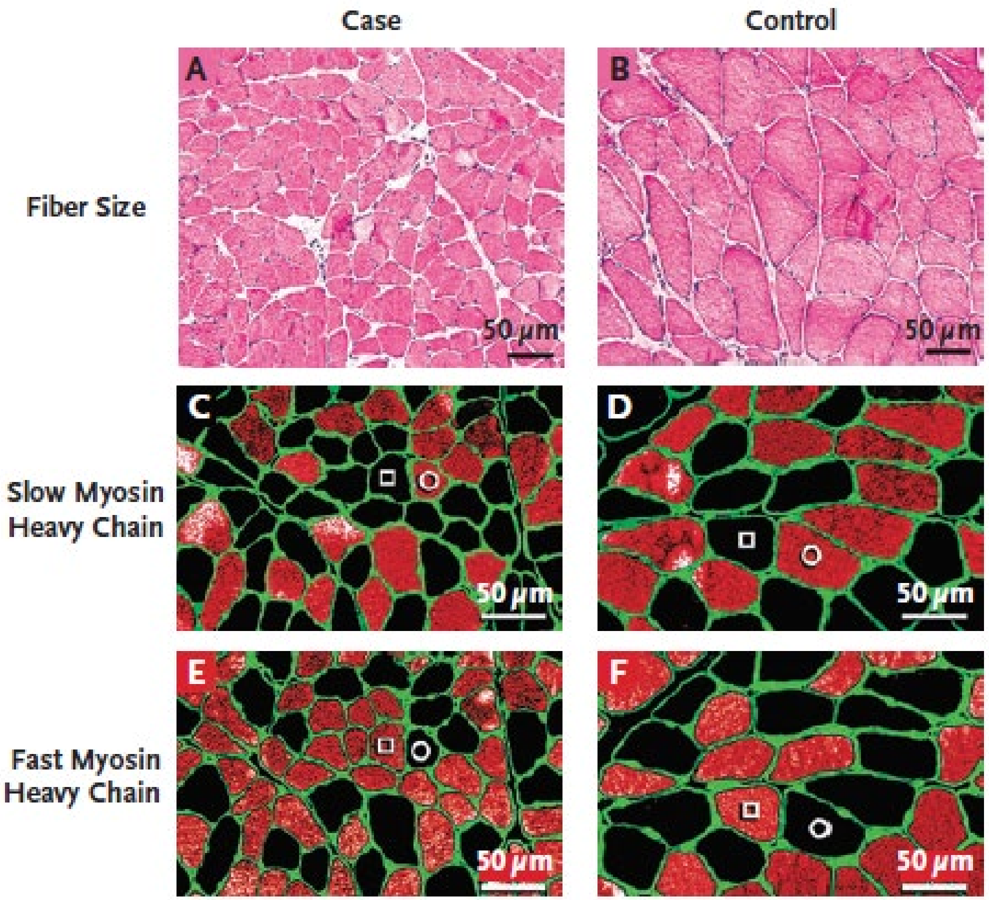
L’atteinte du diaphragme est ultra-précoce

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 27, 2008 VOL. 358 NO. 13

Rapid Disuse Atrophy of Diaphragm Fibers in Mechanically Ventilated Humans

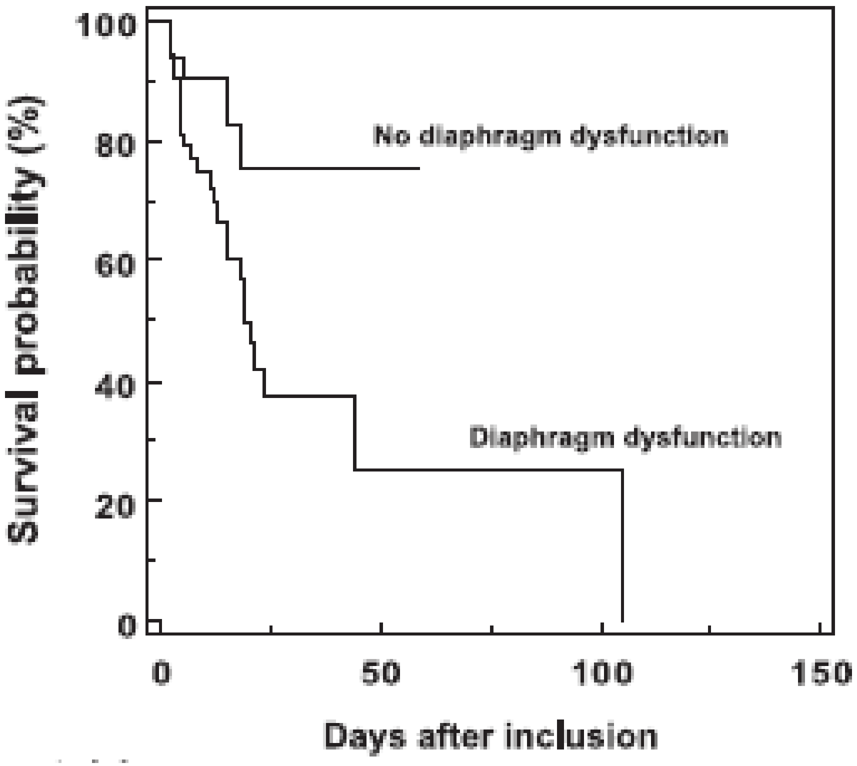




↘50% CSA Fibres I and II

Levine, NEJM, 2008

Associée à un mauvais pronostique

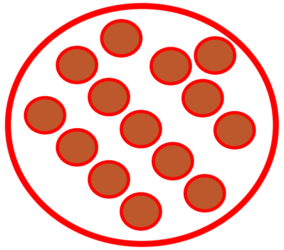


Demoule, Am J Respir Crit Care Med, 2013

2 mécanismes associés à la ventilation mécanique

L'atrophie musculaire

Diminution
de l'activité



La lésion musculaire

Activité
excessive

2 mécanismes pendant la réanimation

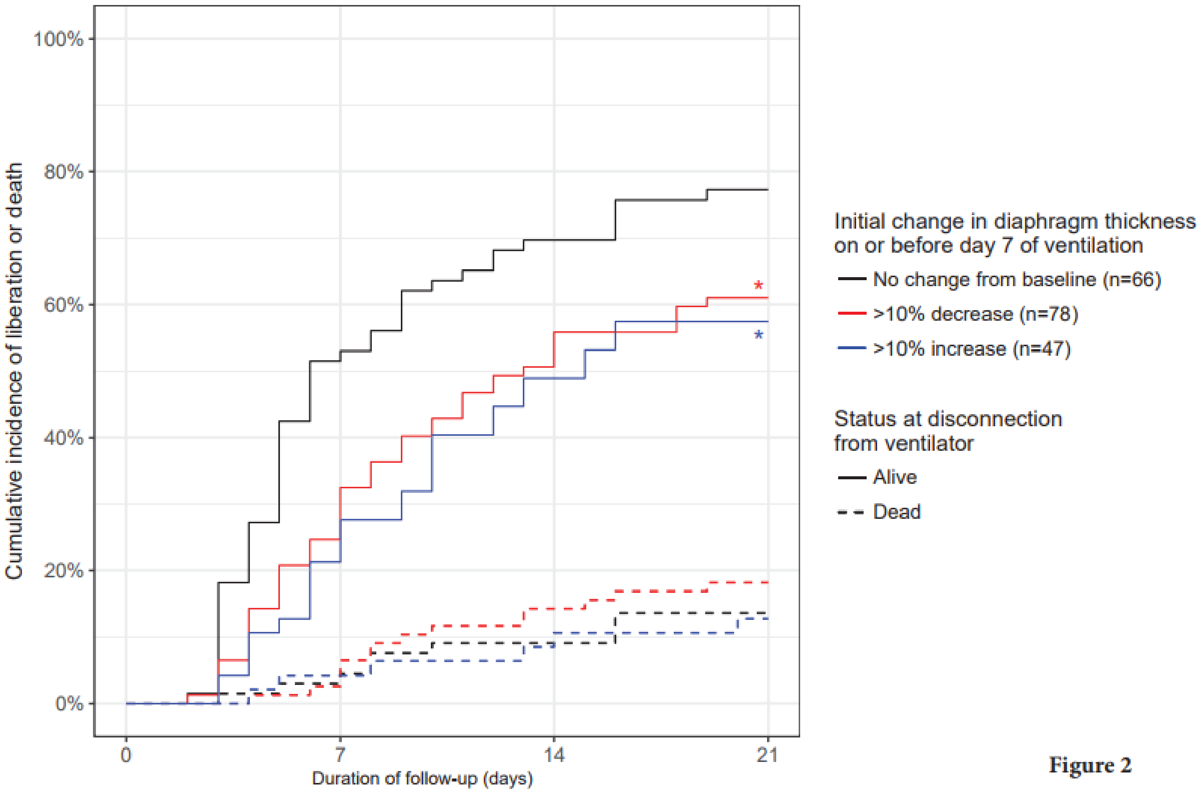
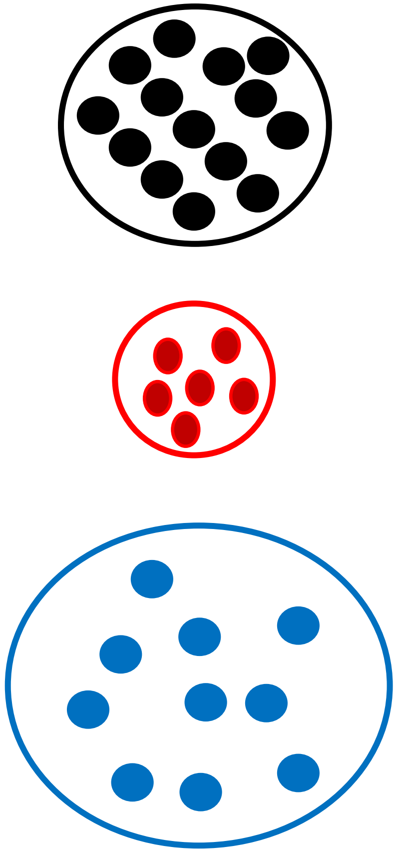


Figure 2



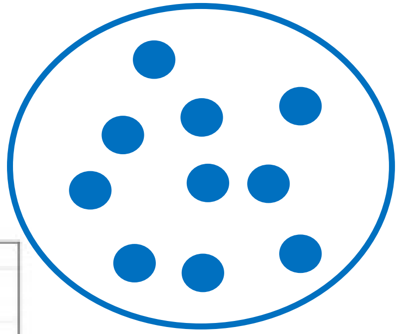
79% liberation from MV

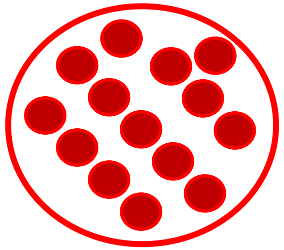
61% liberation from MV

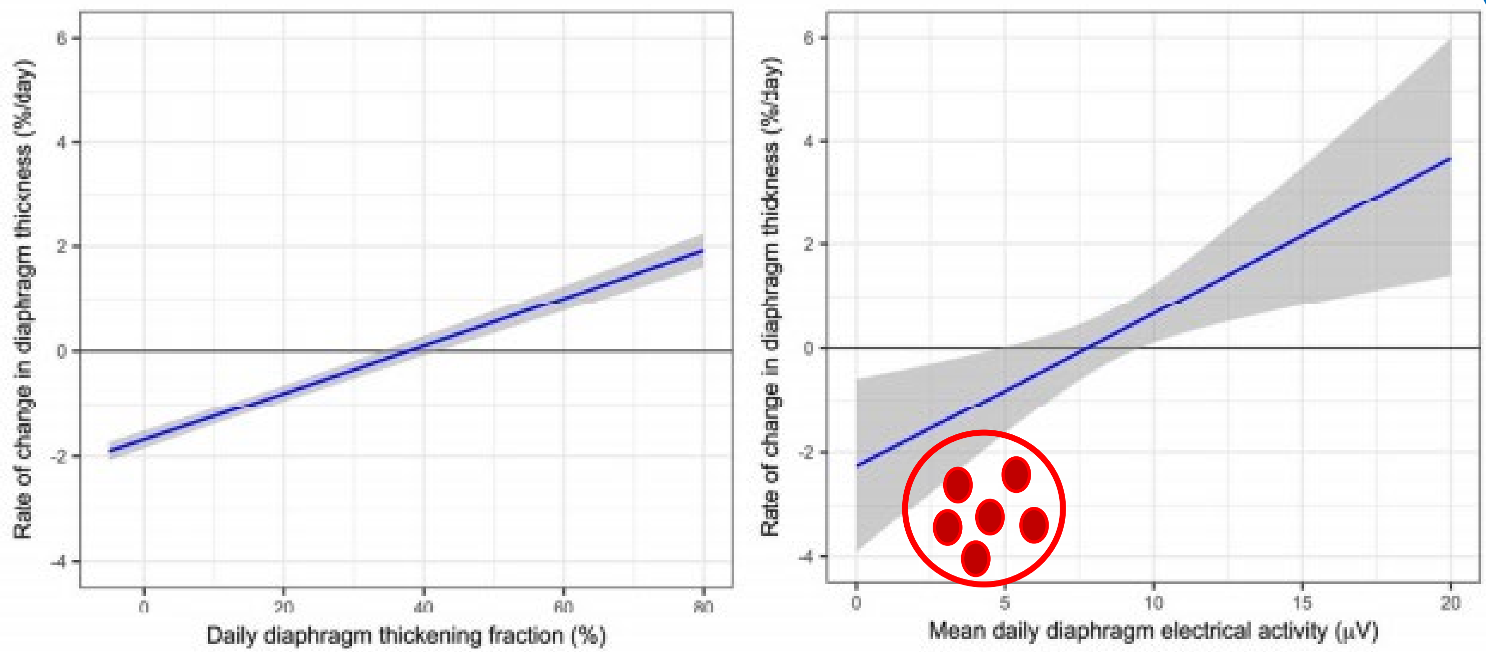
59% liberation from MV

Goligher, Am J Respir Crit Care Med, 2017

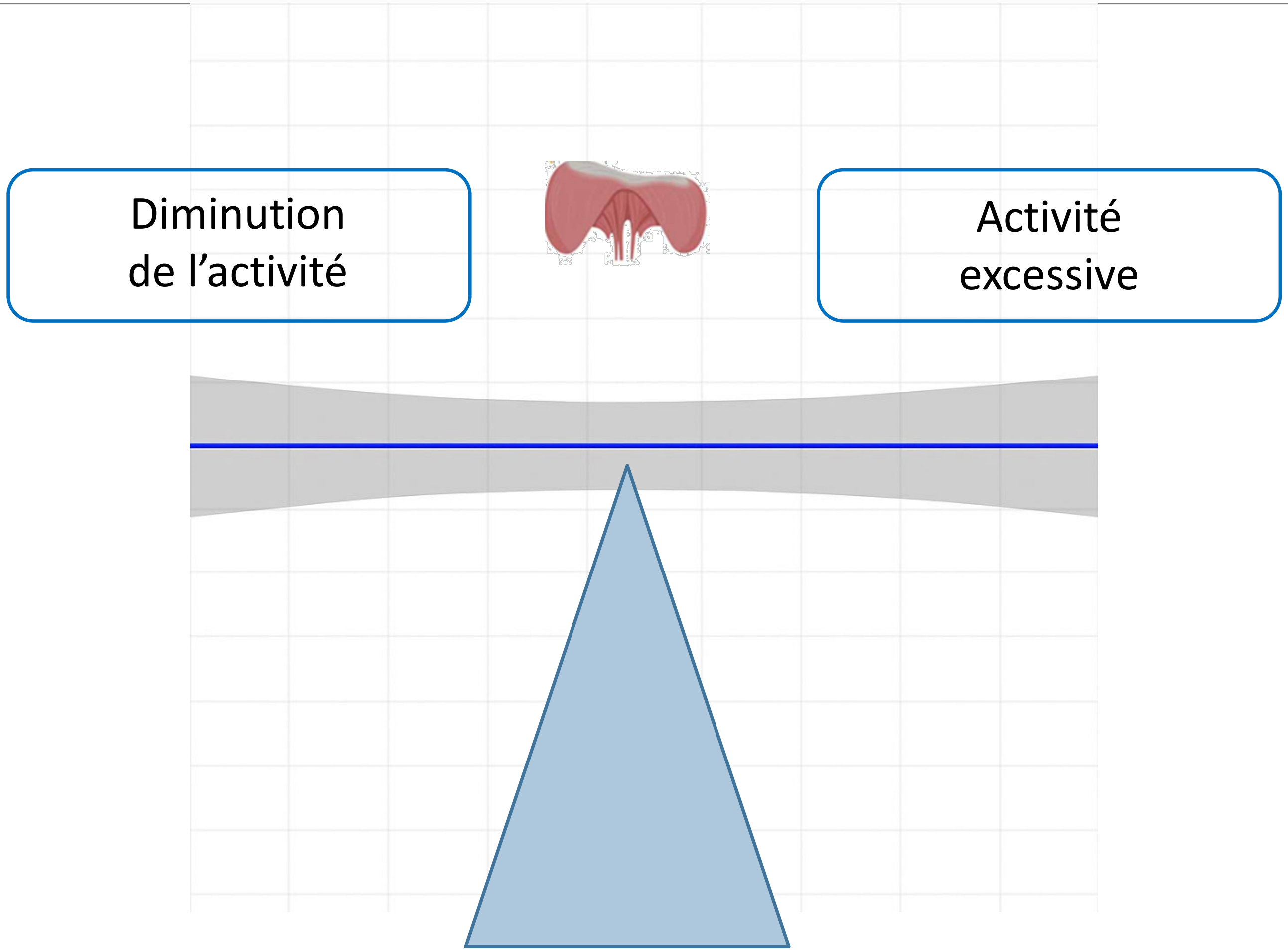
2 mécanismes pendant la réanimation







Idée: Maintenir une activité régulière!



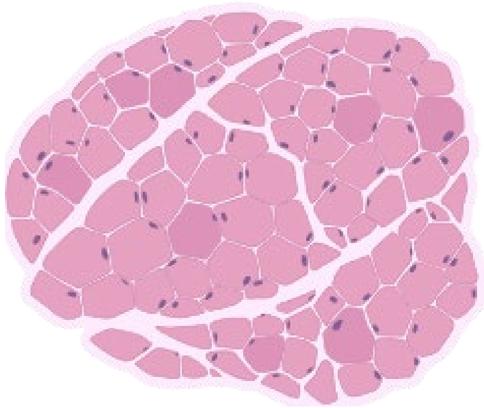
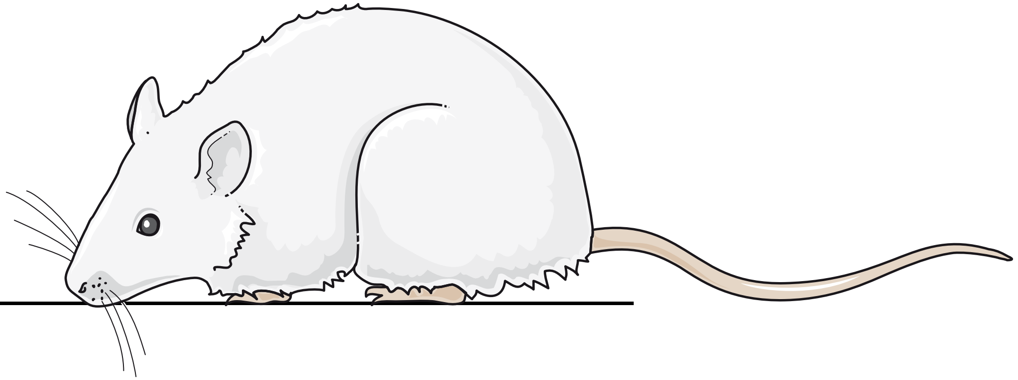
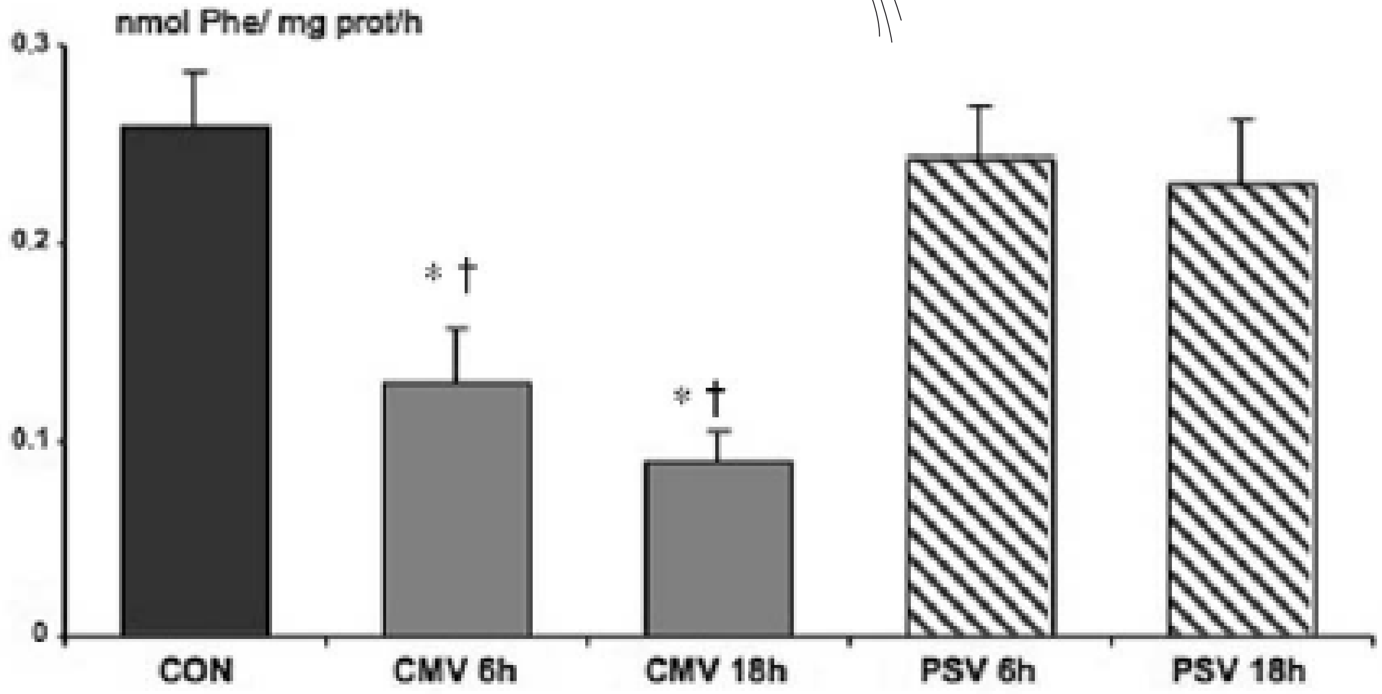


Figure 3





In vitro protein synthesis after 6 and 18 hours of controlled mechanical ventilation (CMV) and pressure support ventilation (PSV).

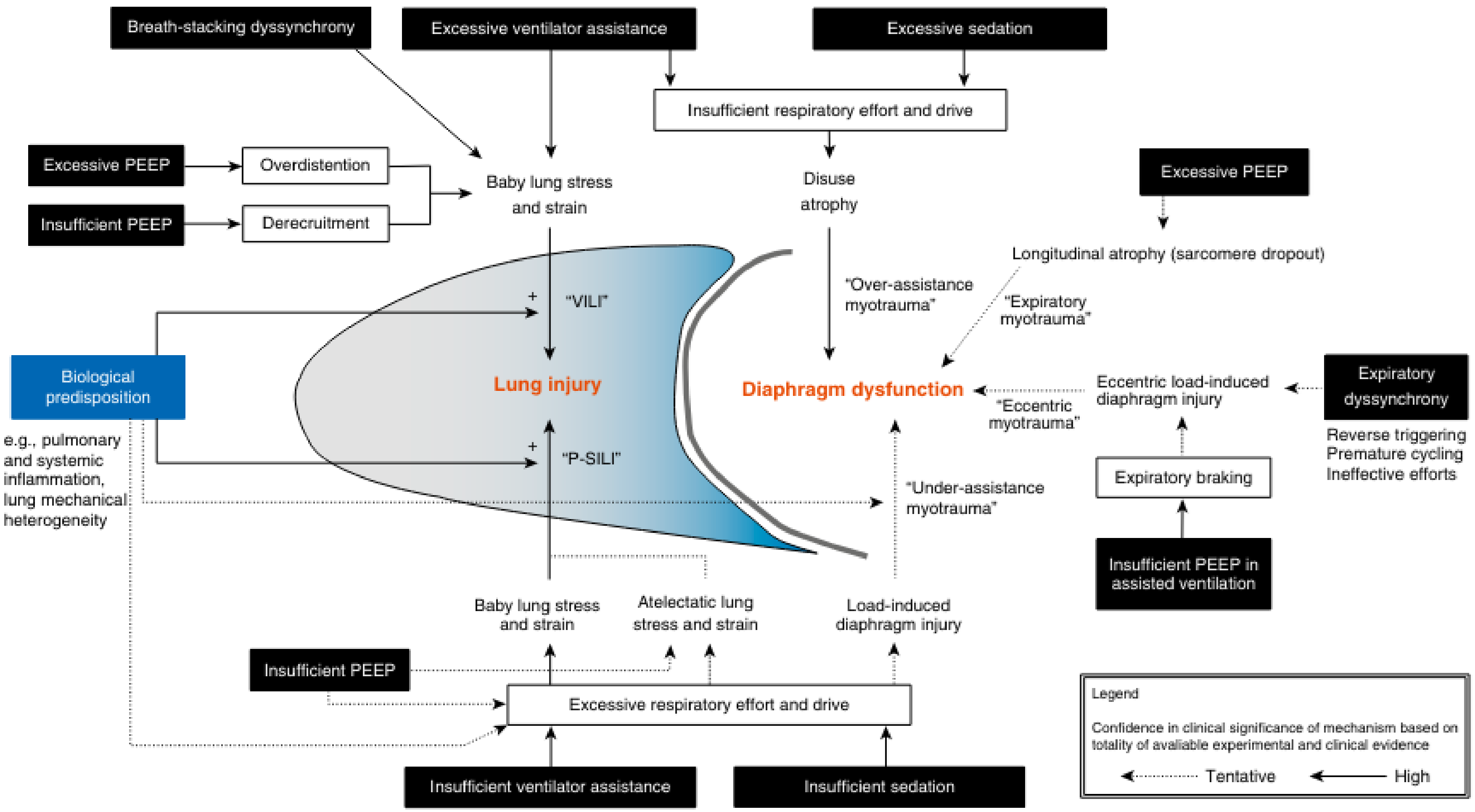
Futier, Crit Care, 2007

Check for updates

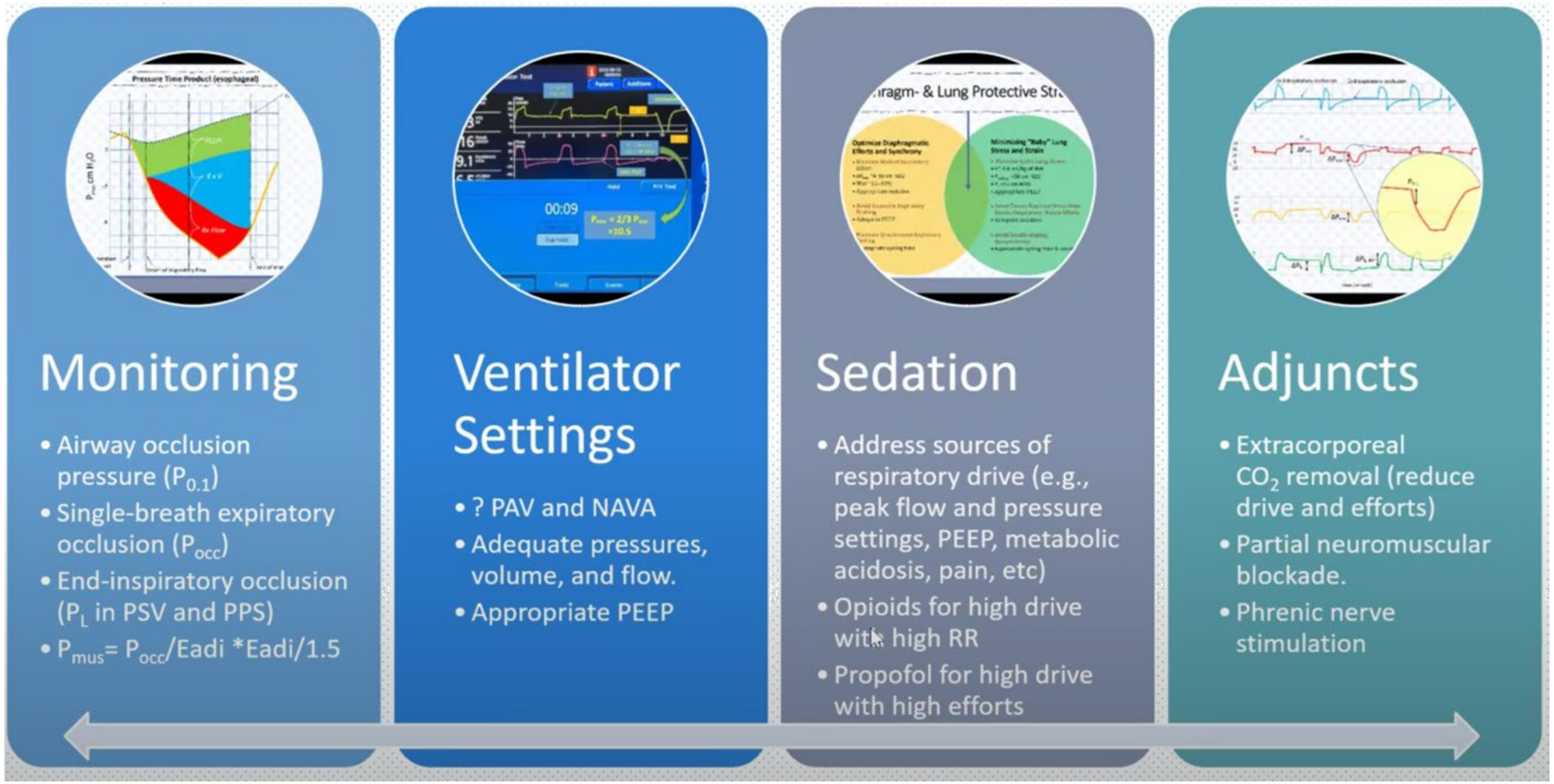
CRITICAL CARE PERSPECTIVE

Maintenir la contraction du diaphragme

Lung- and Diaphragm-Protective Ventilation



Implémentation



CRITICAL CARE PERSPECTIVE

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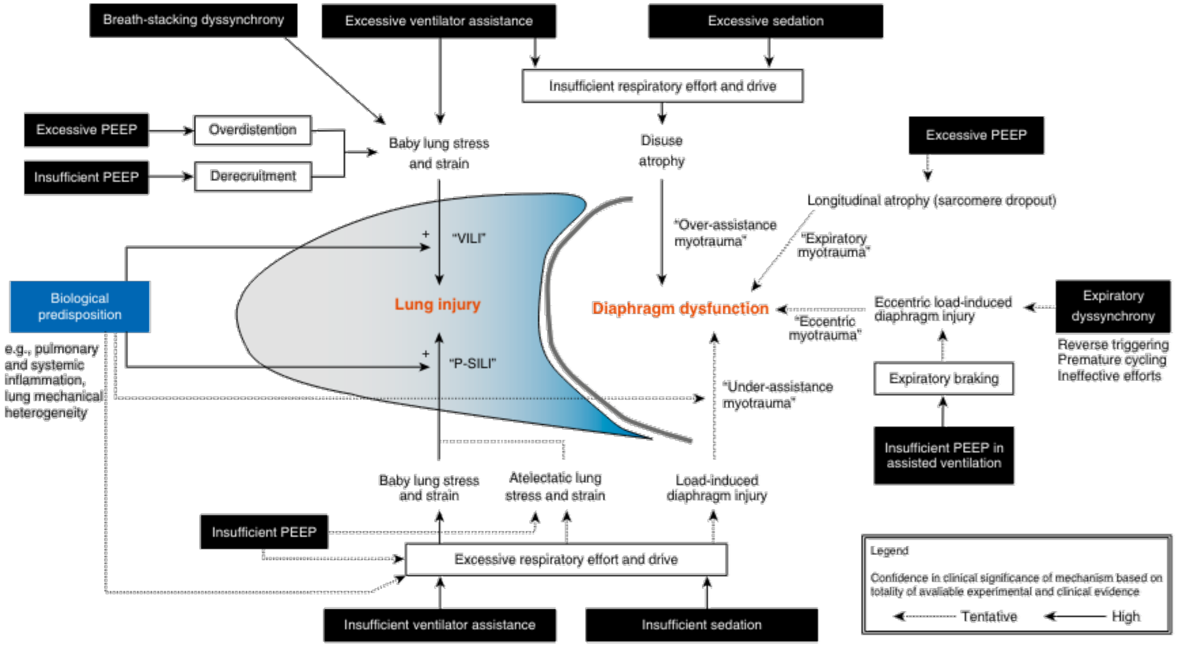


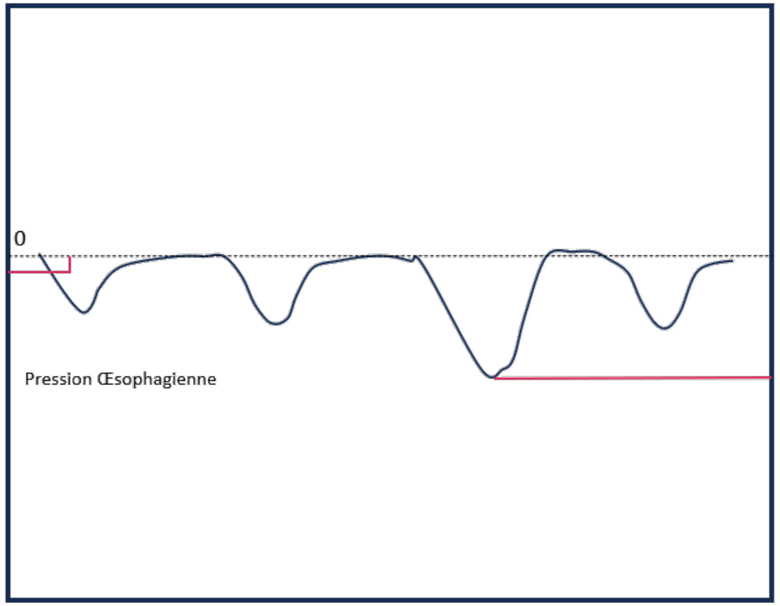
Table 3. Potential Therapeutic Targets for Diaphragm Protection

Goal	Potential Therapeutic Target*
Prevent overassistance myotrauma	Any 1 of: Pmus $\geqslant$ 3 to 5 cm H_2O ΔPdi $\geqslant$ 3 to 5 cm H_2O ΔPes $\leqslant$ −3 to −2 cm H_2O $P_{0.1}$ > 1 to 1.5 cm H_2O TFdi $\geqslant$ 15% EAdi $\geqslant$ target value selected on the basis of Pocc-EAdi index and above targets
Prevent underassistance myotrauma	Any 1 of: Pmus $\leqslant$ 10 to 15 cm H_2O ΔPdi $\leqslant$ 10 to 15 cm H_2O ΔPes $\geqslant$ −12 to −8 cm H_2O Pocc $\geqslant$ −20 to −15 cm H_2O $P_{0.1}$ < 3.5 to 5 cm H_2O TFdi $\leqslant$ 30% to 40% EAdi $\leqslant$ limit value selected on the basis of Pocc-EAdi index and above targets
Prevent eccentric myotrauma	Avoid ineffective triggering and reverse triggering Avoid premature cycling Minimize expiratory braking

Goligher, Am J Respir Crit Care Med, 2020

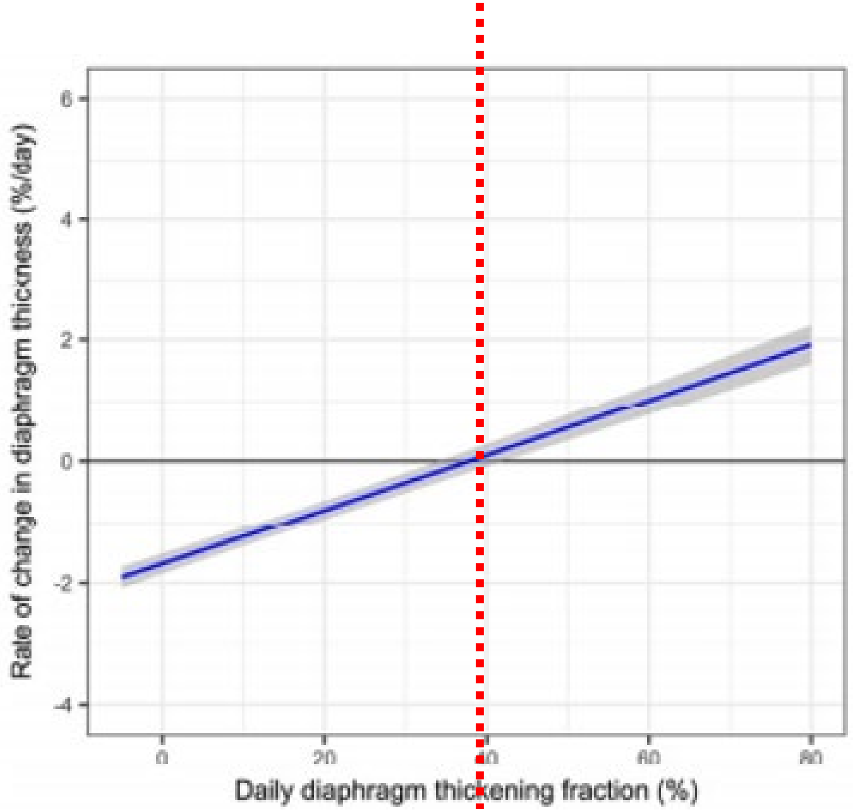
P01

Pression 0.1
Pression occlusion à 100 ms

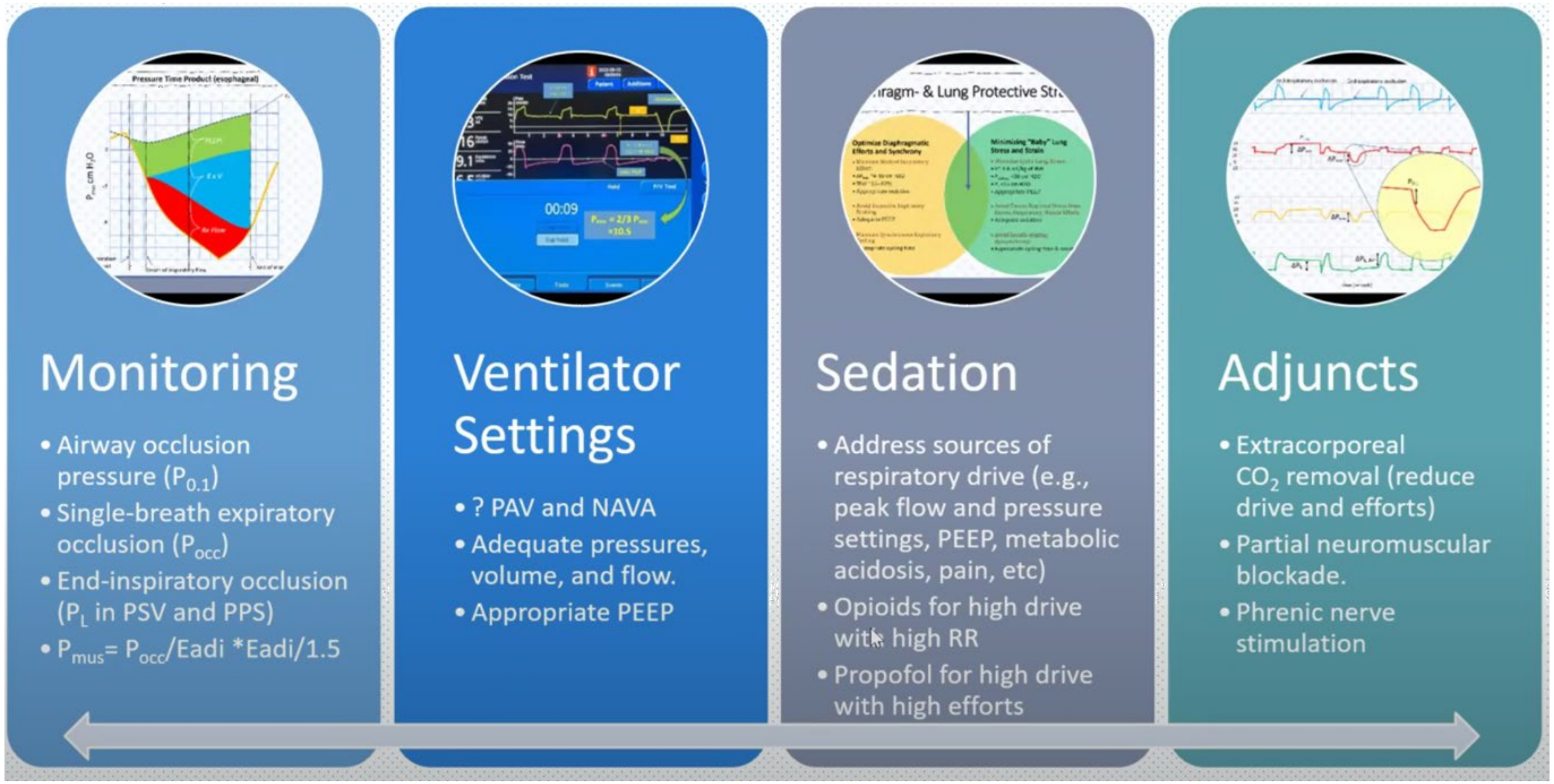


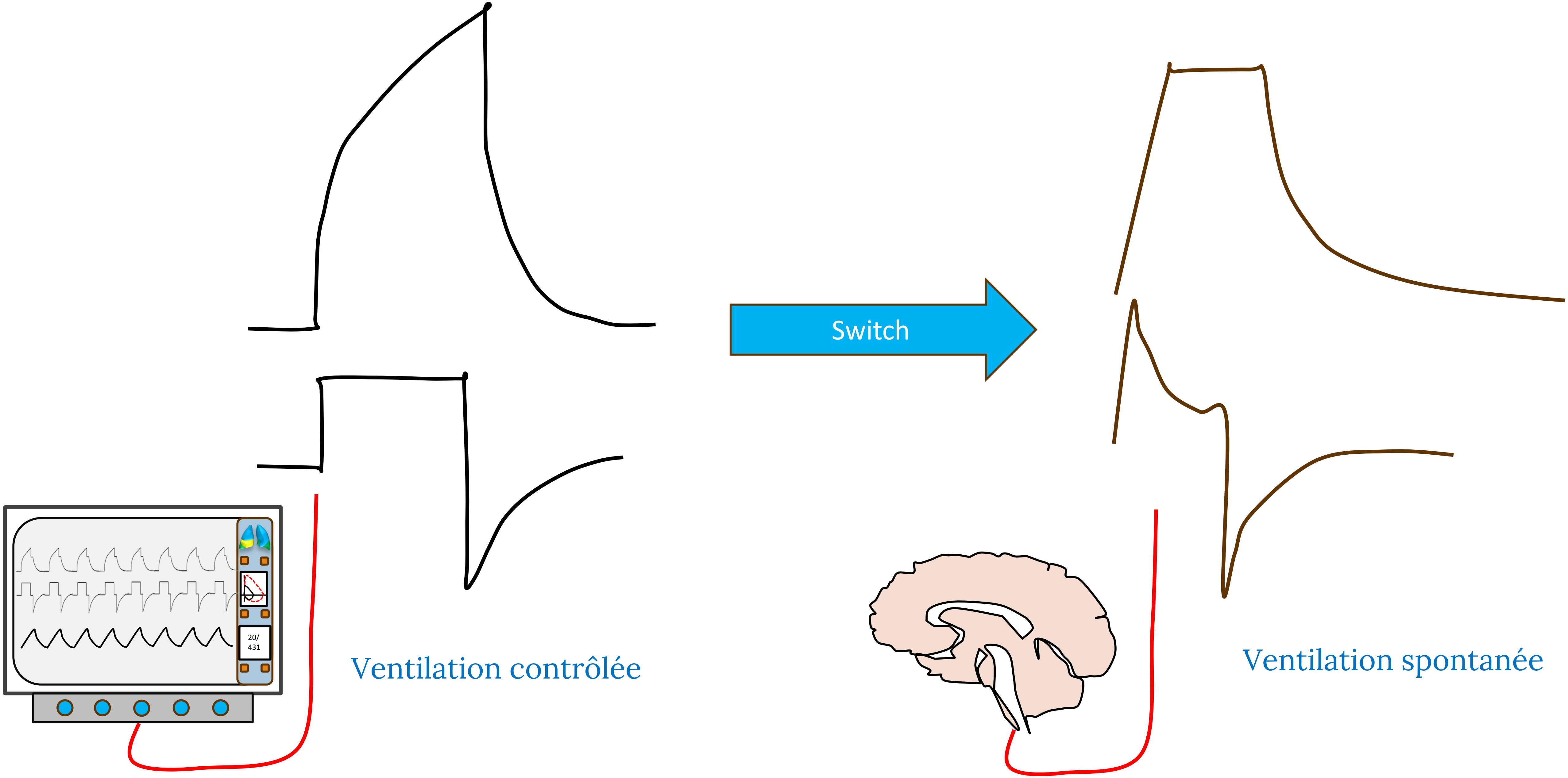
Pimax

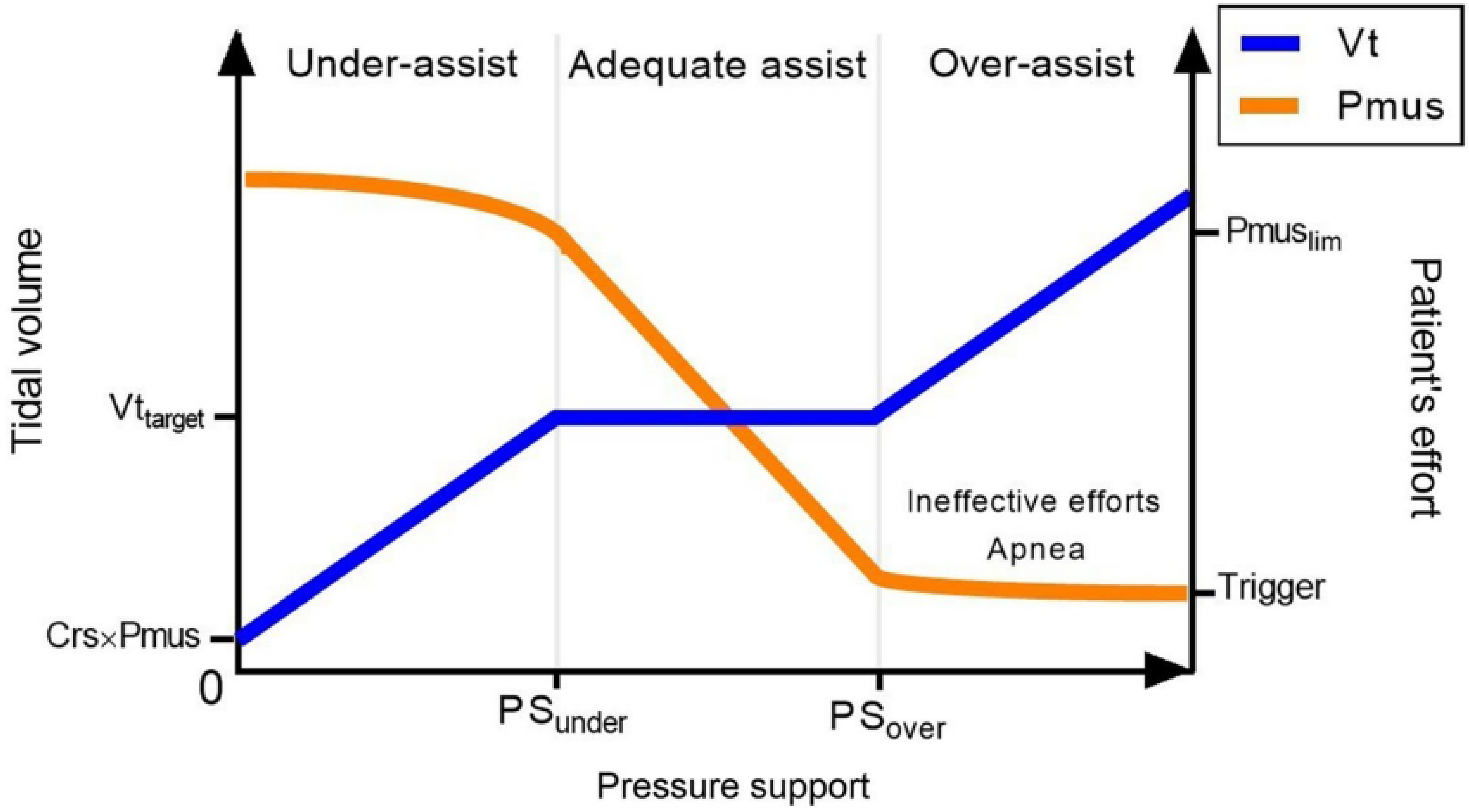
TFdi



Implémentation




20/
431
Switch
Ventilation contrôlée
Ventilation spontanée



Docci, Crit Care, 2024

› Am J Respir Crit Care Med. 2025 Jan 21. doi: 10.1164/rccm.202406-1162OC. Online ahead of print.

Early vs. Delayed Switching from Controlled to Assisted Ventilation: A Target Trial Emulation

Carmen A T Reep [1], Evert-Jan Wils [2], Lucas M Fleuren [1], Alexander Breskin [3, 4], Giacomo Bellani [5, 6], John G Laffey [7], Laurent J Brochard [8, 9], Tài Pham [10], Leo Heunks [11]; WEAN SAFE investigators

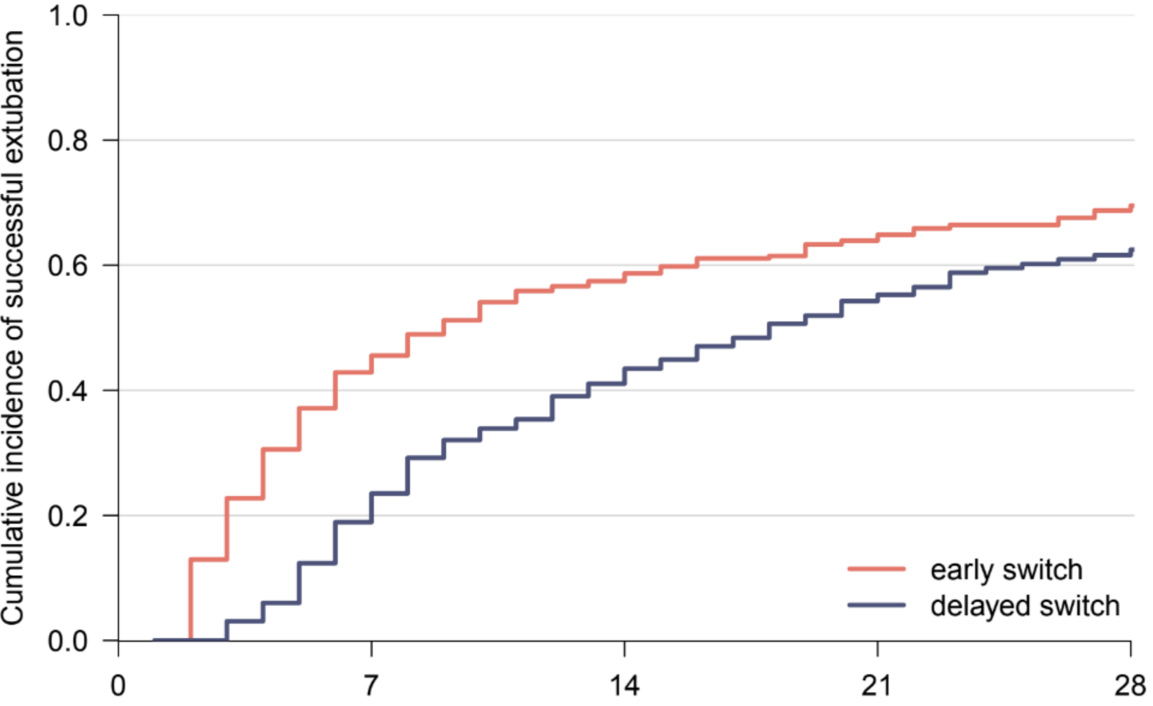
Pas de curares-PaO2/FiO2>150

Extubation 4j plus tôt

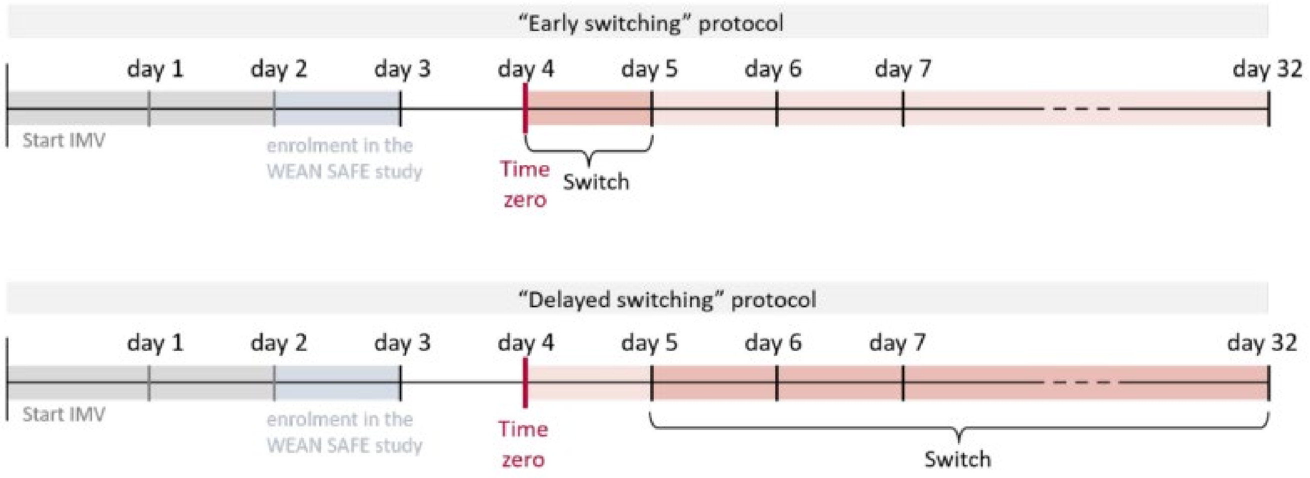
11% de plus de sortie de réanimation

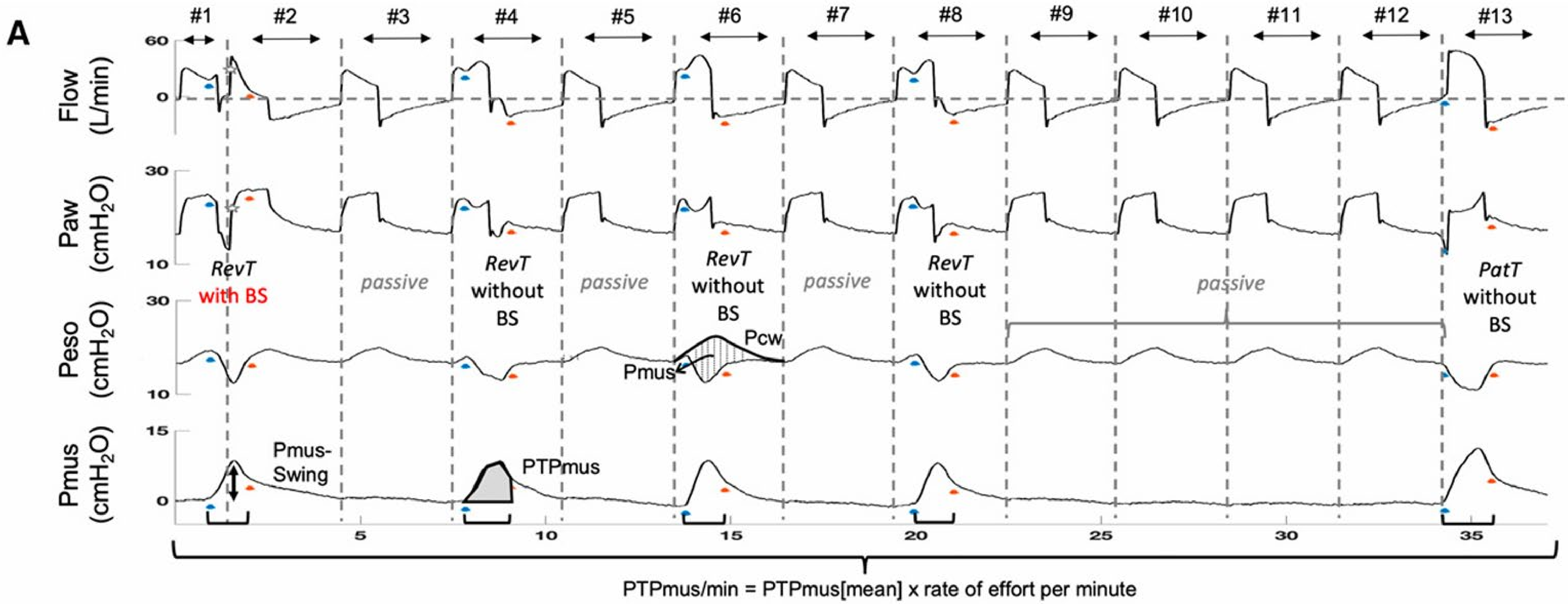
7% de plus d'extubation

7 j de moins en réanimation

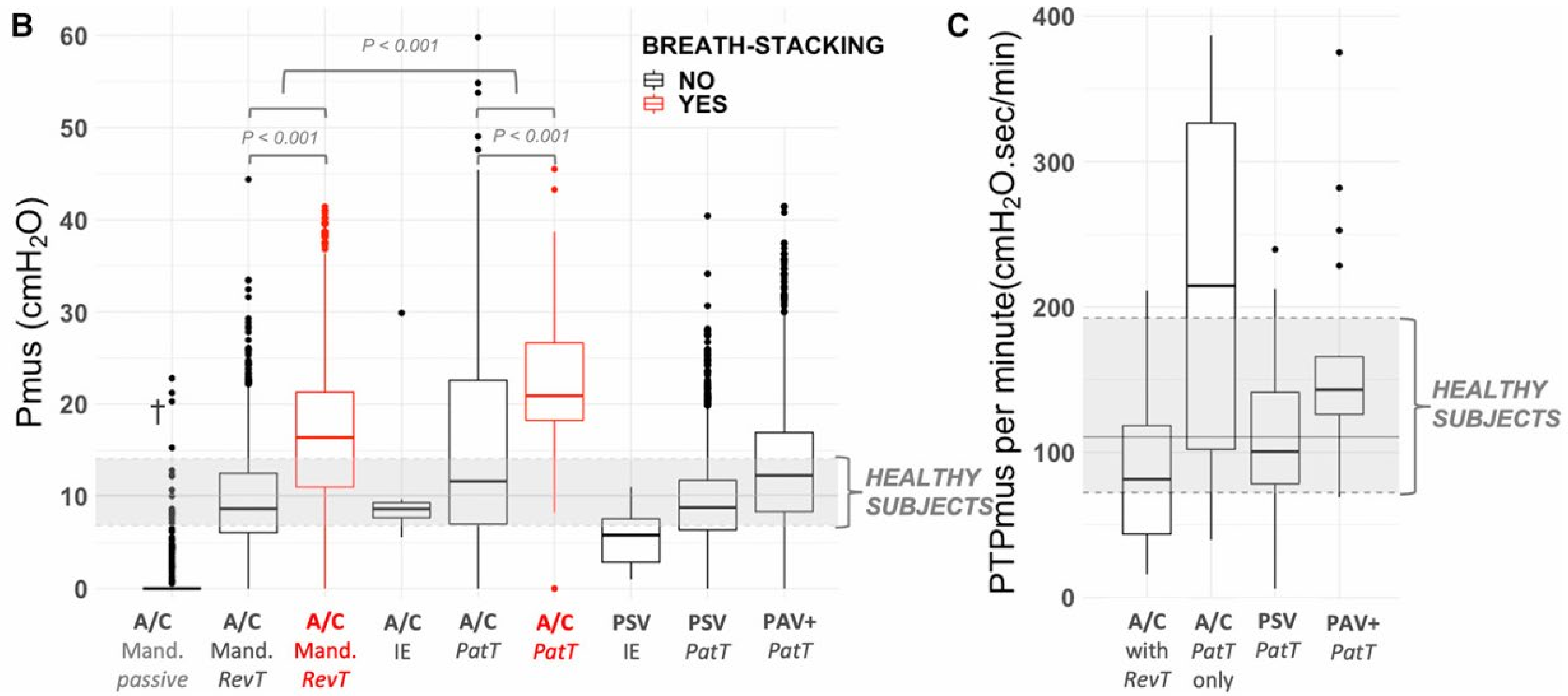


A. The two treatment protocols



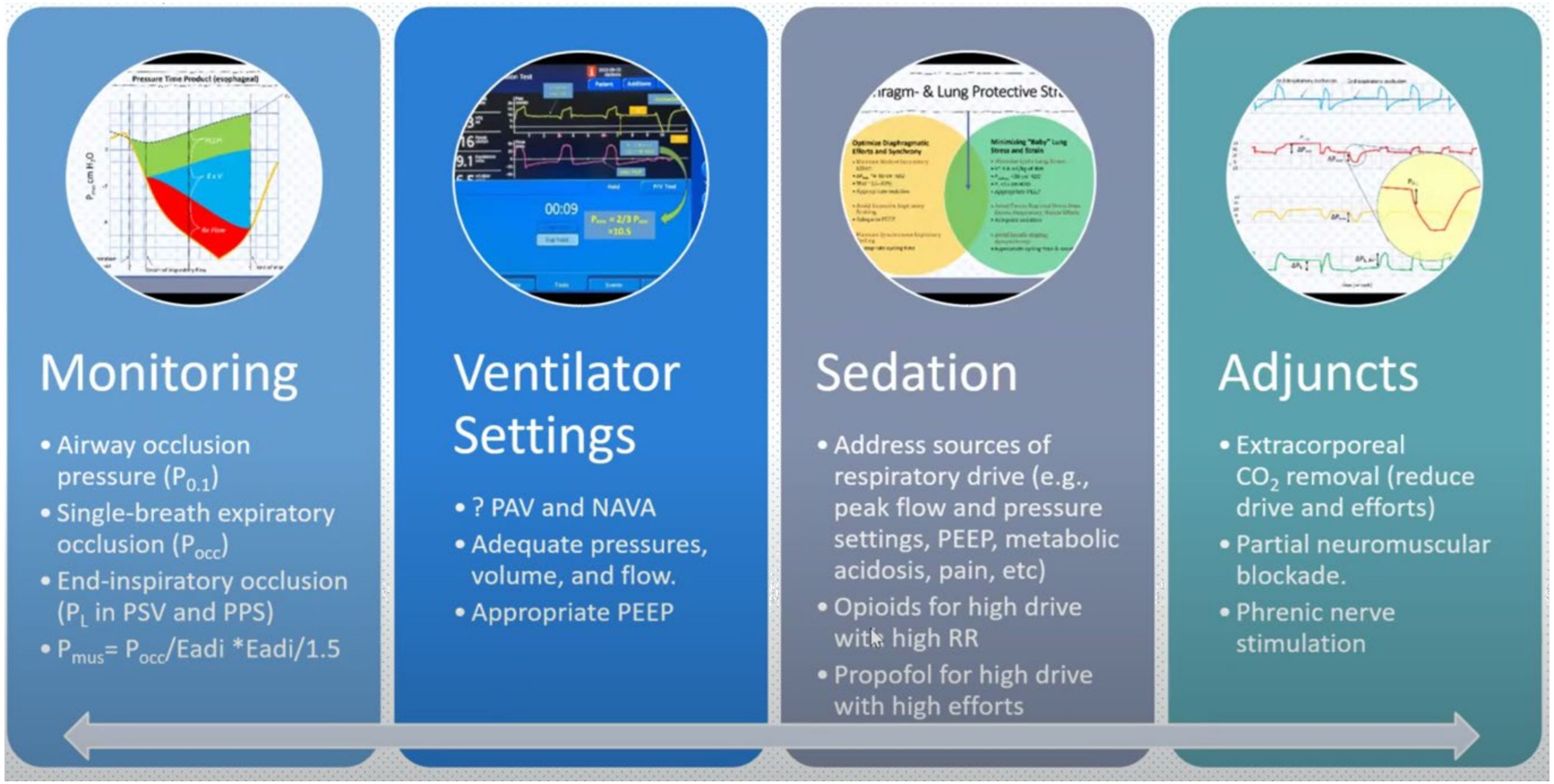


Telias, Am J Respir Crit Care Med, 2023

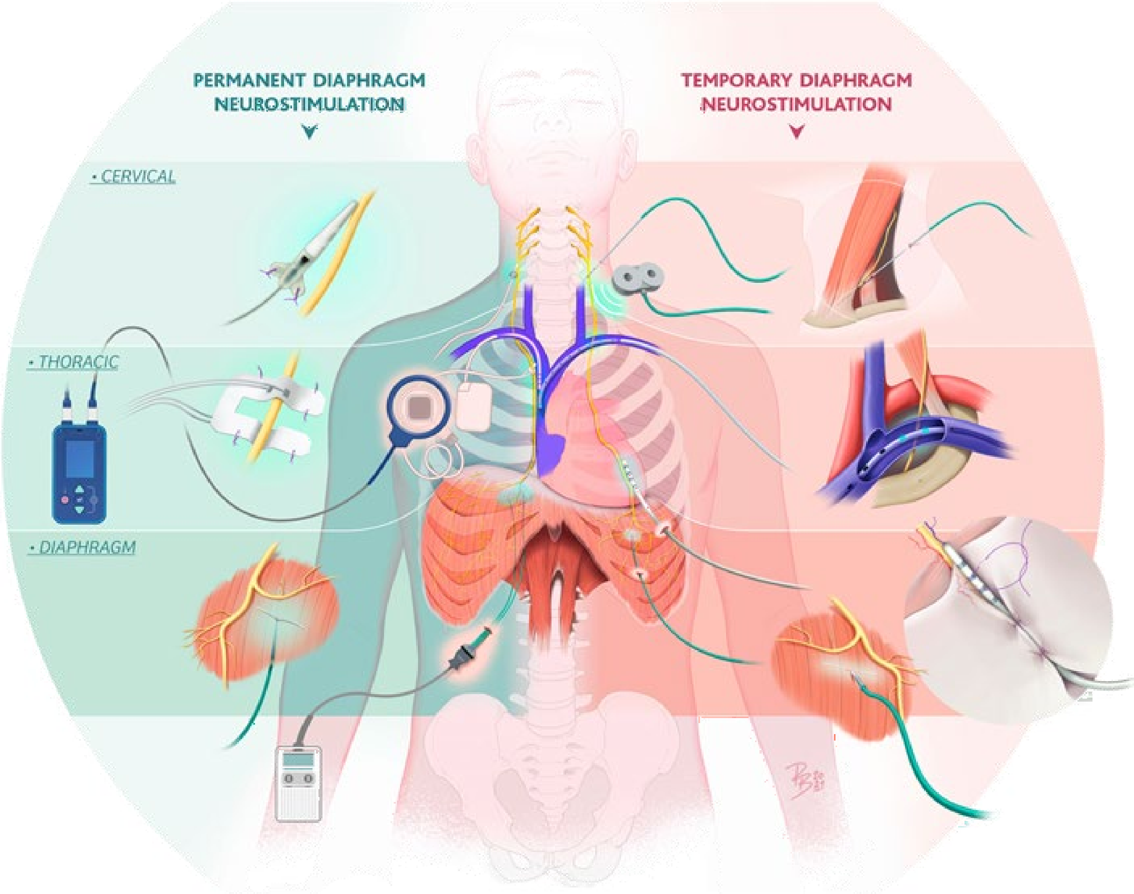


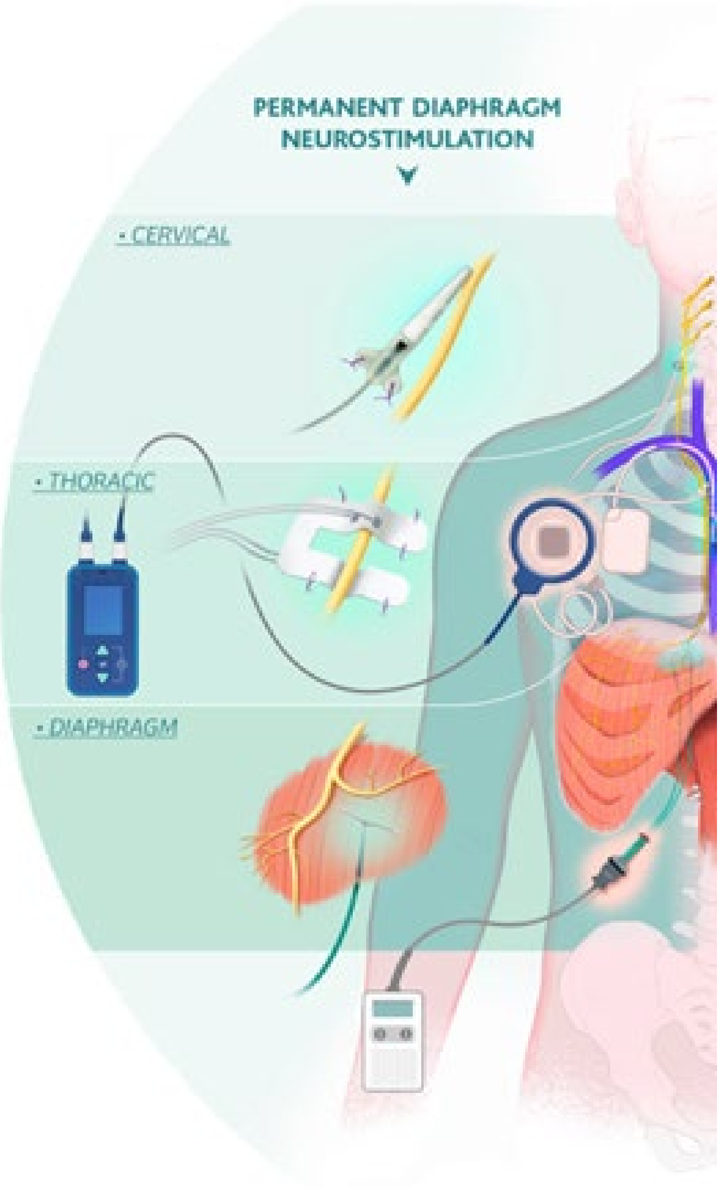
Telias, Am J Respir Crit Care Med, 2023

Implémentation



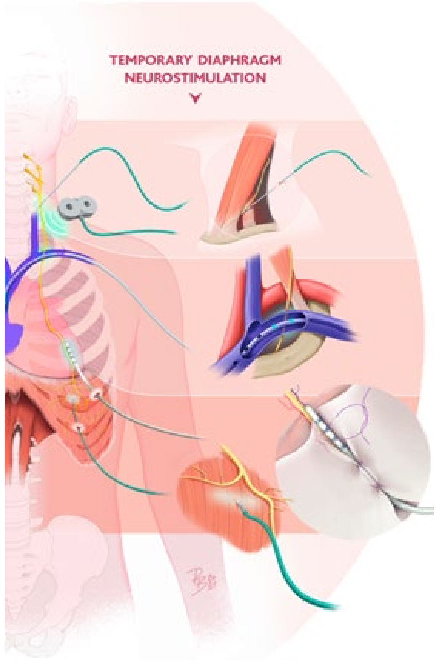
Stimulation du diaphragme

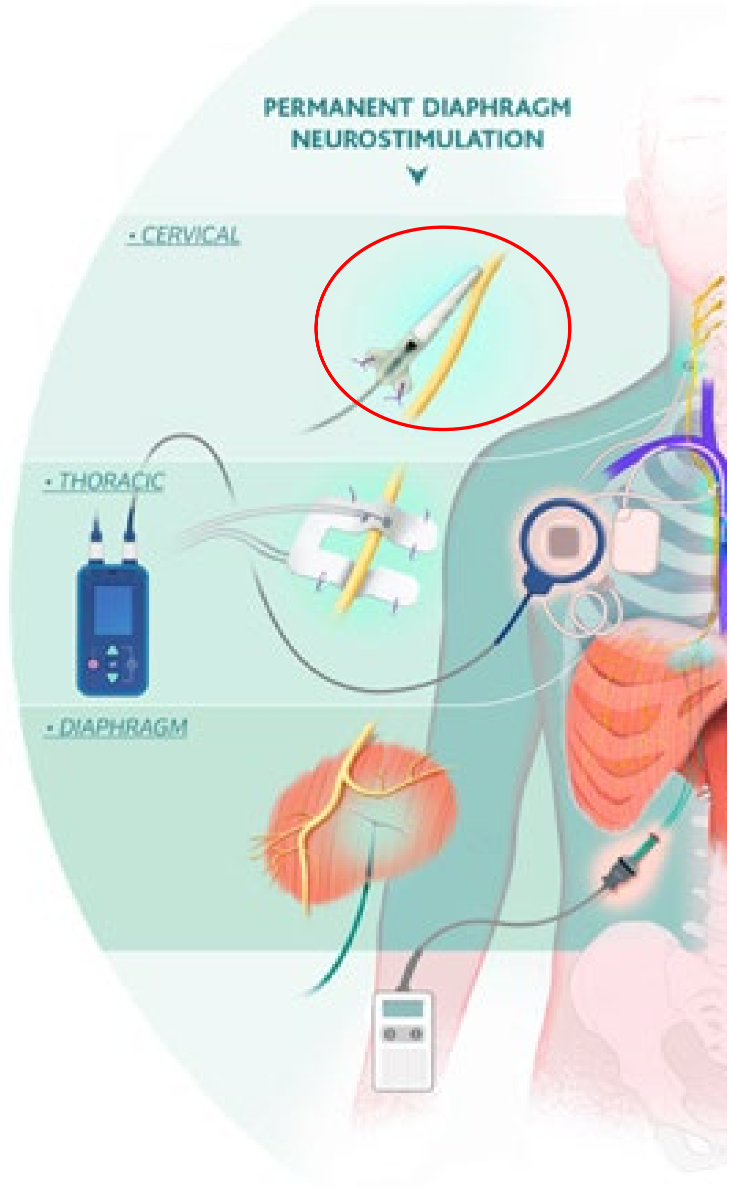




Voies chirurgicales

Cervicale ouverte
Cervicale percutanée
Transthoracique
Laparoscopique intramusculaire





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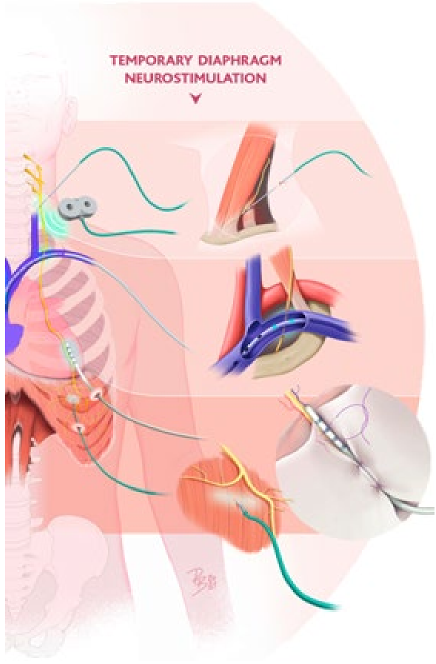

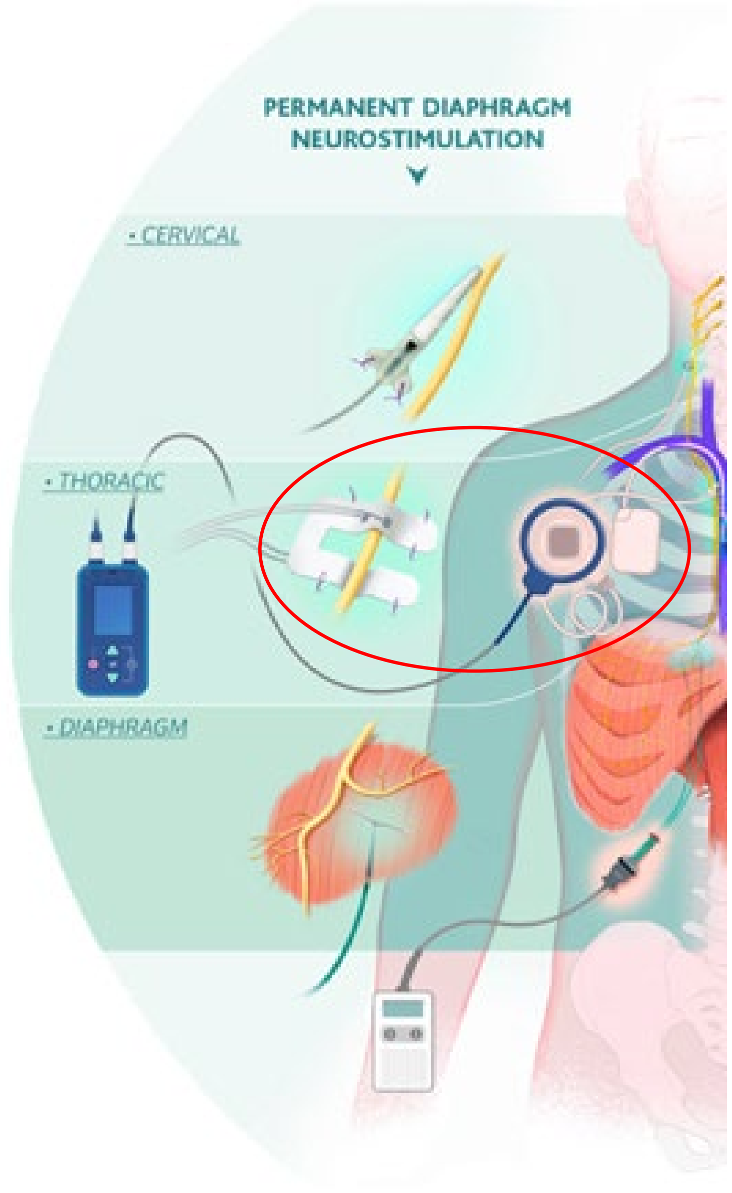

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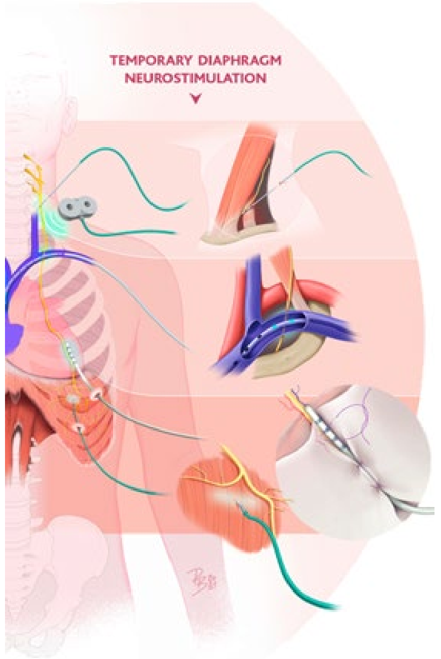

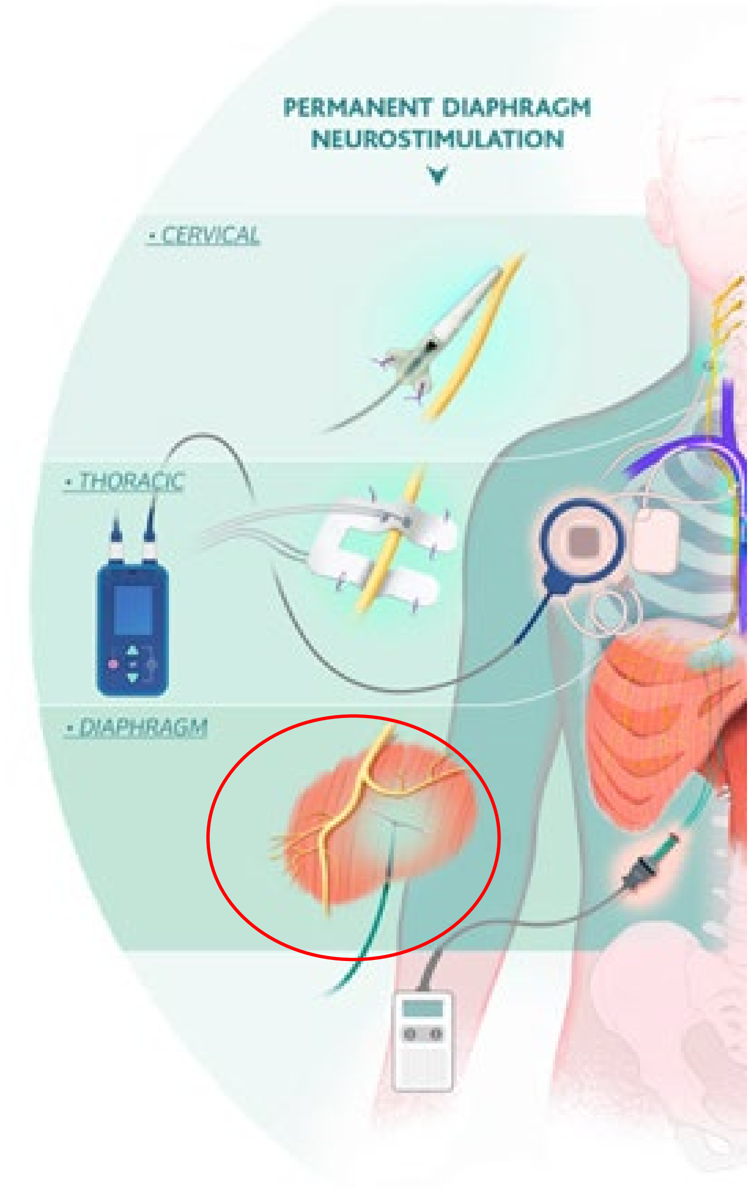

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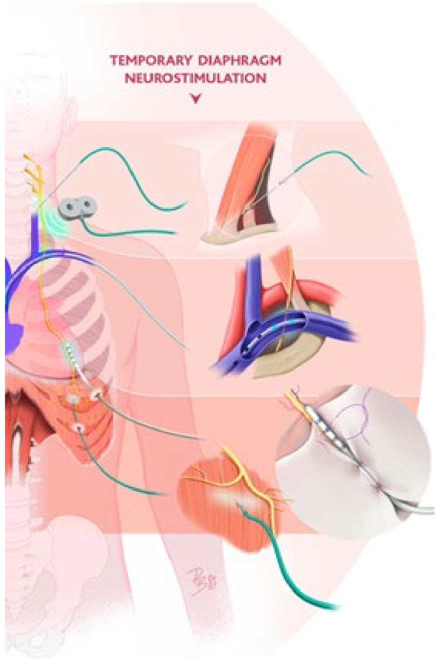
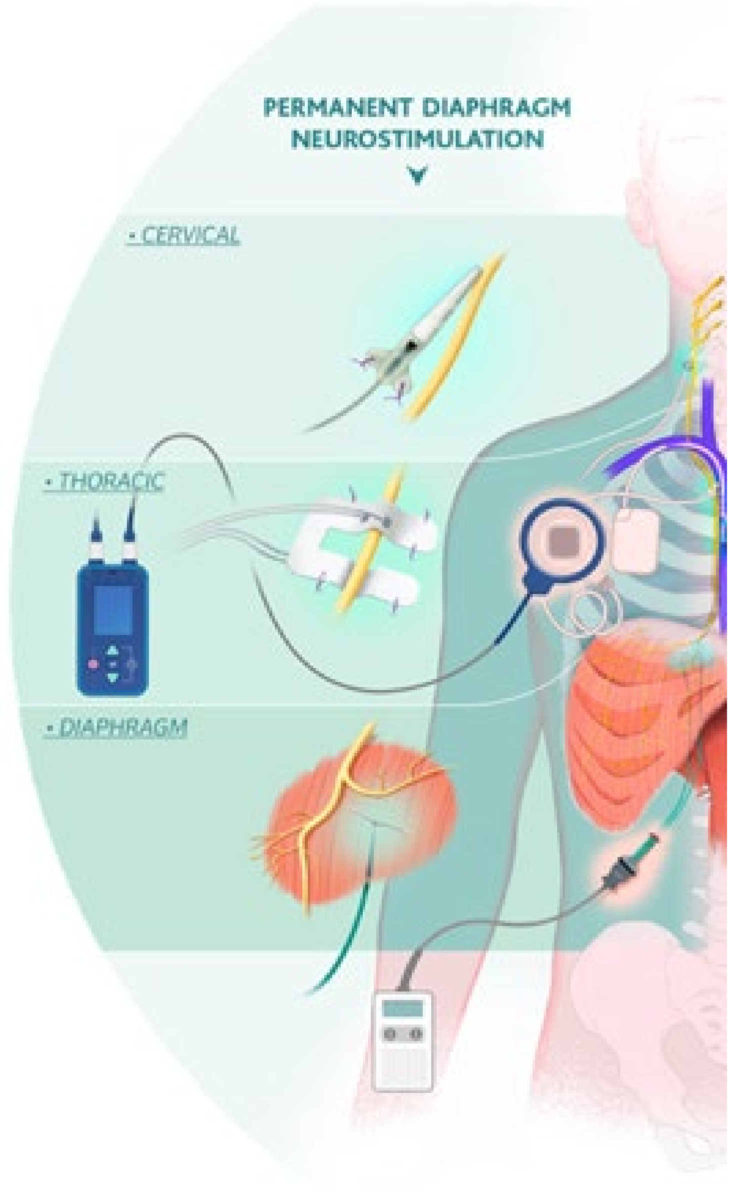


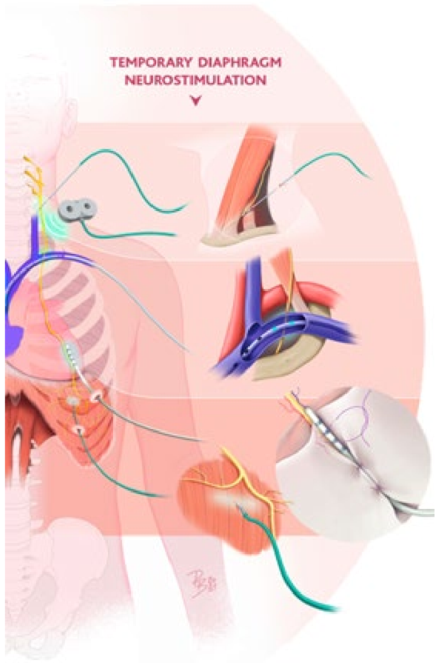


Voies chirurgicales

Cervicale ouverte
Cervicale percutanée
Transthoracique
Laparoscopique intramusculaire

Tétraplégiques, syndrome d’hypoventilation centrale (> 300 patients depuis les années 1970)

Pas de déploiement en aigu

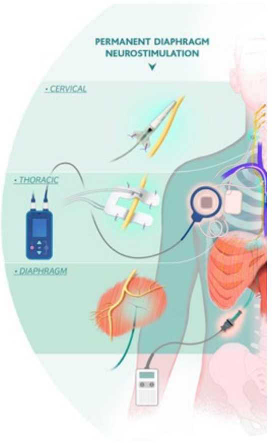


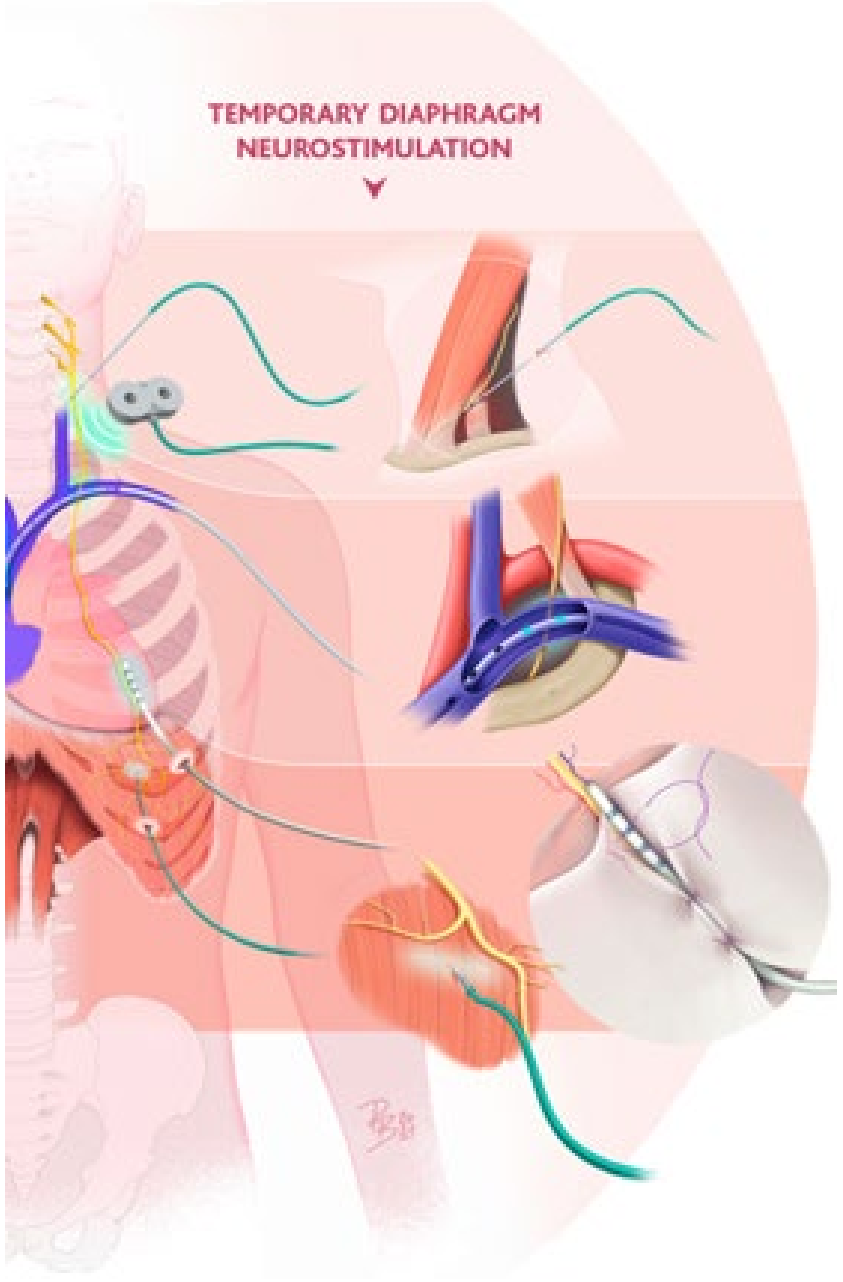
Transveineux électrique temporaire

Stimulation magnétique répétée

Électrique cervicale percutanée

Electrodes temporaires





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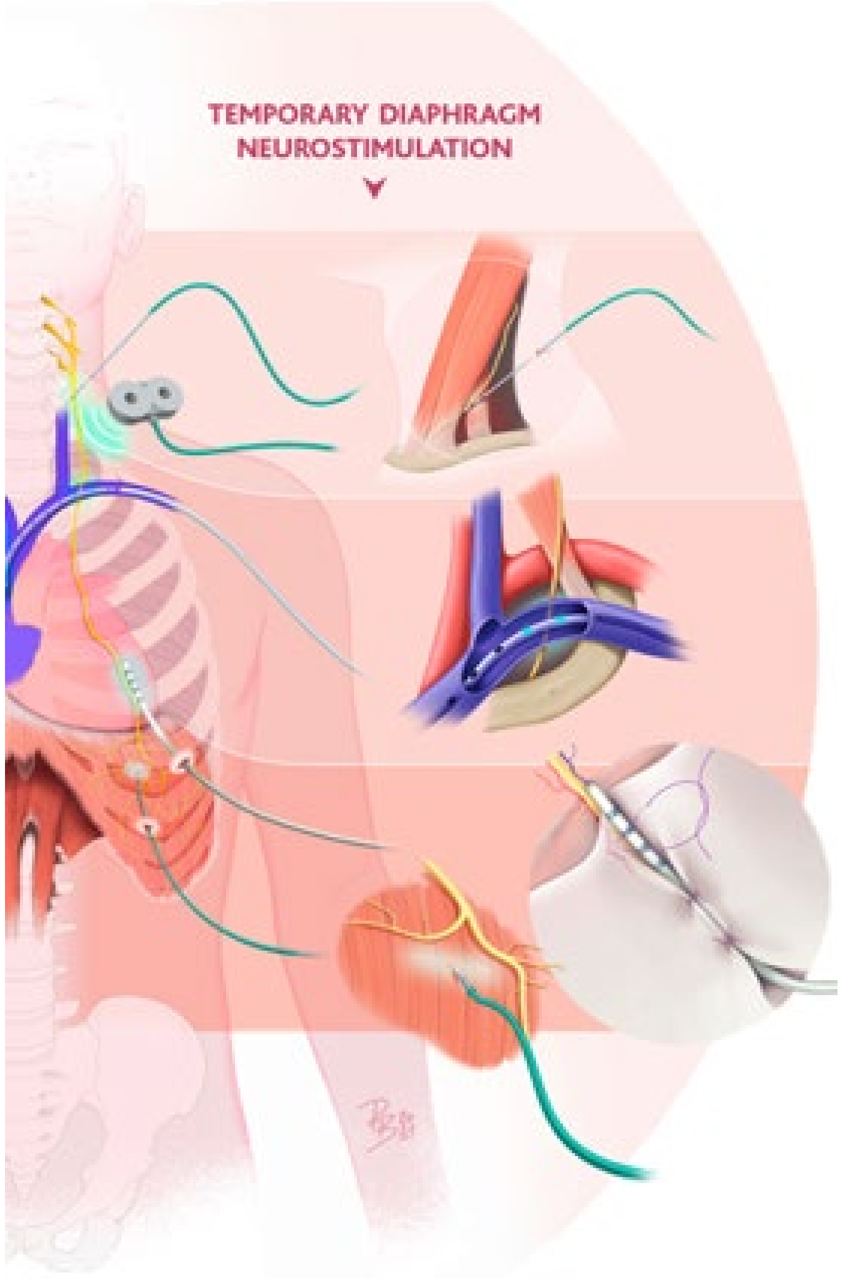
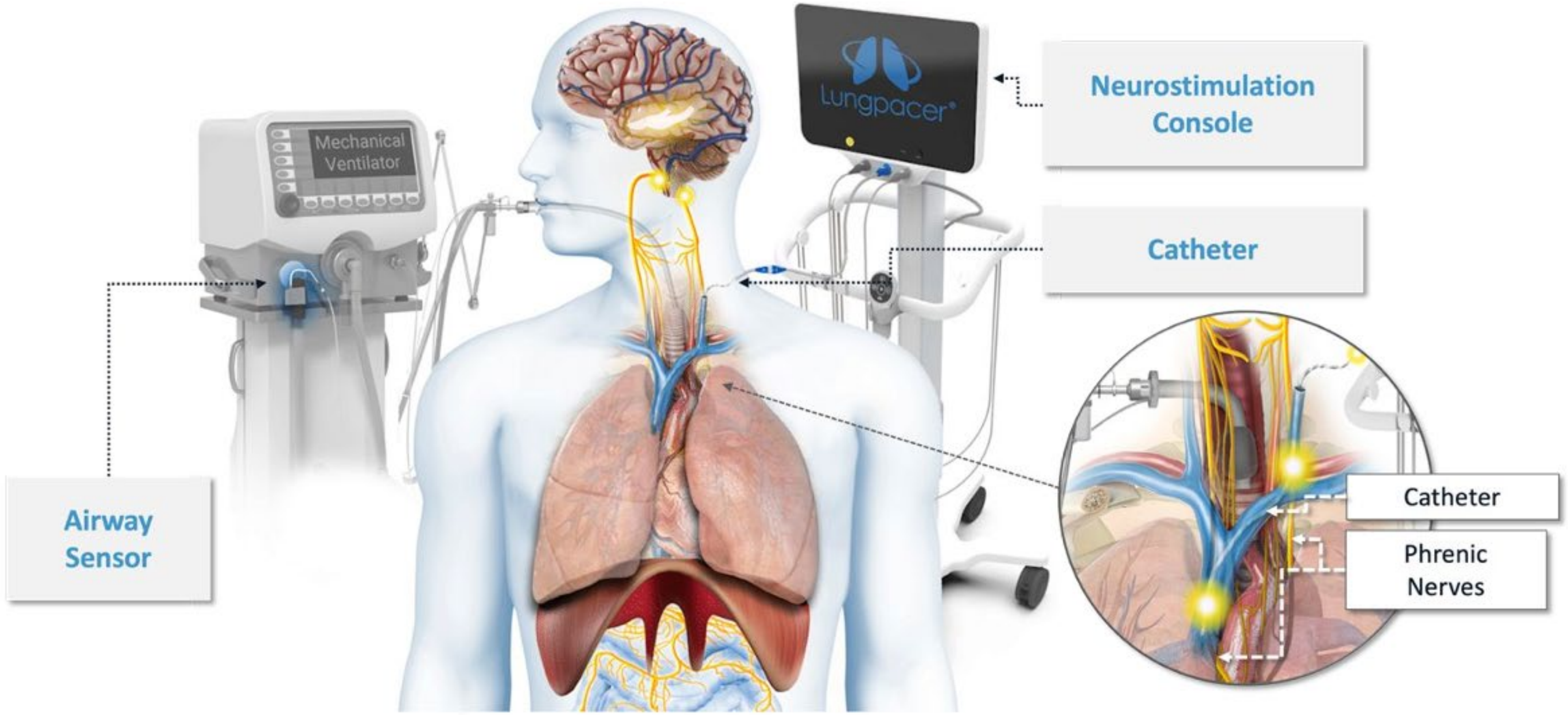


Rescue-2



Lungpacer Diaphragm Pacing Therapy System, Lungpacer Medical, Inc.

Stimulation pulses had an intensity of <13 mA and a duration of 200-300 µs and frequency 15Hz.
Manually

4-6x10 pacing sessions
2-3/day
(120 contractions/day)

Dres, Am J Respir Crit Care Med, 2022

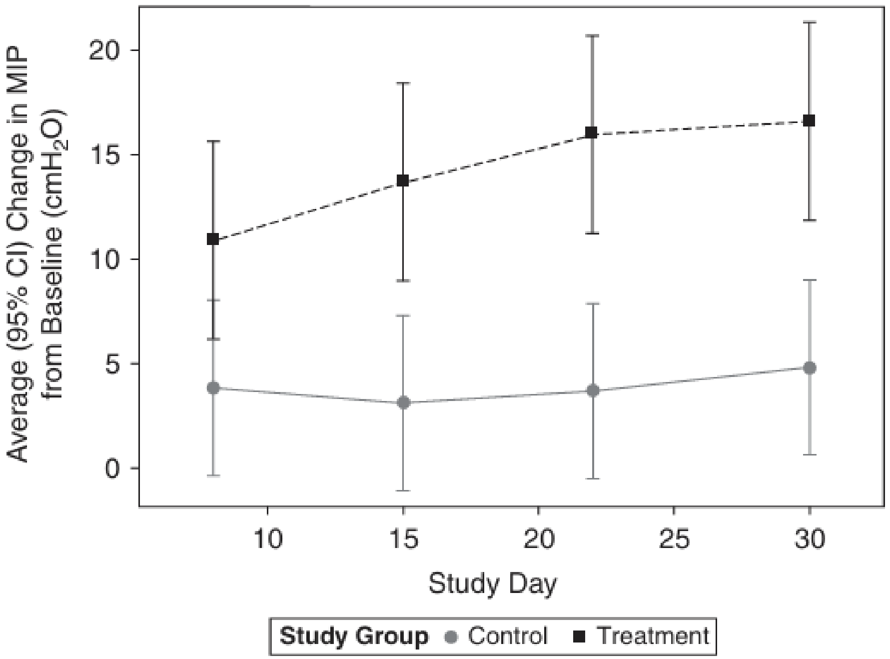
Rescue-2

Table 2. Primary and Secondary Outcomes

Outcome	mITT	Control	Absolute Difference, % (95% CI)	*P* Value
Successful weaning and days on mechanical ventilation (Day 30, mITT)				
Cumulative incidence for successful weaning, %*	82	74	7 (−10 to 25)	0.586
Use of NIV in the 48-h period post extubation, %	62	55	7 (−16 to 29)	0.639
Cumulative incidence for death before successful weaning, %	3	9	−7% (−16 to 3)	0.191
Days on mechanical ventilation from baseline to successful weaning or Study Day 30, mean ± SD†	12.7 ± 9.9	14.1 ± 10.8	−1.4 (−5.6 to 2.7)	0.498
Number of patients placed back on mechanical ventilation within study period after successful weaning	3	4	NA	NA
Number of patients with tracheostomy placed during the study period	2	5	NA	NA
Cumulative incidence for first successful SBT, %	86	80	7 (−9 to 23)	0.607
Cumulative incidence for ICU discharge, %	43	37	6 (−14 to 27)	0.600
Cumulative incidence for hospital discharge, %	5	8	−3 (−13 to 7)	0.587

Dres, Am J Respir Crit Care Med, 2022

Rescue-2



	Mean Change in MIP (95% CI), mITT			
	Day 8	Day 15	Day 22	Day 30
Treatment	10.9 (6, 16)	13.7 (9, 19)	16.0 (11, 21)	16.6 (12, 21)
Control	3.8 (–0, 8)	3.1 (–1, 7)	3.7 (–1, 8)	4.8 (1, 9)
p-value	0.0288	0.0011	0.0002	0.0003

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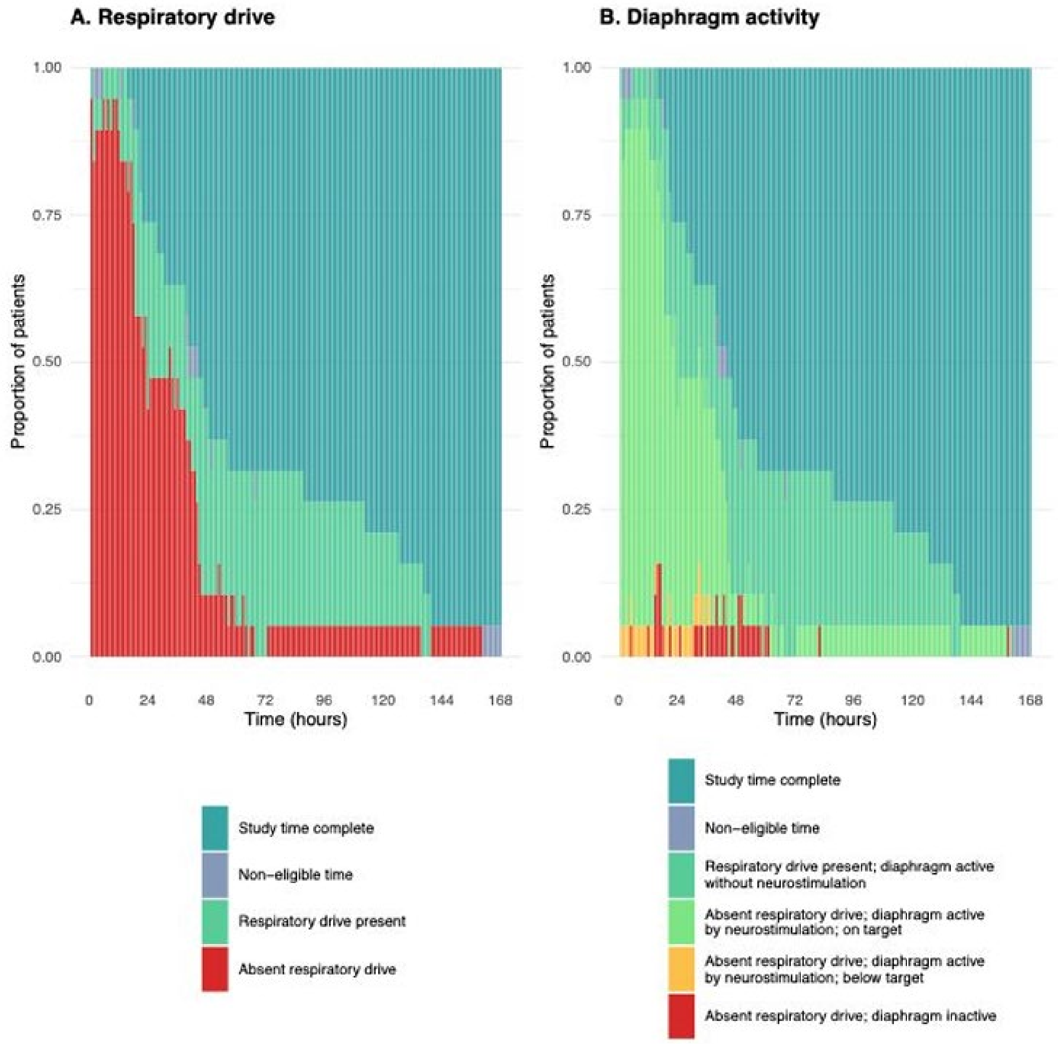
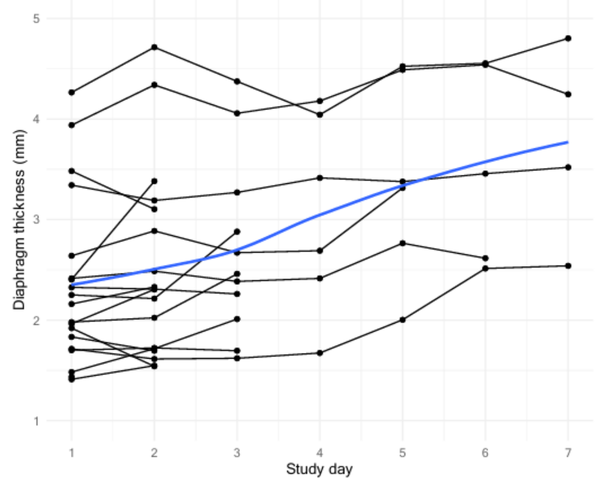
Dres, Am J Respir Crit Care Med, 2022

Stimulus



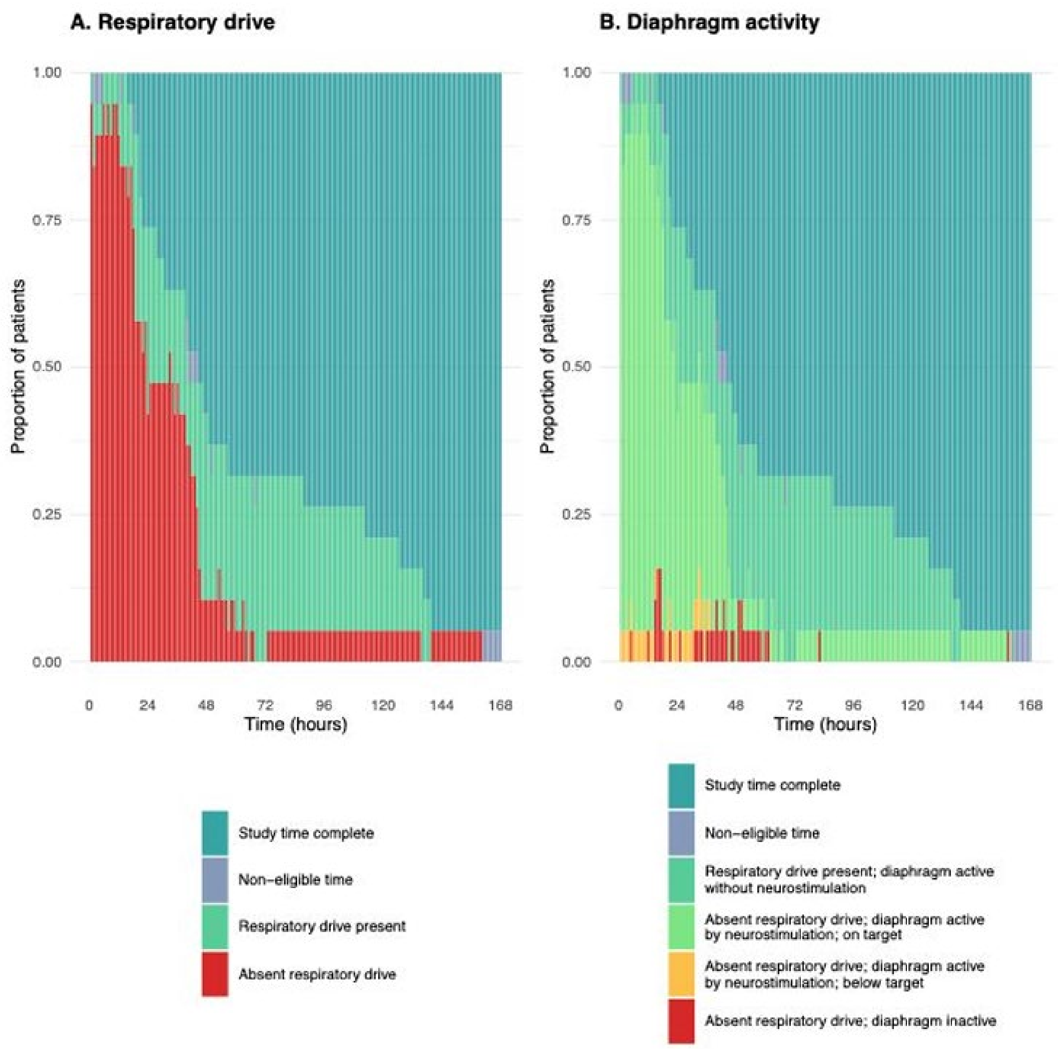
Target: Expiratory occlusion pressure (Pocc)
-5 to – 10 cmH2O.

« On demand »

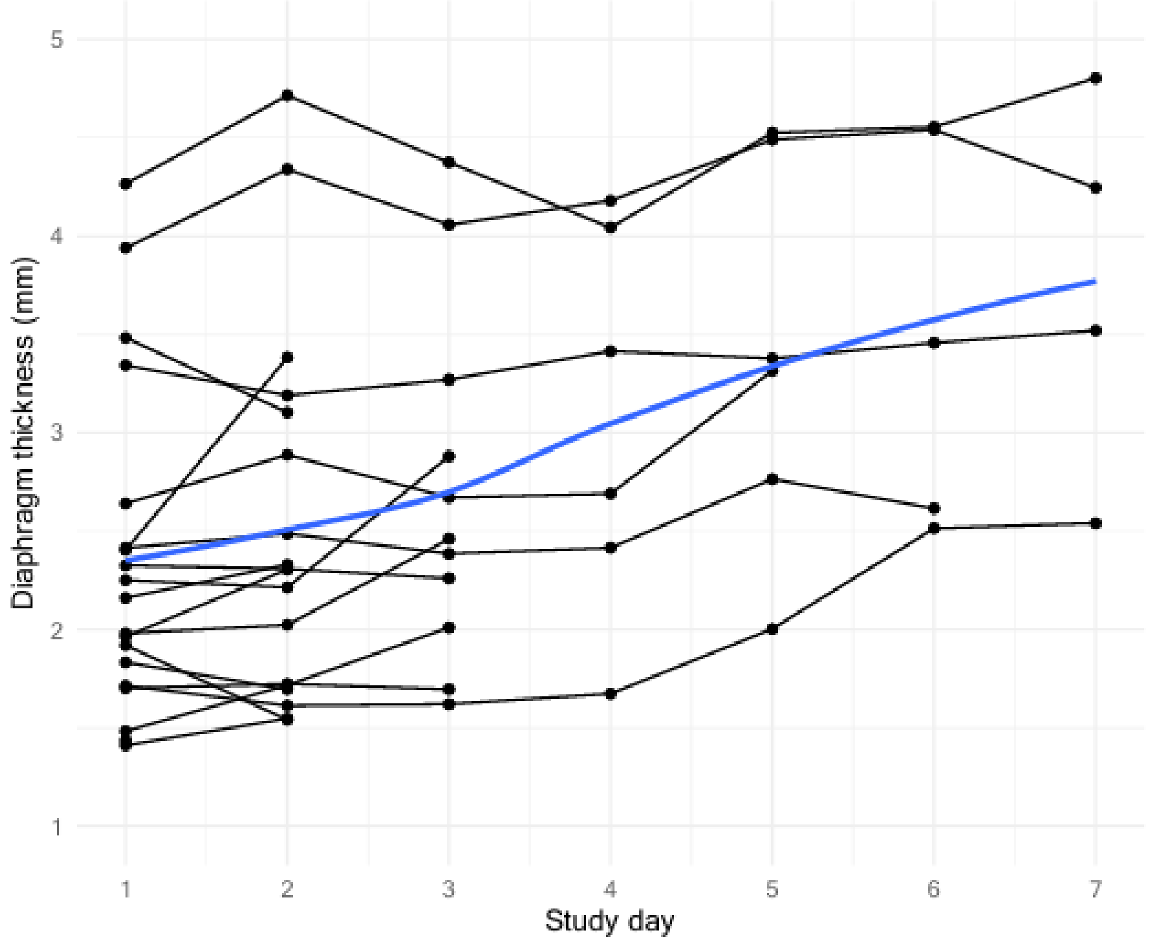


Morris, Am J Respir Crit Care Med, 2025

Stimulus



A. Respiratory drive
B. Diaphragm activity
Proportion of patients
1.00
0.75
0.50
0.25
0.00
0
24
48
72
96
120
144
168
Time (hours)
Study time complete
Non−eligible time
Respiratory drive present
Absent respiratory drive
Respiratory drive present; diaphragm active without neurostimulation
Absent respiratory drive; diaphragm active by neurostimulation; on target
Absent respiratory drive; diaphragm active by neurostimulation; below target
Absent respiratory drive; diaphragm inactive

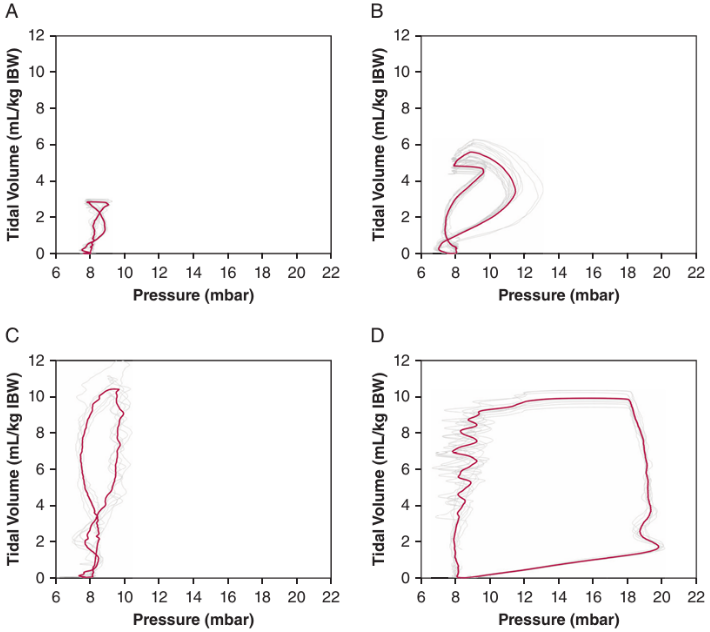


Diaphragm thickness (mm)
5
4
3
2
1
1
2
3
4
5
6
7
Study day

Stimit-2

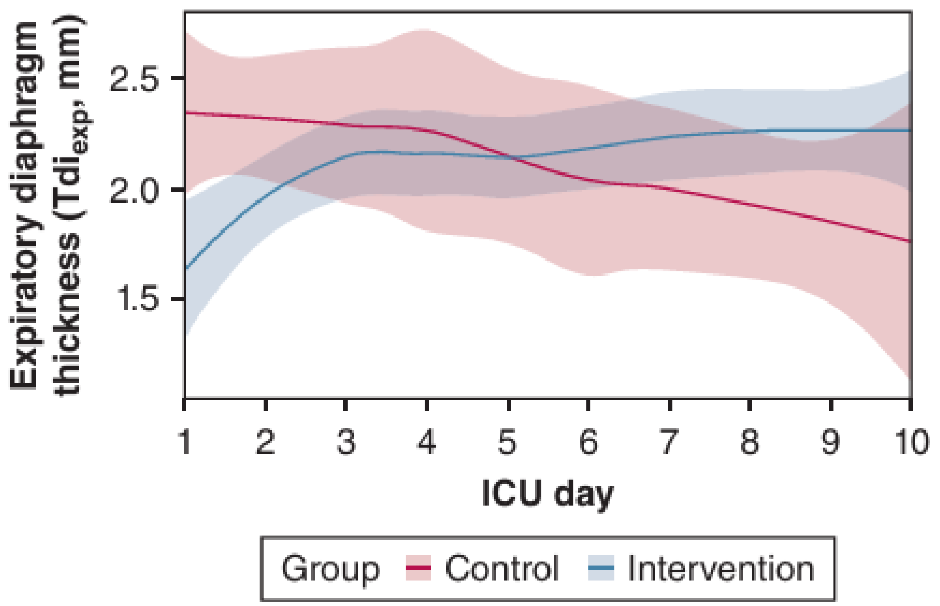
Virolle, Crit Care, 2024

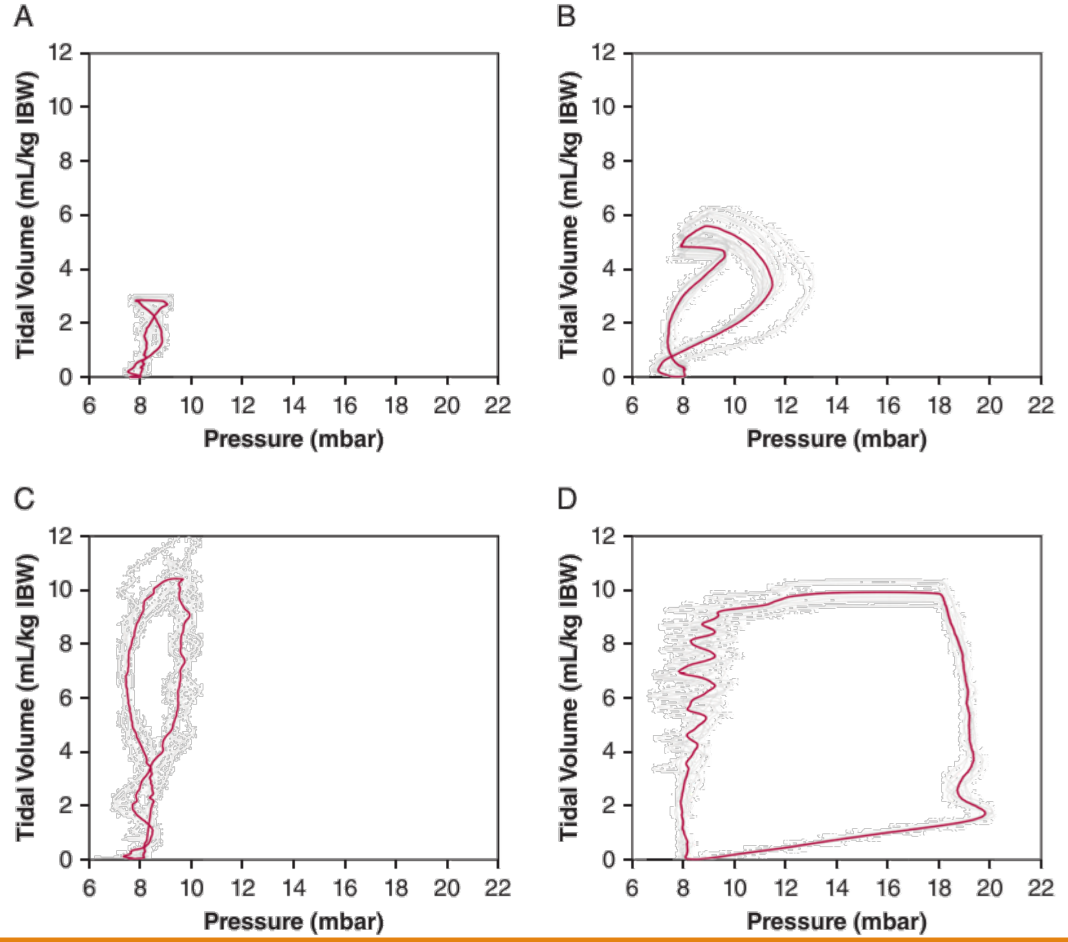
N=5 patients
15 min NEPNS



Panelli, Chest, 2024

Stimit-2





Panelli, Chest, 2024

Take Home Message

Laisser le diaphragme travailler

Réduire l'assistance pour maintenir une activité musculaire modérée.

Surveiller en continu :

- *P0.1*, *ΔPocc*, ou courbe Pes pour la charge inspiratoire.
- *Échographie* : épaisseur & thickening fraction (cible ≈ 15-30 %).

Lorsque la ventilation protectrice ne suffit pas

Indications potentielles de la stimulation

TTDN (cathéter transveineux) : renforcement musculaire pendant le sevrage.

NEPNS (colliers magnétiques) : prévention précoce, non invasive.

Merci de votre attention