Réentrainement du diaphragme en réanimation? NON!

(Diaphragm strengthening strategies in the ICU: No!)

CLÉMENT MEDRINAL

GROUPE HOSPITALIER DU HAVRE

SRLF 2024

GROUPE HOSPITALIER DU HAVRE

Aucun conflit d'intérêt en lien avec la présentation

Conflits d'intérêts:

Fullphysio academy
Asten Santé
SOS Oxygène
Air Liquide medical system

RESEARCH — Open Access

Transcutaneous electrical diaphragmatic stimulation in mechanically ventilated patients: a randomised study

Clément Medrinal[1,2*], Margaux Machefert[1,3], Bouchra Lamia[4,5,6,7], Tristan Bonnevie[4,5,8], Francis-Edouard Gravier[4,5,8], Roger Hilfiker[9], Guillaume Prieur[2,6] and Yann Combret[1,2,6]

RESEARCH — Open Access

Respiratory weakness after mechanical ventilation is associated with one-year mortality - a prospective study

Clément Medrinal[1,2*], Guillaume Prieur[1], Éric Frenoy[1], Aurora Robledo Quesada[1], Antoine Poncet[3], Tristan Bonnevie[4], Francis-Edouard Gravier[4], Bouchra Lamia[1,2] and Olivier Contal[5]

LETTER

Is overlap of respiratory and limb muscle weakness at weaning from mechanical ventilation associated with poorer outcomes?

Clément Medrinal[1,2,3*], Guillaume Prieur[3], Eric Frenoy[3], Yann Combret[4], Francis Edouard Gravier[5], Tristan Bonnevie[5], Antoine Poncet[6], Aurora Robledo Quesada[3], Bouchra Lamia[1,2,7] and Olivier Contal[8]

ICU outcomes can be predicted by noninvasive muscle evaluation: a meta-analysis

Clément Medrinal[1,2,3], Yann Combret[3,4], Roger Hilfiker[5], Guillaume Prieur[1,2,3,4], Nadine Aroichane[6], Francis-Edouard Gravier[1,2,7], Tristan Bonnevie[1,2,7], Olivier Contal[8,11] and Bouchra Lamia[1,2,9,10,11]

RESEARCH — Open Access

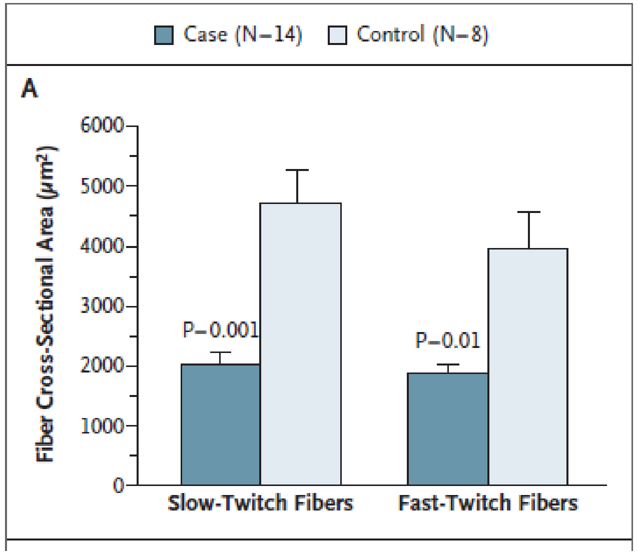
The relationship between maximal expiratory pressure values and critical outcomes in mechanically ventilated patients: a post hoc analysis of an observational study

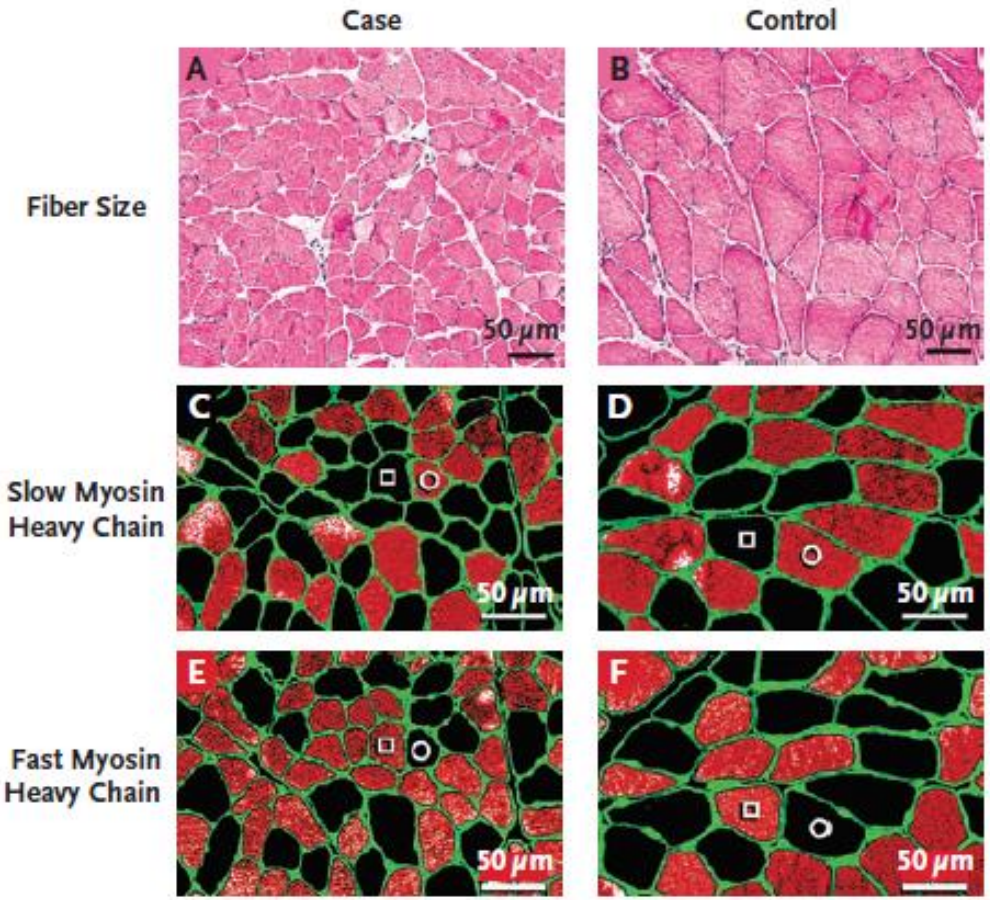
Yann Combret[1,2*], Guillaume Prieur[1,2,3], Roger Hilfiker[4], Francis-Edouard Gravier[3,5], Pauline Smondack[5], Olivier Contal[6], Bouchra Lamia[3,7,8], Tristan Bonnevie[3,5] and Clément Medrinal[1,9,10]

Background

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



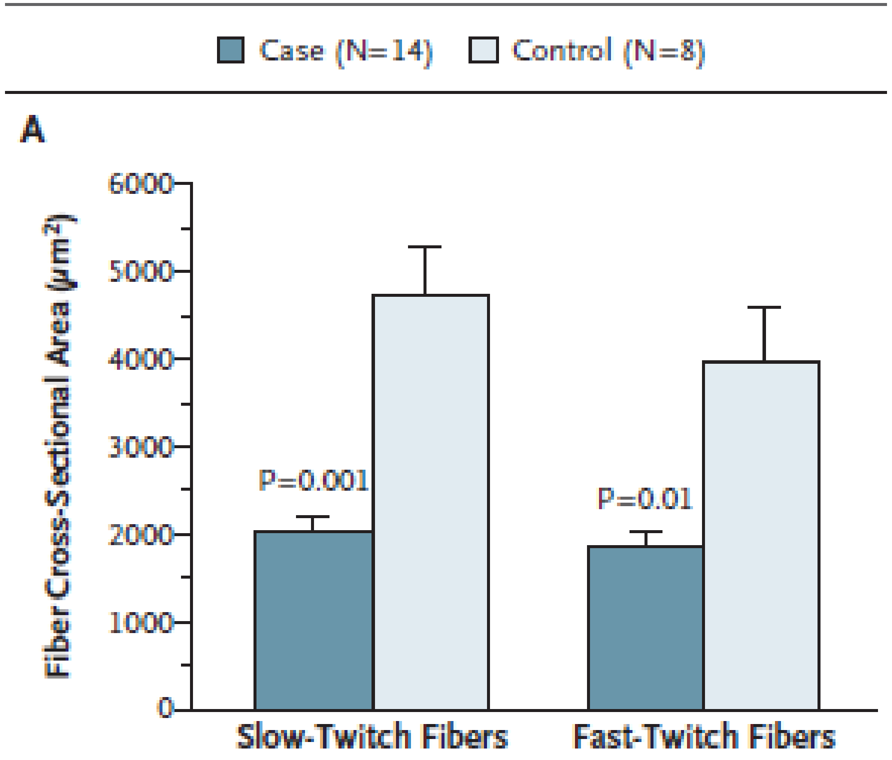


18 à 69h MV

↘50% CSA Fibers I and II

Levine, NEJM, 2008

Very Fast Illness



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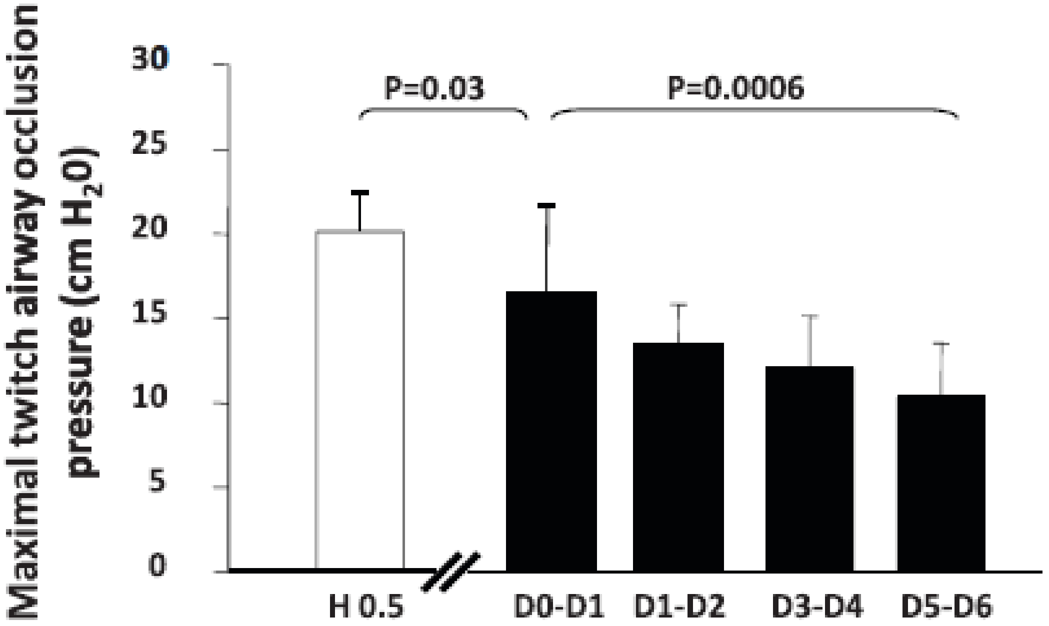
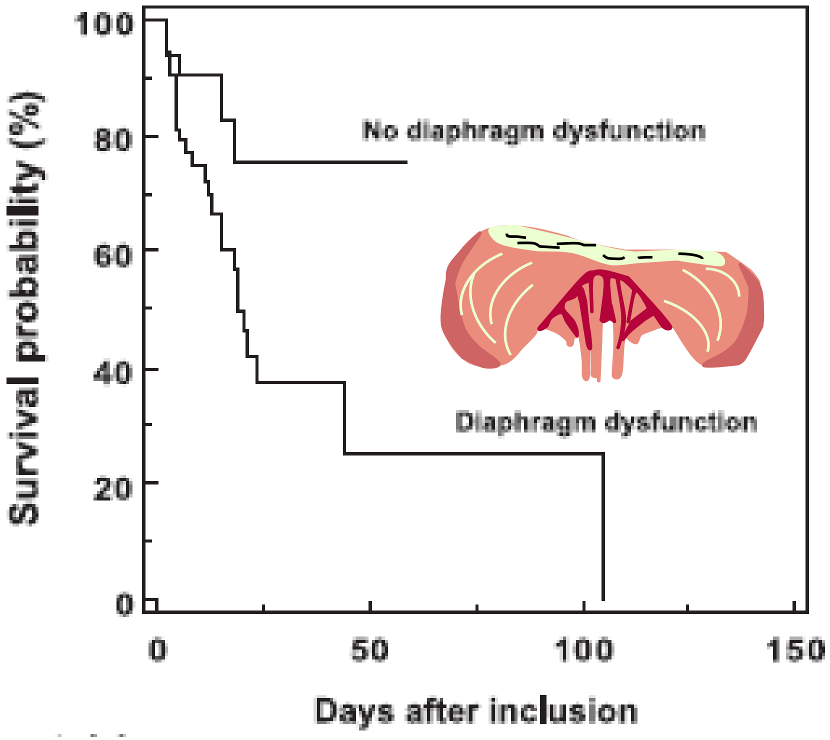


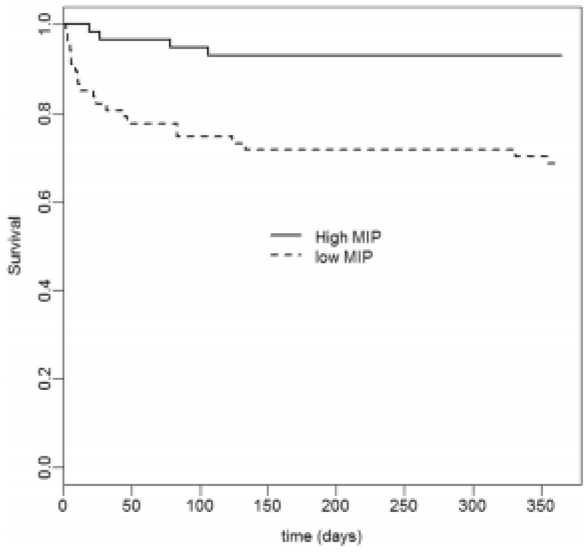
Jaber, Am J Respir Crit Care Med

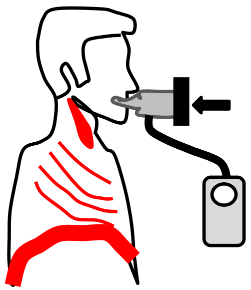
Poor long term outcomes…

DIAPHRAGM WEAKNESS



INSPIRATORY MUSCLES WEAKNESS

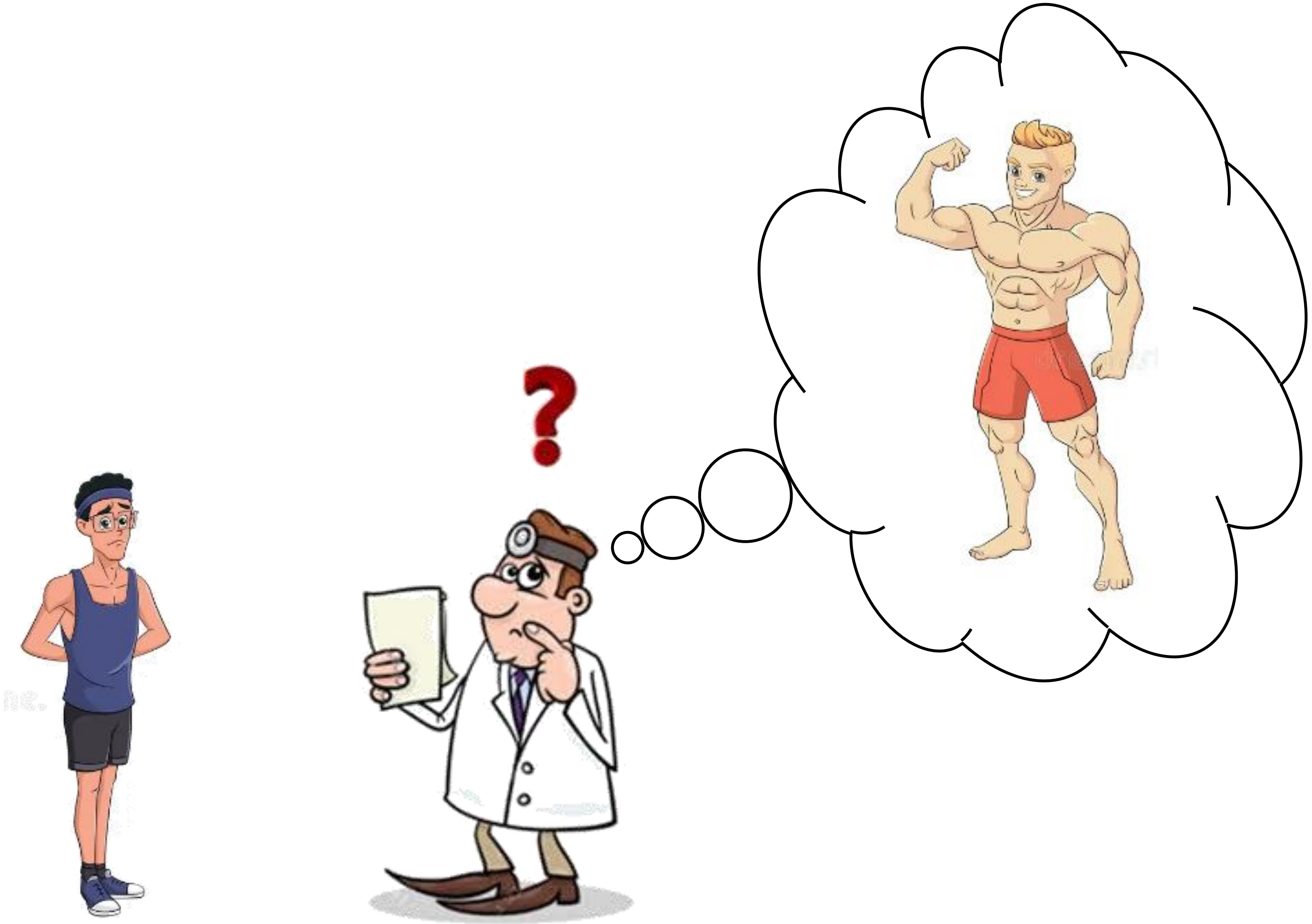


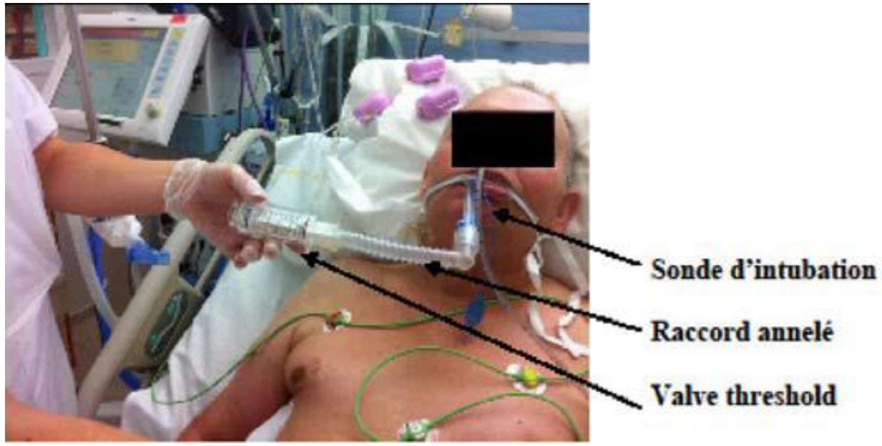


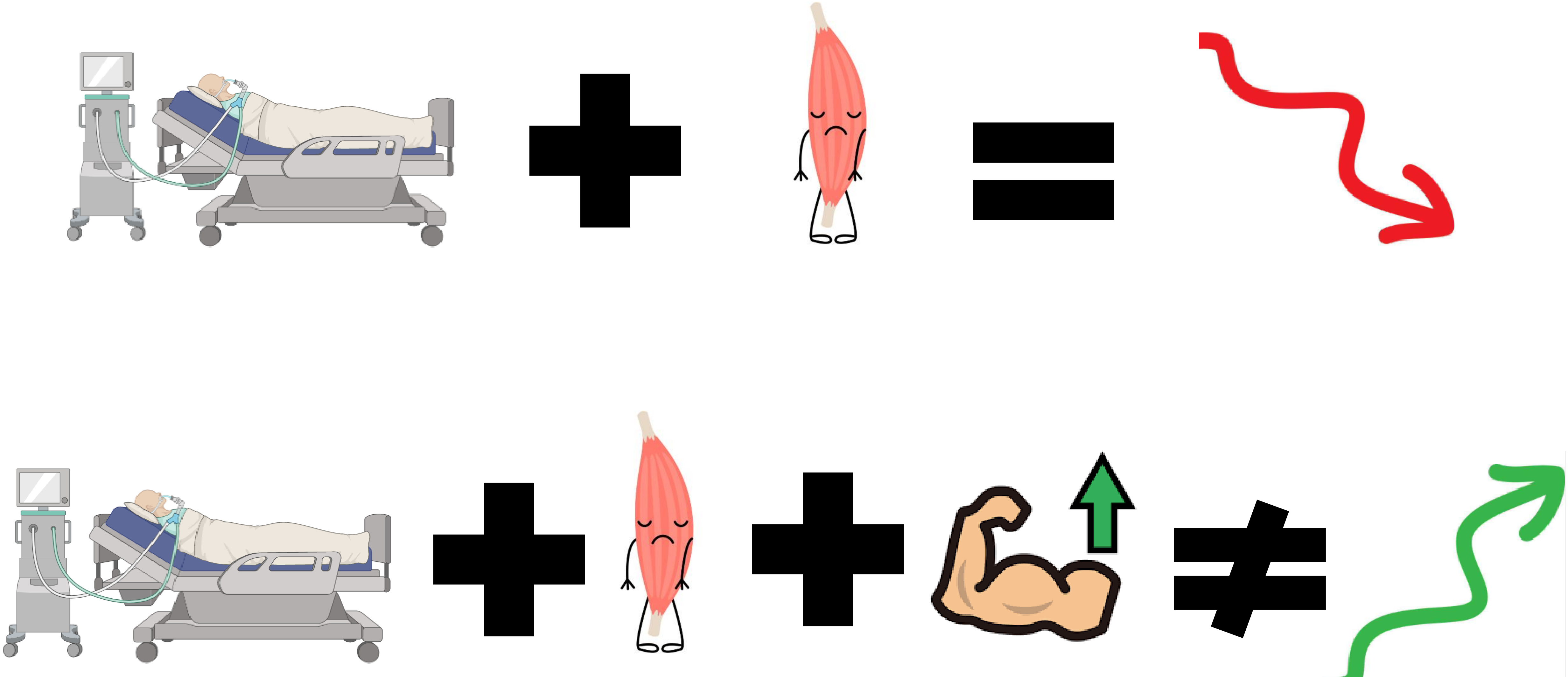
Outcome and measurment	Number of studies	Sensitivity (95% CI)	Specificity (95% CI)	Area under the curve (95% CI)	Likelihood ratio (95% CI)	
					Positive	Negative
Overall Death						
Diaphragm excursion	4	0.59 [0.27 to 0.85]	0.62 [0.54 to 0.70]	0.64 [0.59 to 0.68]	1.60 [0.9 to 2.6]	0.65 [0.30 to 1.41]
Diaphragm thickening fraction	4	0.71 [0.41 to 0.90]	0.64 [0.49 to 0.77]	0.71 [0.67 to 0.75]	2.00 [1.50 to 2.70]	0.45 [0.21 to 0.97]
Transdiaphragmatic twitch pressure	5	0.87 [0.76 to 0.93]	0.36 [0.27 to 0.43]	0.74 [0.70 to 0.78]	1.36 [1.15 to 1.61]	0.36 [0.19 to 0.68]
Maximal Inspiratory Pressure	4	0.79 [0.41 to 0.95]	0.61 [0.44 to 0.75]	0.71 [0.67 to 0.75]	2.01 [1.56 to 2.6]	0.34 [0.11 to 1.05]
MRC Score	12	0.70 [0.62 to 0.77]	0.57 [0.52 to 0.63]	0.68 [0.63 to 0.72]	1.64 [1.47 to 1.84]	0.52 [0.42 to 0.63]
ICU Death						
Transdiaphragmatic twich pressure	4	0.88 [0.76 to 0.94]	0.34 [0.23 to 0.48]	0.85 [0.82 to 0.88]	1.33 [1.08 to 1.64]	0.36 [0.16 to 0.77]
MRC Score	10	0.78 [0.65 to 0.87]	0.54 [0.48 to 0.59]	0.66 [0.61 to 0.70]	1.68 [1.48 to 1.91]	0.41 [0.26 to 0.64]
Hospital Death						
Diaphragm excursion	4	0.56 [0.21 to 0.86]	0.62 [0.54 to 0.69]	0.63 [0.58 to 0.67]	1.50 [0.80 to 2.80]	0.71 [0.30 to 1.65]
Diaphragm thickening fraction	4	0.71 [0.41 to 0.90]	0.64 [0.49 to 0.77]	0.71 [0.67 to 0.75]	2.00 [1.50 to 2.70]	0.45 [0.21 to 0.97]
Maximal Inspiratory Pressure	4	0.80 [0.40 to 0.96]	0.60 [0.42 to 0.75]	0.71 [0.67 to 0.75]	1.33 [1.08 to 1.64]	0.36 [0.16 to 0.77]
MRC Score	9	0.75 [0.67 to 0.82]	0.57 [0.51 to 0.63]	0.71 [0.67 to 0.75]	1.74 [1.52 to 2]	0.43 [0.32 to 0.57]
Weaning failure						
Diaphragm excursion	10	0.76 [0.61 to 0.87]	0.80 [0.73 to 0.85]	0.84 [0.81 to 0.87]	5.50 [3.40 to 9.00]	0.28 [0.20 to 0.38]
Diaphragm thickening fraction	10	0.76 [0.67 to 0.83]	0.86 [0.78 to 0.92]	0.86 [0.83 to 0.89]	3.70 [2.70 to 5.10]	0.30 [0.17 to 0.52]
Maximal Inspiratory Pressure	12	0.76 [0.61 to 0.86]	0.66 [0.54 to 0.77]	0.77 [0.73 to 0.80]	2.30 [1.6 to 3.3]	0.36 [0.21 to 0.62]

Medrinal, ERJ, 2020

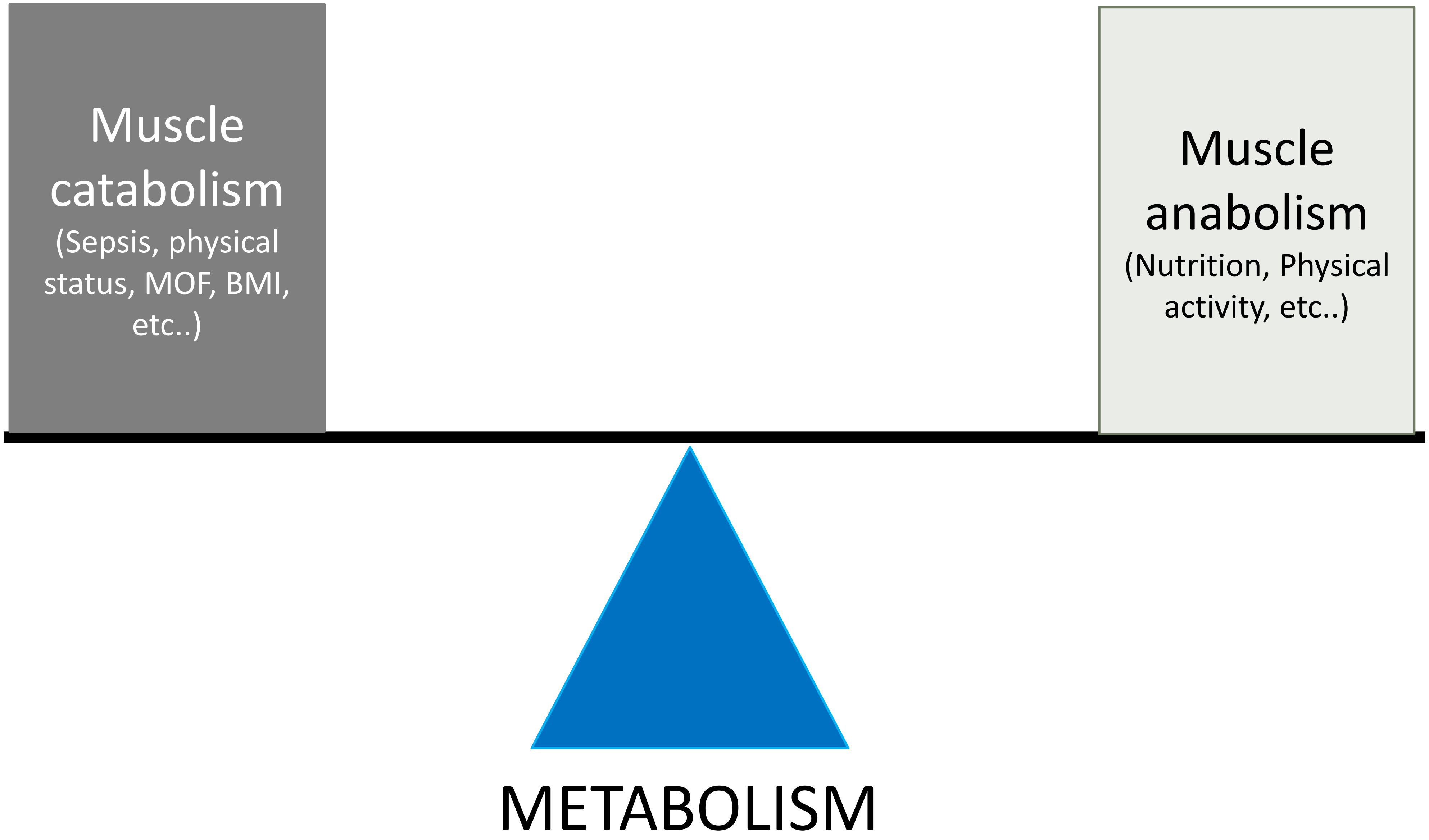
Positive illusion Bias

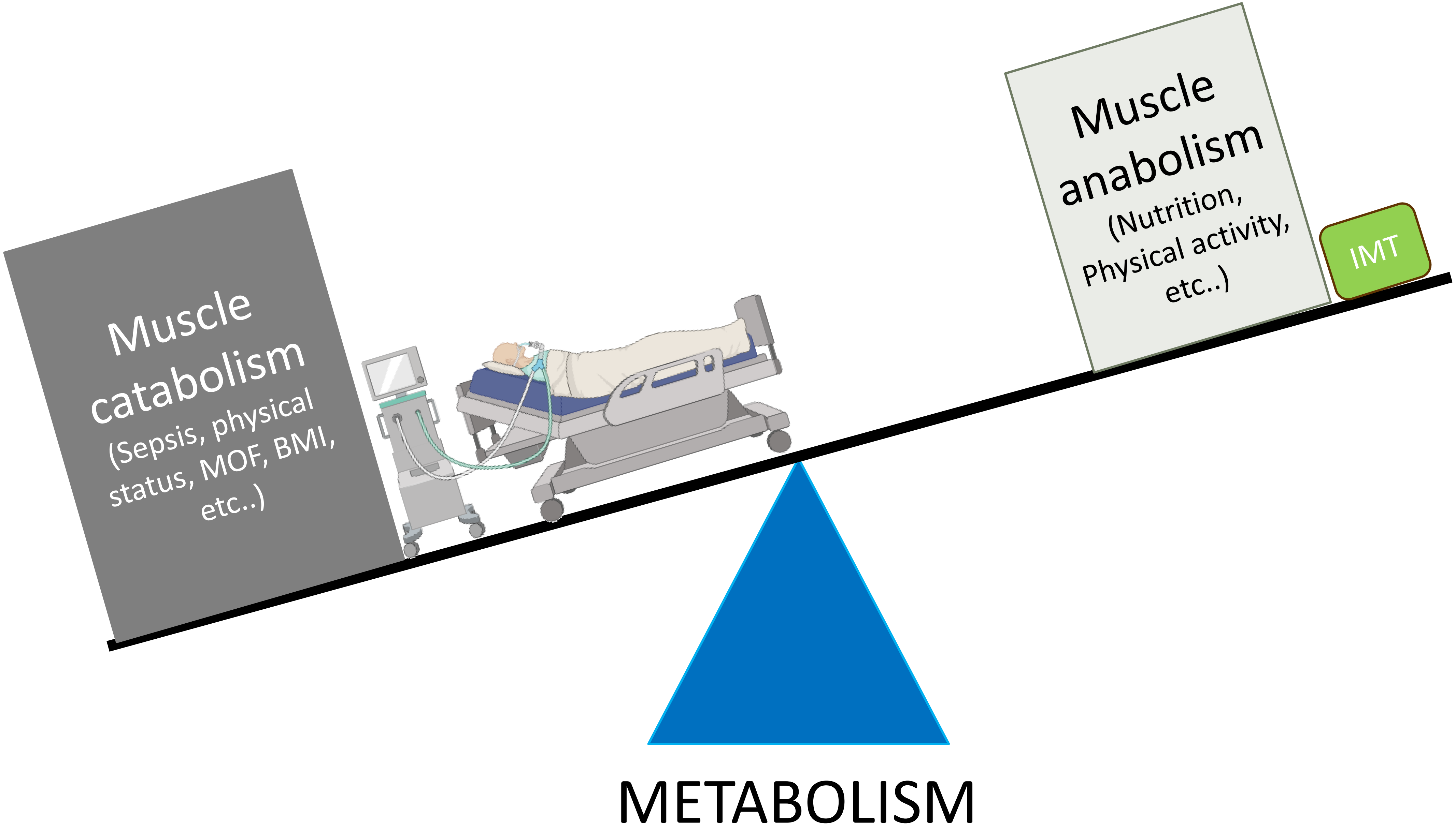






Symmetry cognitive bias


Muscle catabolism
(Sepsis, physical status, MOF, BMI, etc..)
Muscle anabolism
(Nutrition, Physical activity, etc..)
METABOLISM


Muscle catabolism (Sepsis, physical status, MOF, BMI, etc..)
Muscle anabolism (Nutrition, Physical activity, etc..)
IMT
METABOLISM

Inspiratory muscles with Mechanical ventilation

Currently	Under mechanical ventilation
Active work against resistance 24/24h	Ø work
Active Shortening fibers	Passive shortening fibers
Negative Thoracic Pressure	Positive thoracic pressure

Inspiratory Muscle Rehabilitation in Critically Ill Adults

A Systematic Review and Meta-Analysis

Stefannie Vorona[1], Umberto Sabatini[1], Sulaiman Al-Maqbali[1], Michele Bertoni[1], Martin Dres[2,3], Bernie Bissett[4,5], Frank Van Haren[5,6,7], A. Daniel Martin[8], Cristian Urrea[1], Debbie Brace[1], Matteo Parotto[9,10,11], Margaret S. Herridge[1,9,12], Neill K. J. Adhikari[9,13,14], Eddy Fan[1,9,12,15], Luana T. Melo[16], W. Darlene Reid[9,16], Laurent J. Brochard[2,9,12], Niall D. Ferguson[1,9,12,14,15], and Ewan C. Goligher[1,9,15]

Study	Experimental Total	Experimental Mean	Experimental SD	Control Total	Control Mean	Control SD	MD	95% CI	Weight
Regimen = Endurance									
Özyürek 2014	15	35.00	9.0000	16	25.00	9.0000	10.00	[3.66; 16.34]	4.1%
Holliday 1990	20	12.00	4.0000	16	6.00	2.0000	6.00	[3.99; 8.01]	12.1%
Porta 2005	32	9.00	12.0000	34	5.00	9.0000	4.00	[−1.14; 9.14]	5.5%
Caruso 2005	12	5.00	9.0000	13	7.00	19.0000	−2.00	[−13.52; 9.52]	1.5%
Chang 2011	8	10.00	8.0000	5	14.00	10.0000	−4.00	[−14.37; 6.37]	1.9%
Random effects model	87			84			4.75	[1.28; 8.22]	25.2%
Regimen = Strength									
Bissett 2016	33	16.00	19.0000	36	5.00	17.0000	11.00	[2.46; 19.54]	2.6%
Condessa 2013	45	7.00	8.0000	47	−3.00	6.0000	10.00	[7.10; 12.90]	9.8%
Pascotini 2014	7	5.00	13.0000	7	−4.00	4.0000	9.00	[−1.08; 19.08]	2.0%
Cader 2010	14	10.00	2.0000	14	2.00	1.0000	8.00	[6.83; 9.17]	14.1%
Dixit 2014	15	15.00	6.0000	15	7.00	3.0000	8.00	[4.61; 11.39]	8.7%
Martin 2011	35	10.00	11.0000	34	2.00	11.0000	8.00	[2.81; 13.19]	5.5%
Mohamed 2014	20	8.00	2.0000	20	2.00	1.0000	6.00	[5.02; 6.98]	14.5%
Ibrahiem 2014	15	5.00	1.0000	15	1.00	2.0000	4.00	[2.87; 5.13]	14.2%
Tonella 2017	11	7.00	12.0000	8	10.00	11.0000	−3.00	[−13.41; 7.41]	1.8%
Shimizu 2014	8	−5.00	7.0000	5	2.00	11.0000	−7.00	[−17.79; 3.79]	1.7%
Random effects model	203			201			6.62	[4.82; 8.43]	74.8%
Random effects model	**290**			**285**			**6.22**	**[4.71; 7.72]**	**100.0%**

Heterogeneity: $I^2 = 72\%$, $\tau^2 = 3.8396$, $p < 0.01$
Test for subgroup differences: $\chi^2_1 = 0.88$, df = 1 ($p = 0.35$)

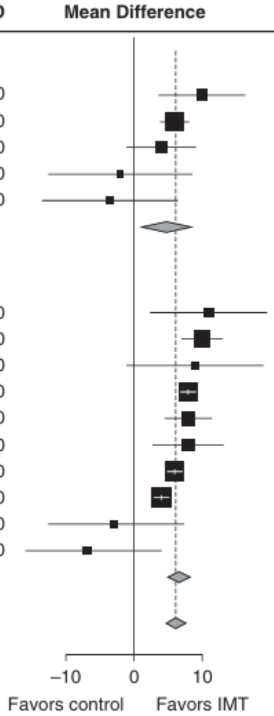


Figure 2. Effect of inspiratory muscle training (IMT) on the change in maximal inspiratory pressure from baseline to the completion of the treatment course. The effect of IMT did not significantly differ with strength training versus endurance training regimens. Weight refers to the contribution of each study to the meta-analysis estimate of effect. CI = confidence interval; MD = mean difference; SD = standard deviation.

Study	Experimental Total	Experimental Mean	Experimental SD	Control Total	Control Mean	Control SD	MD	95% CI	Weight
Condessa 2013	45	9.1	4.0	47	9.2	3.3	−0.10	[−1.60; 1.40]	16.4%
Shimizu 2014	8	17.8	6.8	5	18.1	4.7	−0.30	[−6.56; 5.96]	10.5%
Chang 2011	8	6.4	4.0	5	6.9	5.3	−0.50	[−5.91; 4.91]	11.6%
Caruso 2005	12	8.6	3.6	13	9.8	8.0	−1.20	[−6.00; 3.60]	12.5%
Martin 2011	35	57.3	29.5	34	63.5	34.0	−6.20	[−21.24; 8.84]	3.7%
Mohamed 2014	20	3.3	1.6	20	10.4	2.5	−7.10	[−8.40; −5.80]	16.6%
Yosef-Brauner 2015	9	9.0	5.0	9	16.2	2.0	−7.20	[−10.72; −3.68]	14.2%
Tonella 2017	11	14.5	10.0	8	21.8	9.8	−7.30	[−16.30; 1.70]	7.4%
Holliday 1990	20	20.6	8.9	16	32.6	17.6	−12.00	[−21.46; −2.54]	7.0%
Random effects model	**168**			**157**			**−4.07**	**[−7.35; −0.80]**	**100.0%**

Heterogeneity: $I^2 = 86\%$, $\tau^2 = 16.41$, $p < 0.01$

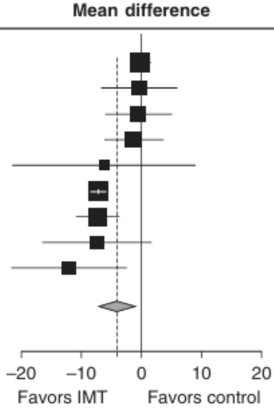


Figure 3. Impact of inspiratory muscle training (IMT) on the duration of ventilation in mechanically ventilated patients. After exclusion of studies at serious risk of bias, the treatment effect was no longer significant (mean difference, 4.6 d; 95% CI, −1.0 to 10.1 d; $I^2 = 94\%$). Weight refers to the contribution of each study to the meta-analysis estimate of effect. CI = confidence interval; MD = mean difference; SD = standard deviation.

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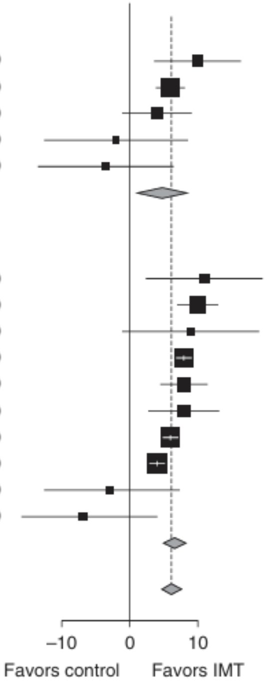

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Yosef-Brauner 2015	9	9.0	5.0	9	16.2	2.0	−7.20	[−10.72; −3.68]	14.2%
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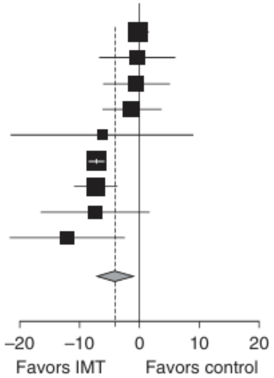

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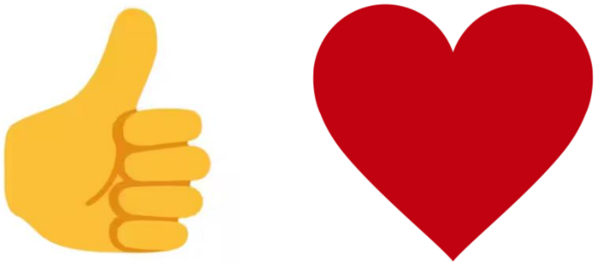
Table 1. GRADE summary of findings for the impact of inspiratory muscle training in critically ill patients

Outcome	Impact Effect (95% CI)	No. of Participants (RCTs)	Quality of the Evidence (GRADE)
Change in maximal inspiratory pressure from baseline after IMT	Mean difference in change 6 (5 to 8) cm H_2O higher in IMT group than in control group Pooled ratio of means for change in MIP relative to baseline MIP, 1.21 (1.16 to 1.26)	647 (15 RCTs)	⊕○○○ Very low[*,†,‡]
Change in maximal inspiratory pressure from baseline after IMT (sensitivity analysis excluding studies at high risk of bias)	Mean difference 9 (7 to 12) cm H_2O higher in IMT group than in control group	175 (3 RCTs)	⊕⊕⊕⊕ High
Maximal inspiratory pressure after IMT	Mean difference 7 (6 to 8) cm H_2O higher in IMT group than in control group	575 (15 RCTs)	⊕⊕○○ Low[*,‡]
Change in maximal expiratory pressure from baseline after IMT	Mean difference in change 9 (5 to 14) cm H_2O higher in IMT group than in control group Pooled ratio of means for change in MEP relative to baseline MEP, 1.39 (1.27 to 1.54)	153 (4 RCTs)	⊕⊕⊕○ Moderate*
Change in maximal expiratory pressure from baseline after IMT (sensitivity analysis excluding studies at high risk of bias)	Mean difference in change 9 (5 to 14) cm H_2O higher in IMT group than in control group	106 (2 RCTs)	⊕⊕⊕⊕ High
Duration of ventilation	Pooled duration of ventilation was 4.1 (0.8 to 7.4) d shorter in IMT group than in control group	325 (9 RCTs)	⊕○○○ Very low[*,†,‡,§]
Duration of ventilation (sensitivity analysis excluding studies at high risk of bias)	Pooled duration of ventilation was 4.6 (−1.0 to 10.1) d shorter in IMT group than in control group	220 (4 RCTs)	⊕⊕○○ Low[†,§]
Duration of weaning from mechanical ventilation	Pooled duration of weaning from mechanical ventilation was 2.3 (0.7 to 3.9) d shorter in IMT group than in control group	257 (8 RCTs)	⊕○○○ Very low[*,†,§]
Duration of weaning (sensitivity analysis excluding studies at high risk of bias)	Pooled duration of weaning from mechanical ventilation was 3.2 (0.6 to 5.8) d shorter in IMT group than in control group	209 (5 RCTs)	⊕⊕○○ Low[†,§]
ICU length of stay	Length of stay in ICU was 3.1 (−1.0 to 7.1) d shorter in IMT group than in control group	28 (2 RCTs)	⊕○○○ Very low[*,‡,§]
Mortality in ICU	Pooled relative risk of death in ICU was 0.67 (0.20 to 2.20) in IMT group compared with control group	197 (3 RCTs)	⊕⊕○○ Low[‡,§]

Inspiratory Muscle Rehabilitation in Critically Ill Adults

A Systematic Review and Meta-Analysis

Stefannie Vorona[1], Umberto Sabatini[1], Sulaiman Al-Maqbali[1], Michele Bertoni[1], Martin Dres[2,3], Bernie Bissett[4,5], Frank Van Haren[5,6,7], A. Daniel Martin[8], Cristian Urrea[1], Debbie Brace[1], Matteo Parotto[9,10,11], Margaret S. Herridge[1,9,12], Neill K. J. Adhikari[9,13,14], Eddy Fan[1,9,12,15], Luana T. Melo[16], W. Darlene Reid[9,16], Laurent J. Brochard[2,9,12], Niall D. Ferguson[1,9,12,14,15], and Ewan C. Goligher[1,9,15]



+567

Change in maximal inspiratory pressure from baseline after IMT (sensitivity analysis excluding studies at high risk of bias)	Mean difference 9 (7 to 12) cm H_2O higher in IMT group than in control group	175 (3 RCTs)	⊕⊕⊕⊕ High

How do weak respiratory muscles progress?

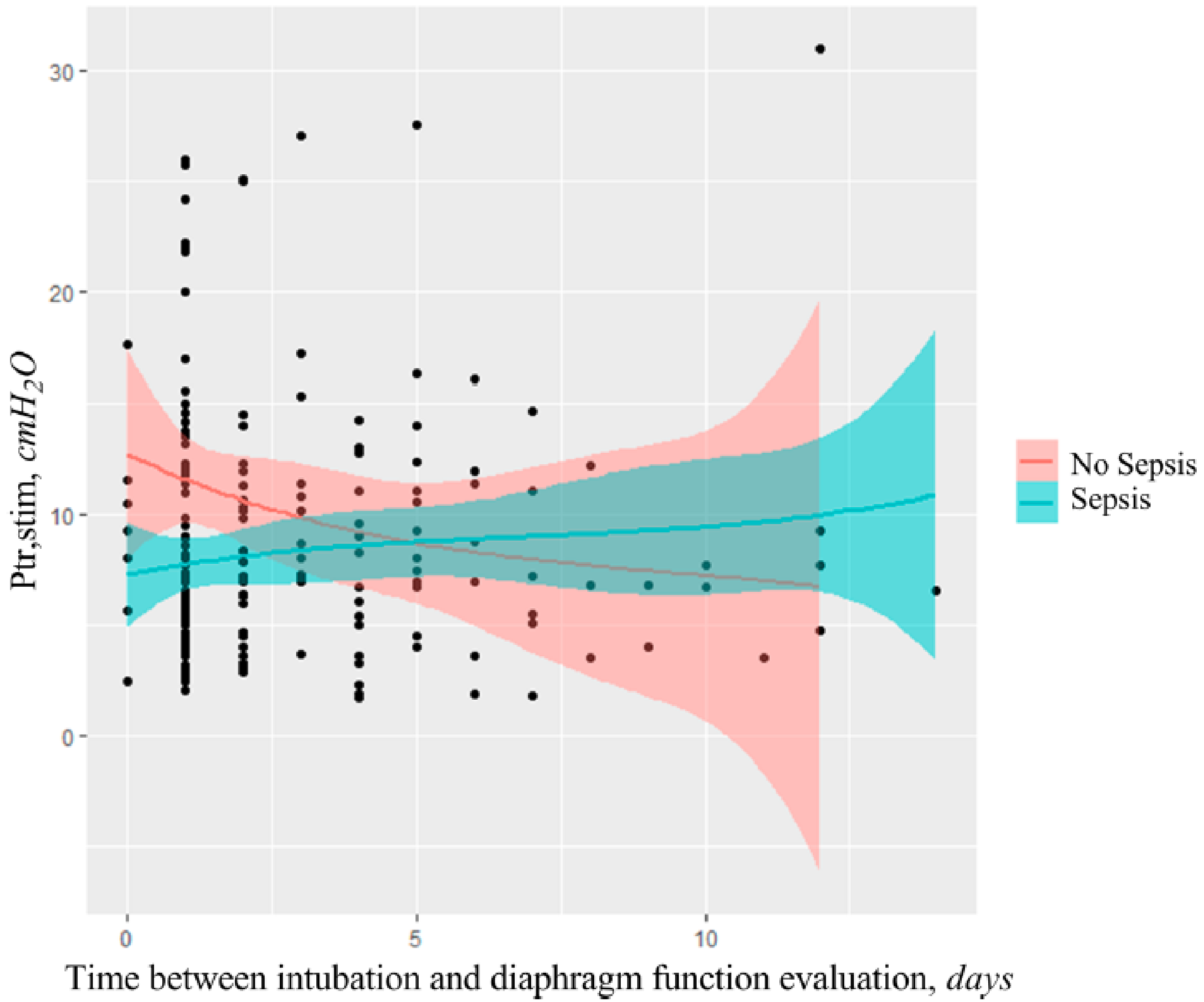


Fig. 2 Diaphragm function time course represented by endotracheal tube pressure induced by bilateral phrenic nerve stimulation during airway occlusion (Ptr,stim) according to time between intubation and measure in septic and non-septic patients. Each black circle represents a single measure of the diaphragm function for a given patient (184 circles in total). The lines represent the regression and the colored shaded areas represent 95% confidence interval for the regression curve

Dres, Ann ICM, 2022

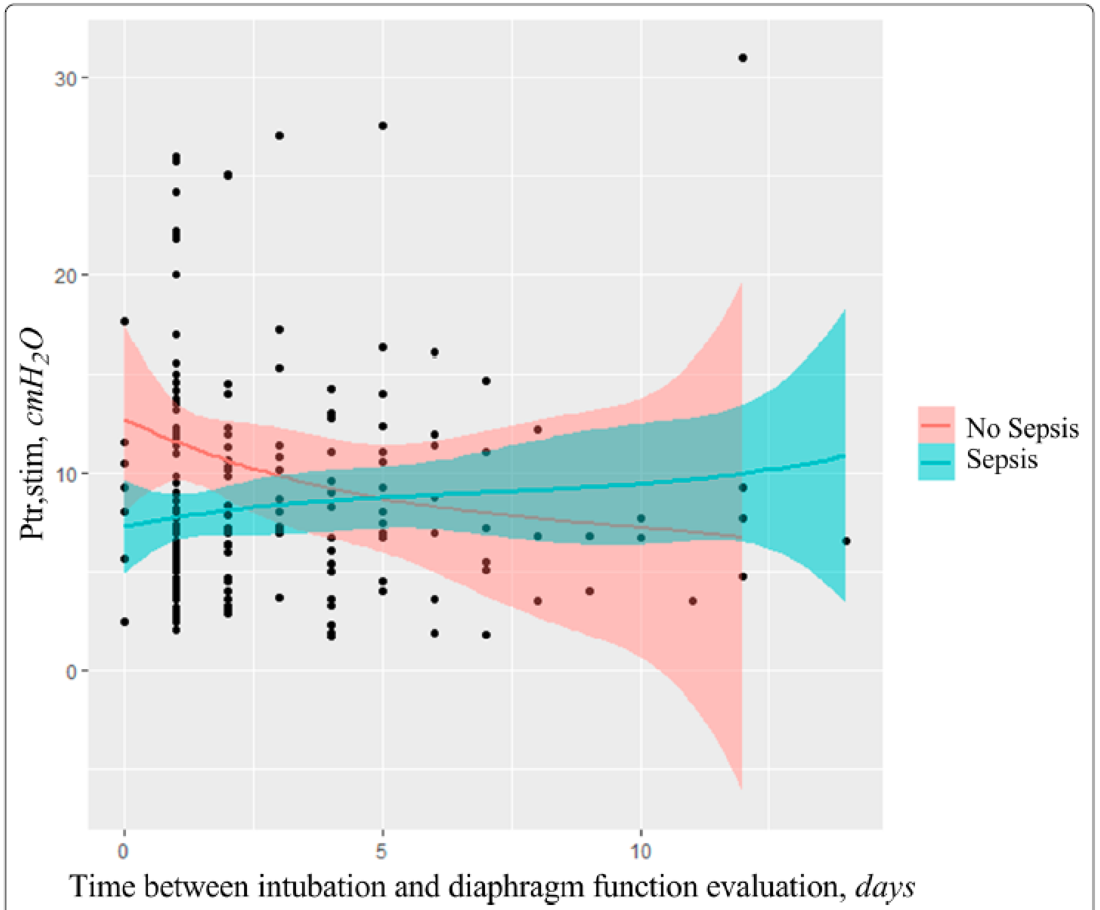
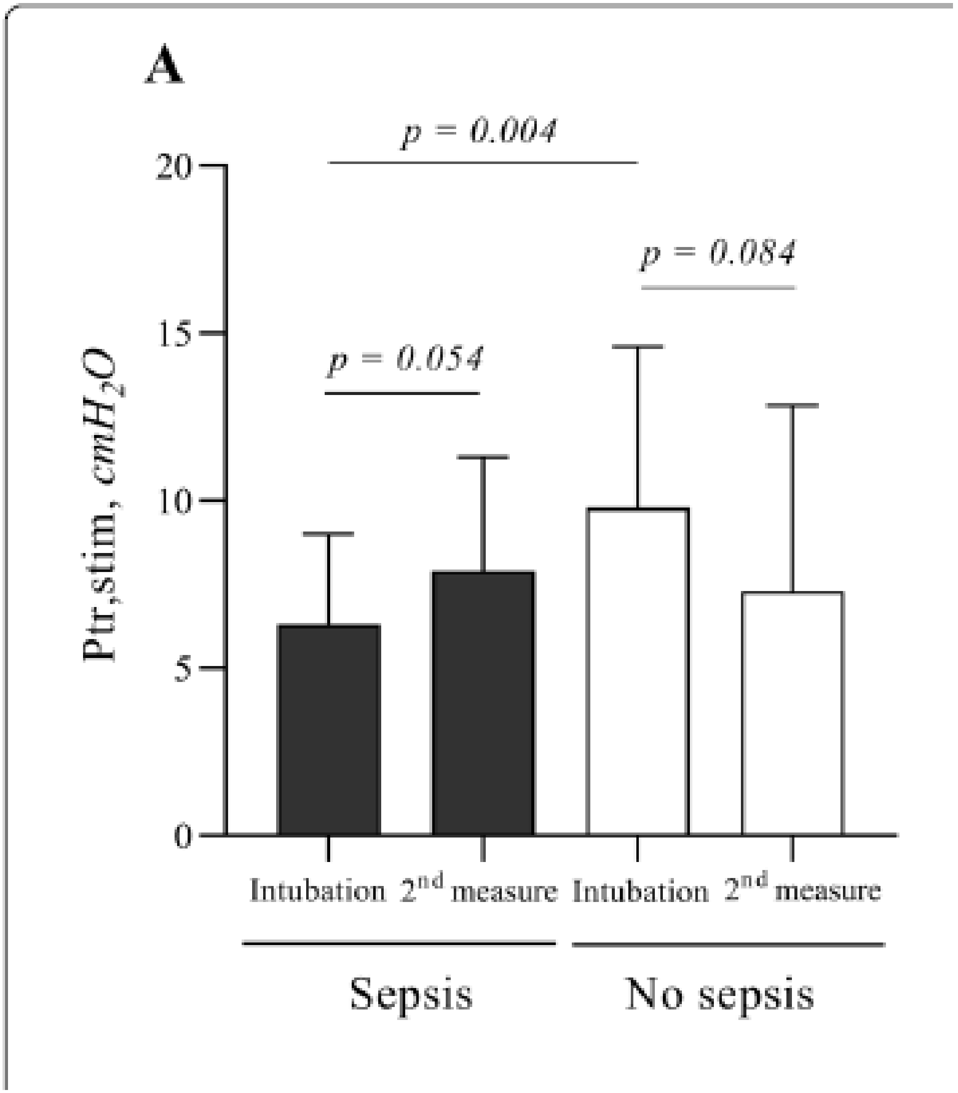


Fig. 2 Diaphragm function time course represented by endotracheal tube pressure induced by bilateral phrenic nerve stimulation during airway occlusion (Ptr,stim) according to time between intubation and measure in septic and non-septic patients. Each black circle represents a single measure of the diaphragm function for a given patient (184 circles in total). The lines represent the regression and the colored shaded areas represent 95% confidence interval for the regression curve



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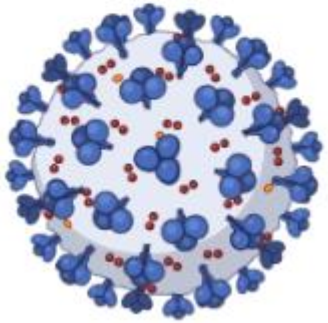

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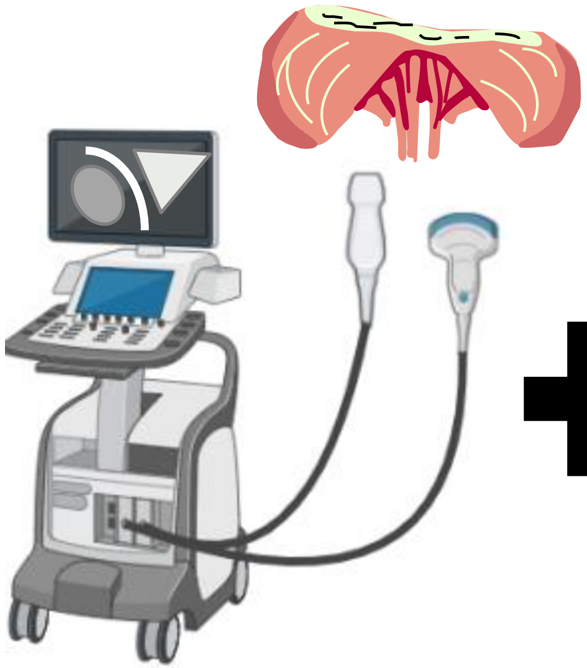

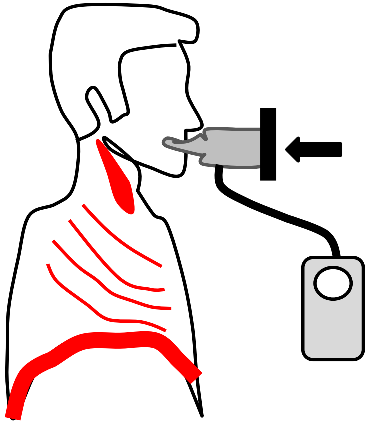

50 patients
61 ans, IMC 28k/m²

Epaisseur de diaphragme: 0,2cm
Fraction épaississement 150%

Pimax: 70cmH20
%Pimax théorique 70%

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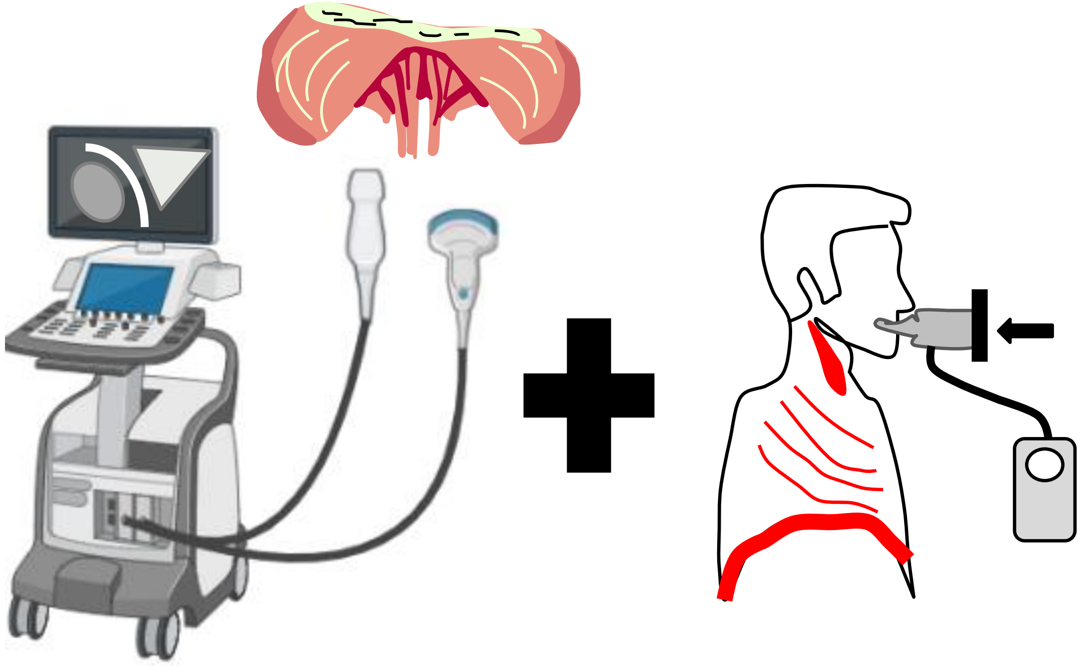
3 mois



3 mois

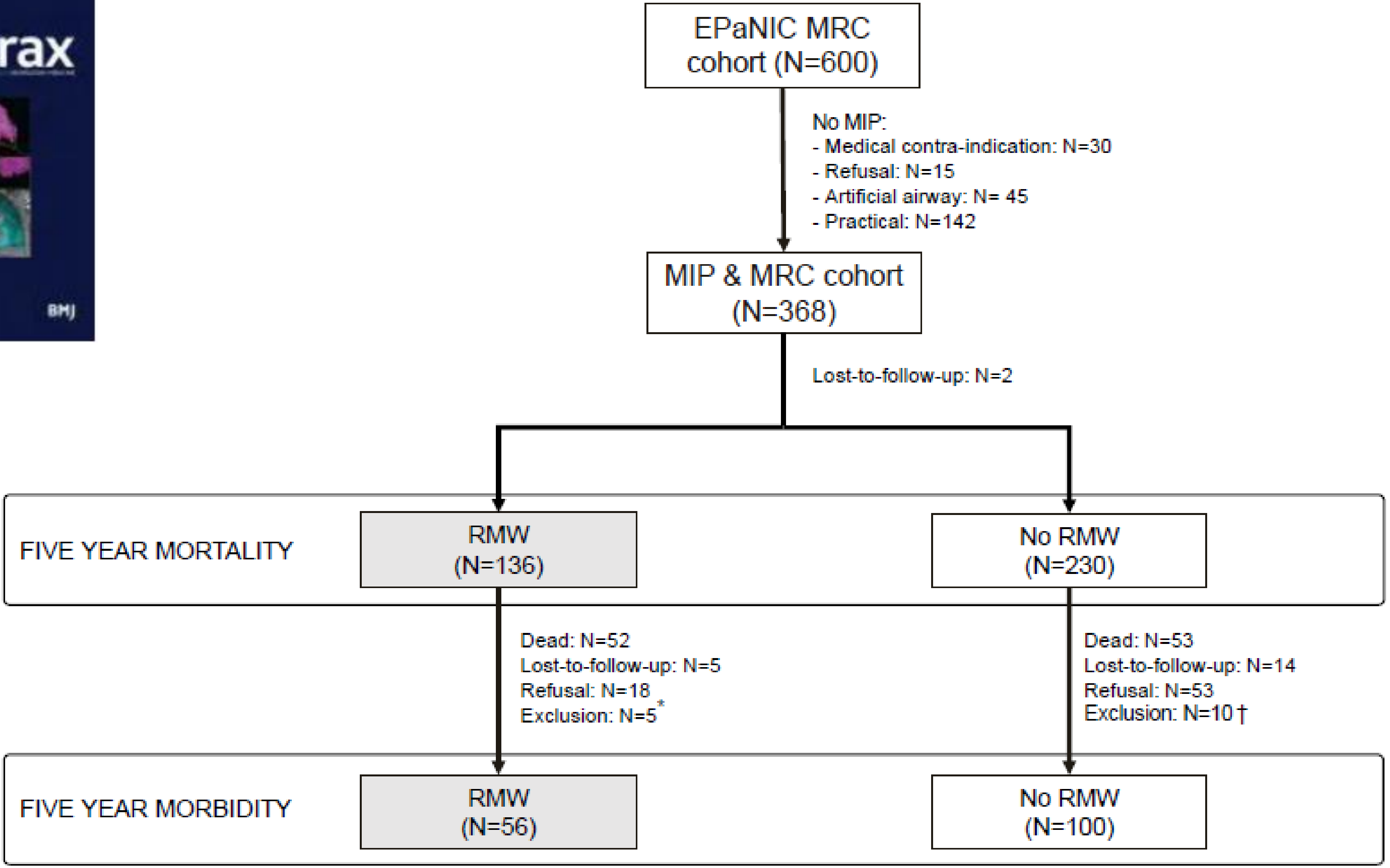
Epaisseur de diaphragme: 0,2cm
Fraction épaississement 150%

Pimax: 70cmH20
%Pimax théorique 70%

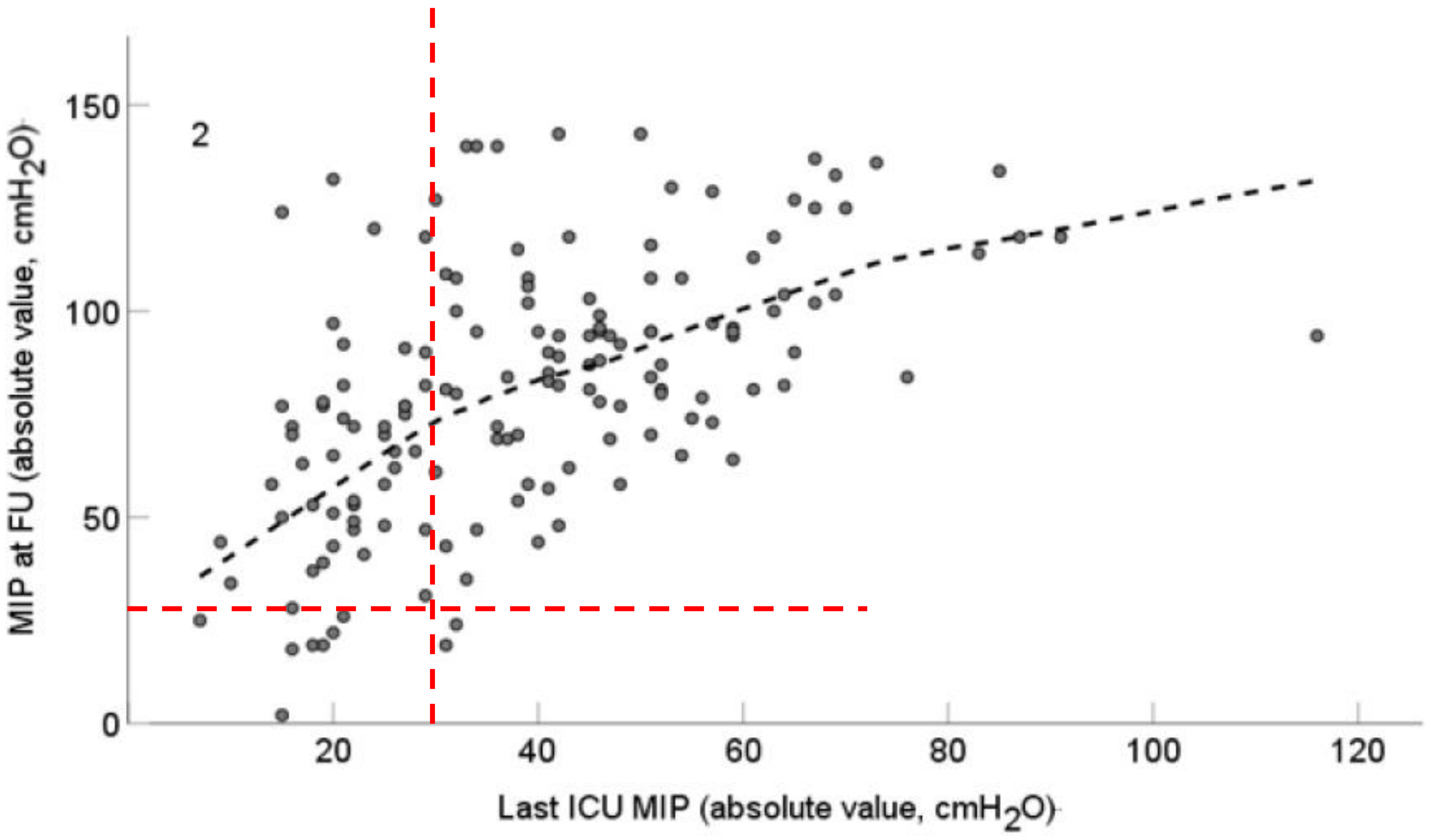
Diaphragm thickeness: +0.04cm

Diaphragm thickening fractio: +10%

Pimax: +13cmH20



Van Aerde, Thorax, 2022



Van Aerde, Thorax, 2022

Heart & Lung 59 (2023) 37–43

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journal homepage: www.heartandlung.com

Early passive orthostatic training prevents diaphragm atrophy and dysfunction in intensive care unit patients on mechanical ventilation: A retrospective case–control study

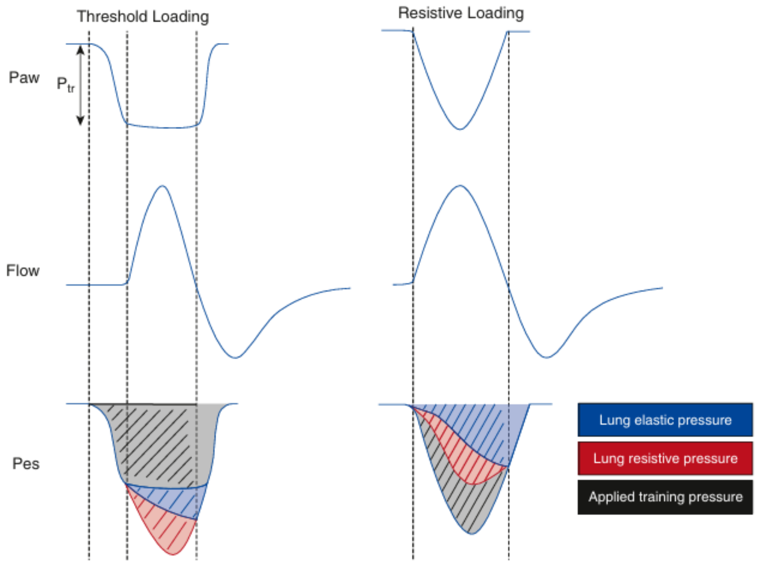
Table 4
Comparison of TD and TFdi values in the two groups after 7 days of early passive orthostatic training (at Day 8).

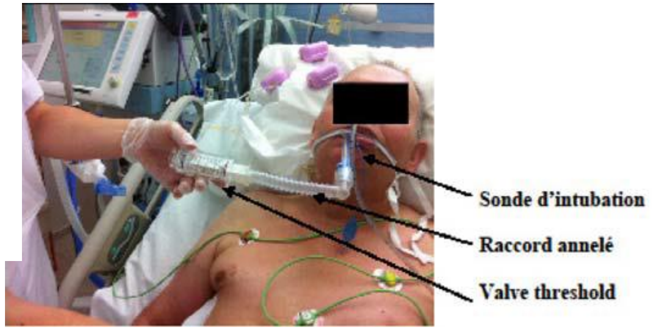
	NG (*n* = 37)	TG (*n* = 44)	*t*	*P* Value*
Tdi,ee (mm)	1.77 ± 0.29	1.91 ± 0.43	1.717	0.090
Tdi,ei (mm)	2.13 ± 0.37	2.34 ± 0.57	1.953	0.055
TFdi	0.20 ± 0.02	0.22 ± 0.03	3.450	0.001

NOTE. Values are means ± SDs.
Abbreviations: TD, thickness of the diaphragm; Tdi,ee, diaphragmatic thickness at end-expiration; Tdi,ei, diaphragmatic thickness at end-inspiration; TFdi, diaphragm thickening fraction; NG, no-training group; TG, training group.
* Estimated by independent *t tests*.

Original Article J Clin Med Res. 2017;9(11):929-934

Inspiratory Muscle Training in the Intensive Care Unit: A New Perspective





ICU DIAPHRAGM protective strategies?

CLÉMENT MEDRINAL
GROUPE HOSPITALIER DU HAVRE
SRLF 2024

CRITICAL CARE PERSPECTIVE

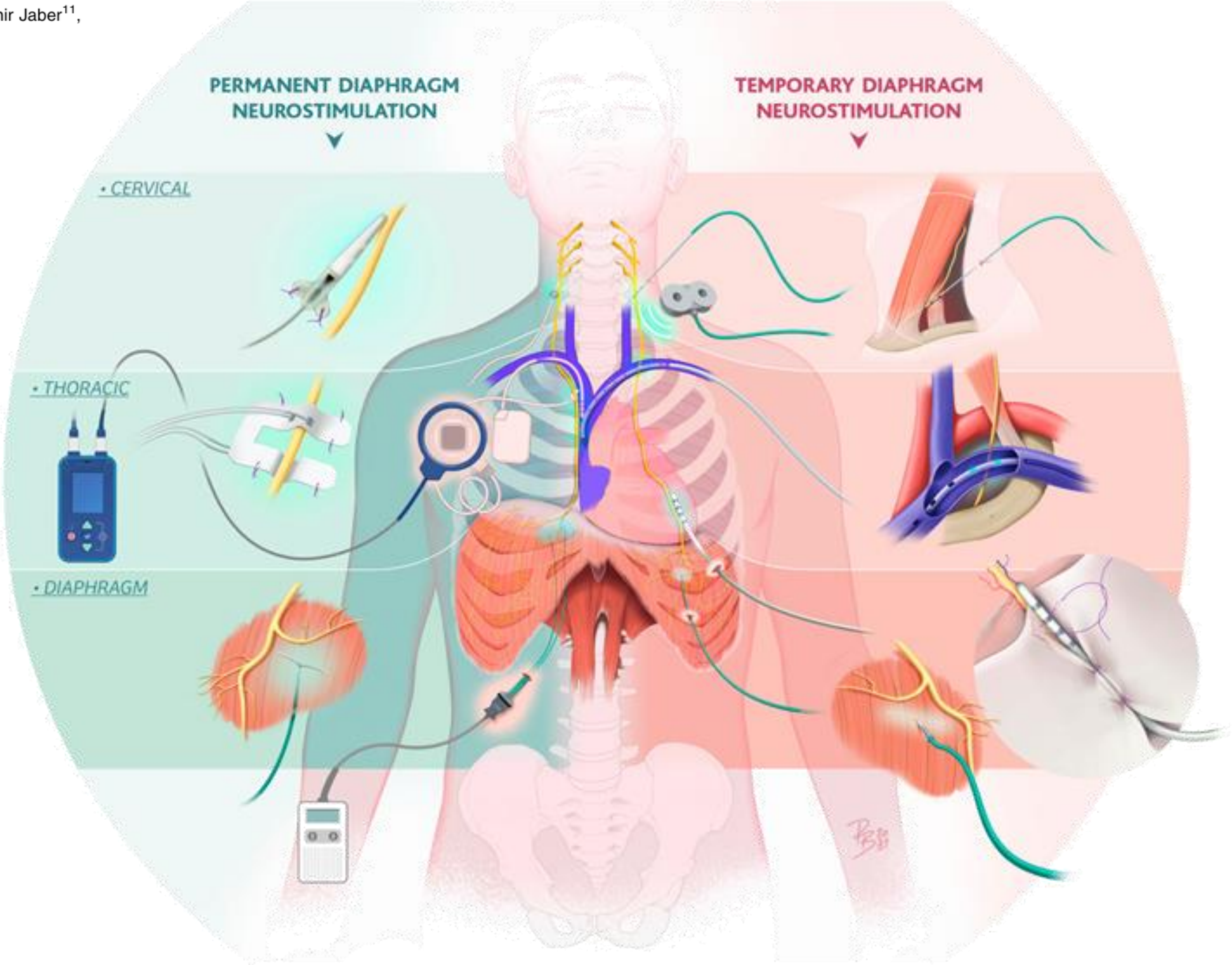
Diaphragm Neurostimulation Assisted Ventilation in Critically Ill Patients

Harry Etienne[1,2], Idunn S. Morris[3,4,5,6], Greet Hermans[7,8], Leo Heunks[9], Ewan C. Goligher[3,4,5,10], Samir Jaber[11], Capucine Morelot-Panzini[1,12], Jalal Assouad[1,2], Jésus Gonzalez-Bermejo[1,13], Laurent Papazian[14], Thomas Similowski[1,15], Alexandre Demoule[1,16], and Martin Dres[1,16]

MIP

=

Length of MV



CRITICAL CARE PERSPECTIVE

Lung- and Diaphragm-Protective Ventilation

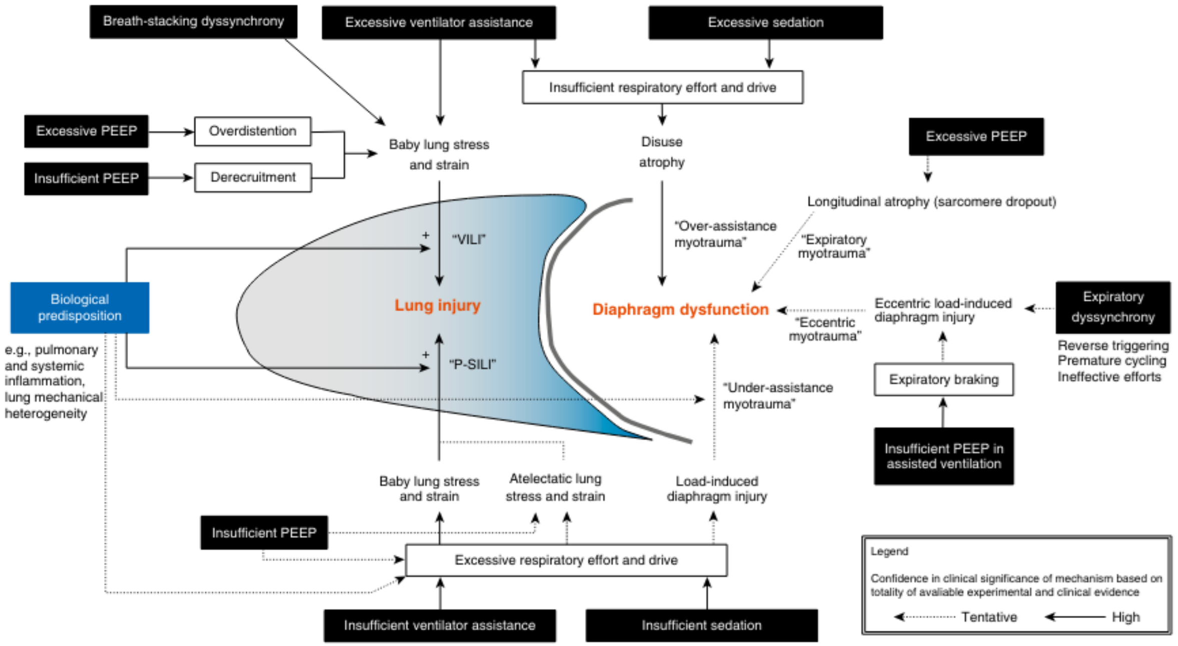
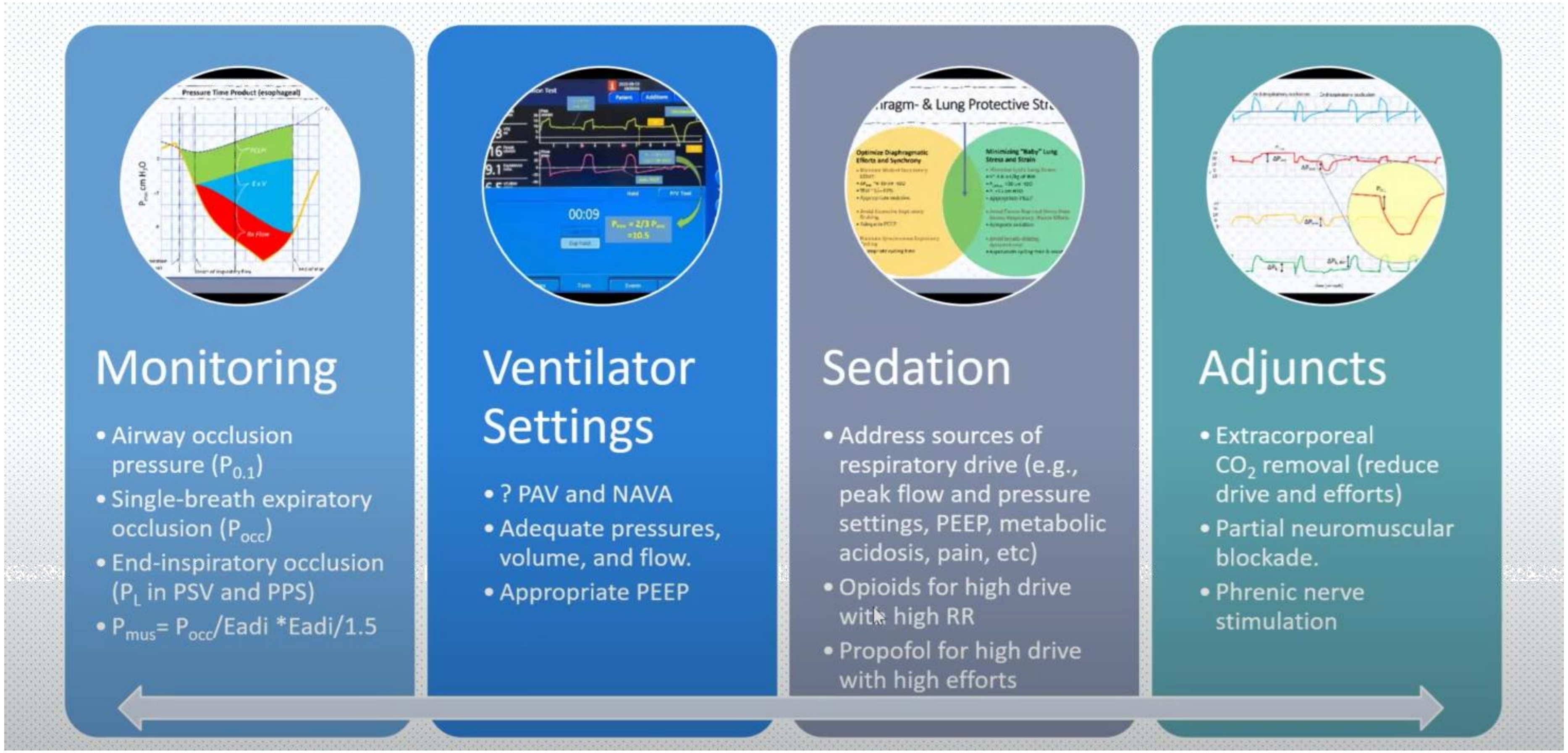


Table 3. Potential Therapeutic Targets for Diaphragm Protection

Goal	Potential Therapeutic Target*
Prevent overassistance myotrauma	Any 1 of: Pmus ⩾ 3 to 5 cm H_2O ΔPdi ⩾ 3 to 5 cm H_2O ΔPes ⩽ −3 to −2 cm H_2O $P_{0.1}$ > 1 to 1.5 cm H_2O TFdi ⩾ 15% EAdi ⩾ target value selected on the basis of Pocc-EAdi index and above targets
Prevent underassistance myotrauma	Any 1 of: Pmus ⩽ 10 to 15 cm H_2O ΔPdi ⩽ 10 to 15 cm H_2O ΔPes ⩾ −12 to −8 cm H_2O Pocc ⩾ −20 to −15 cm H_2O $P_{0.1}$ < 3.5 to 5 cm H_2O TFdi ⩽ 30% to 40% EAdi ⩽ 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

Implementation



Take Home Message

Rehabilitation of respiratory muscles in intensive care presents numerous limitations (workload, cooperation capacity, risks) for uncertain benefits.

Respiratory muscles may have a spontaneously favorable long-term evolution.

Strategies for diaphragm prevention are recent, difficult to implement, and require further research.

Thank you for your attention