Optimiser la stimulation des muscles locomoteurs

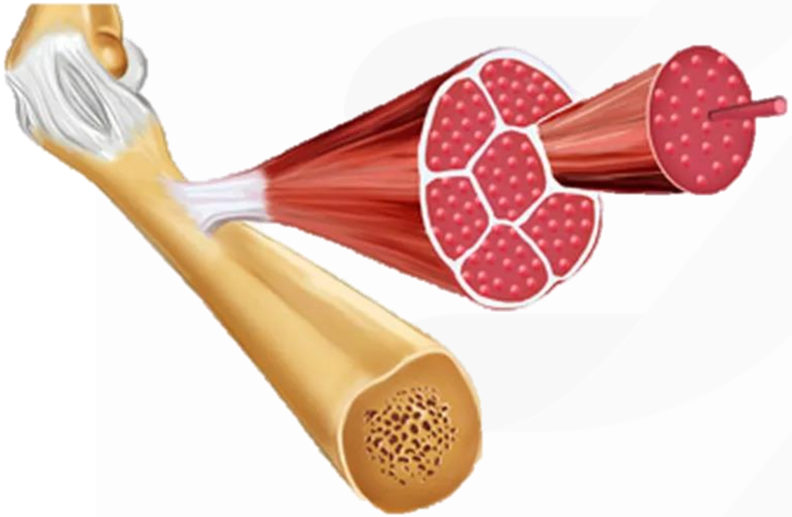
Guillaume FOSSAT
KCC, PhD Student
CHU Orléans
Guillaume.fossat@chu-orleans.fr

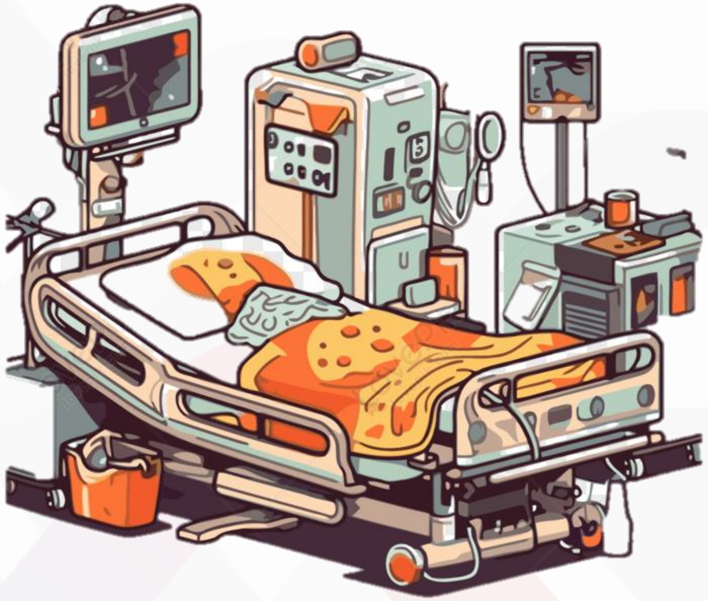
AUCUN CONFLIT D’INTERÊT


SPORT-ELEC®
DÉCOUVREZ
L'ÉLECTROSIMULATION
L'électrostimulation permet de faire travailler la masse musculaire par zone pour des effets de massage de préparation avant effort, de récupération après efforts et de musculation.

Le muscle du patient de réanimation

Une réelle problématique





PATHOLOGIES MUSCULAIRES ACQUISES EN RÉANIMATION

IMMOBILITÉ / ABSENCE DE CONTRAINTE

1. Production de marqueurs de l'inflammation => protéolyse musculaire
2. Diminution des filaments d'actine => diminution de force (5%/sem)
3. Diminution de la synthèse protéique
4. Accélération de la dégradation protéique

Etat septique accélère ces phénomènes

Catabolisme protéique = 2% par j de réanimation

Section de la fibre diminue de 4% par j de réanimation

FAIBLESSE ACQUISE EN RÉANIMATION

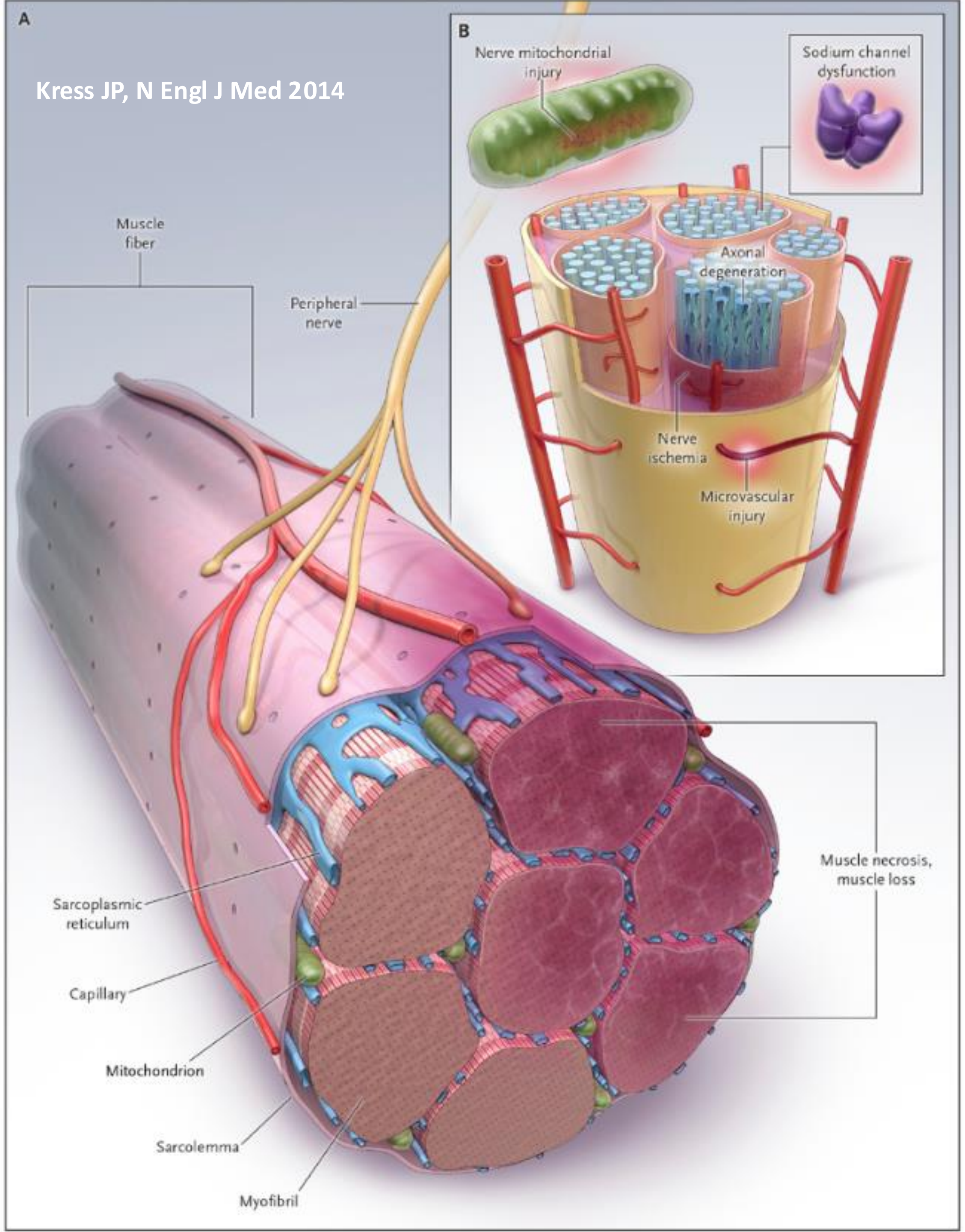
Intensive Care Unit Acquired Weakness

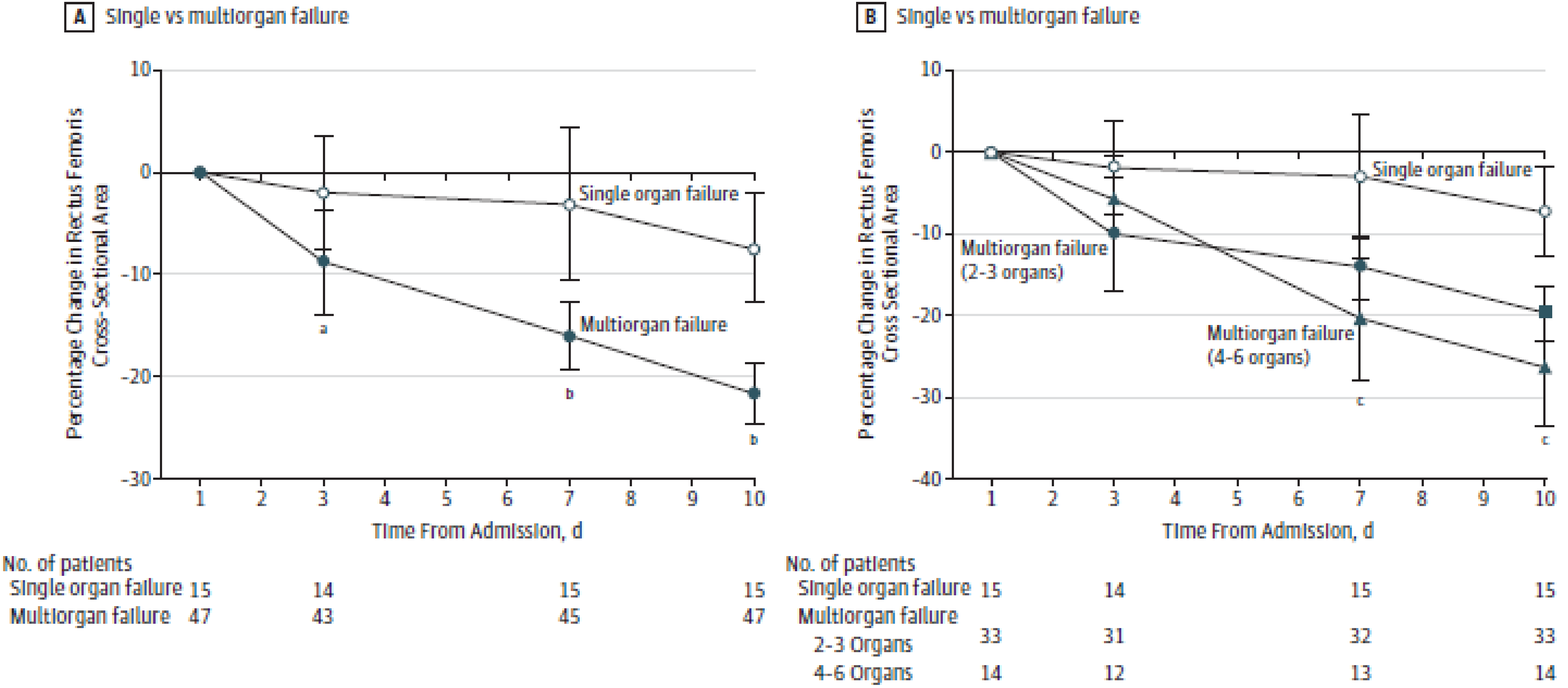
Faiblesse musculaire cliniquement observée avec comme seule cause le séjour en réanimation

3 types de ICUAW

1. Polyneuropathie avec atteinte axonale sensorimotrice.
2. Myopathie de réanimation avec atteinte musculaire.
3. Neuro-myopathie de réanimation avec implication neuromusculaire.

Schefold ; J Cachexia Sarcopenia Muscle ; 2010





Majorée par la défaillance multi-organes

Puthucheary, JAMA, 2013

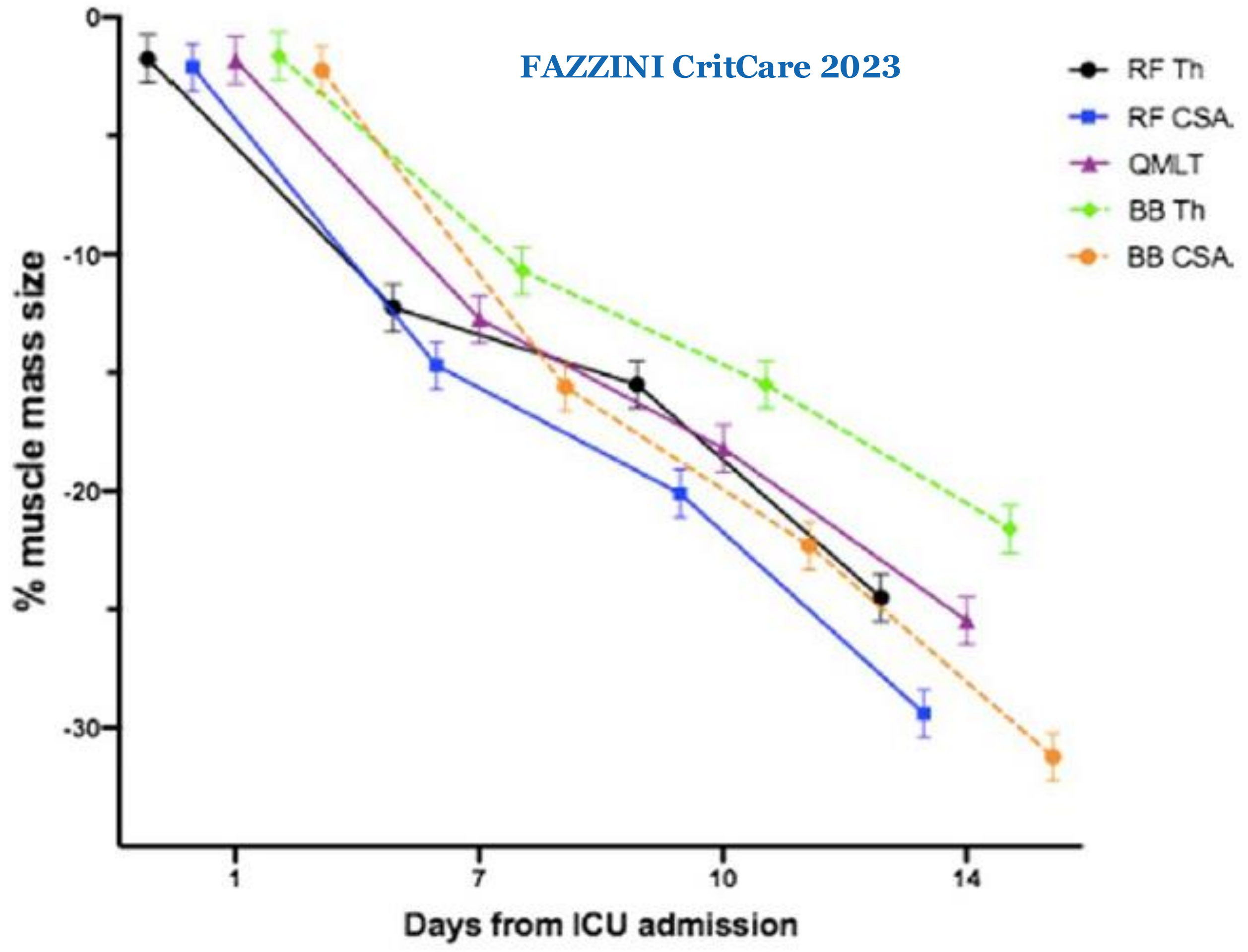
REVIEW Open Access

The rate and assessment of muscle wasting during critical illness: a systematic review and meta-analysis

Brigitta Fazzini[1*], Tobias Märkl[2], Christos Costas[3], Manfred Blobner[4,5,6], Stefan J. Schaller[4,5], John Prowle[1,3], Zudin Puthucheary[1,3†] and Henning Wackerhage[2*†]

Conclusion

Critically ill patients suffer from early and marked muscle wasting. Ultrasound is the most used assessment tool in evaluating loss in muscle mass over time. The muscle mass is about 2% per day, but this rate is different between muscles and depends upon the measurement taken. The prevalence of ICU-AW is 50% amongst critically ill and those have worst outcomes.



% RF th	-1.75	-12.25	-15.5	-24.5
% RF CSA	-2.10	-14.7	-20.1	-29.4
% QMLT	-1.82	-12.74	-18.2	-25.48
% BB Th	-1.64	-10.7	-15.5	-21.6
% BB CSA	-2.23	-15.61	-22.30	-31.22

Fig. 2 Loss in muscle mass from day 1 to day 14 of ICU admission. Abbreviations: percentage, %; rectus femoris: RF; cross-sectional area: CSA, thickness: Th, quadriceps muscle layer thickness: QMLT; biceps brachii: BB

La stimulation électrique

Peut-elle endiguer ce phénomène?

GRUNOW Crit Care 2019

Grunow et al. Critical Care (2019) 23:308
https://doi.org/10.1186/s13054-019-2540-4
Critical Care
RESEARCH Open Access

Differential contractile response of critically ill patients to neuromuscular electrical stimulation

Julius J. Grunow[1], Moritz Goll[1], Niklas M. Carbon[1], Max E. Liebl[2], Steffen Weber-Carstens[1,3] and Tobias Wollersheim[1,3*]

We were able to show that at the initiation of NMES, only two thirds of stimulations led to a contractile response in our cohort and that this number declined to one third throughout the first 7 days of stimulation, which we think is due to progressing pathophysiological processes. Established mechanisms that would hypothetically contribute to this effect are channelopathy, decreasing metabolic flexibility, advanced muscle atrophy and edema.

Table 1 Baseline characteristics

n		21
Sex (m/f)		16/76.2% / 5/ 23.8%
Age (years)		53.0 (45.0/70.0)
Weight (kg)		85.0 (75.0/100.0)
Height (m)		1.78 (1.74/1.80)
BMI (kg/m^2)		27.1 (24.2/30.9)
Diagnosis responsible for ICU admission	ARDS	8/38.1%
	Sepsis	3/14.3%
	Multiple trauma	7/33.3%
	Neurologic	2/9.5%
	Miscellaneous	1/4.8%
SOFA at ICU admission		13.0 (11.0/15.0)
APACHE II at ICU admission		25.0 (20.0/28.0)
SAPS2 at ICU admission		58.0 (47.0/65.0)
GCS at ICU admission		5.0 (3.0/6.0)
Time until first awakening (days)		17.0 (10.0/25.0)
ICU length of stay (days)		32.0 (21.0/43.0)
Percent of days with RASS > − 3 during ICU stay		64.3 (37.5/79.3)
Noradrenalin (µg/kg min)		0.07 (0.05/0.11)
Time requiring noradrenalin (days)		12.0 (9.0/18.0)
Survivors/non-survivors		18/85.7% / 3/ 14.3%
Non-excitable muscle membrane/excitable muscle membrane		7/50% / 7/50%
Start of NMES treatment after ICU admission (days)		3.0 (2.0/6.0)

Grunow *et al. Critical Care* (2019) 23:308
https://doi.org/10.1186/s13054-019-2540-4

Critical Care

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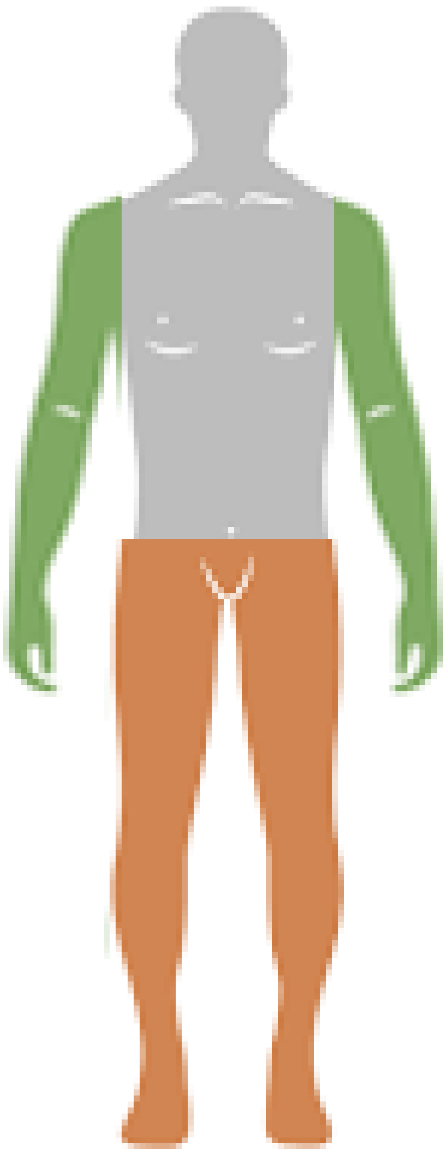
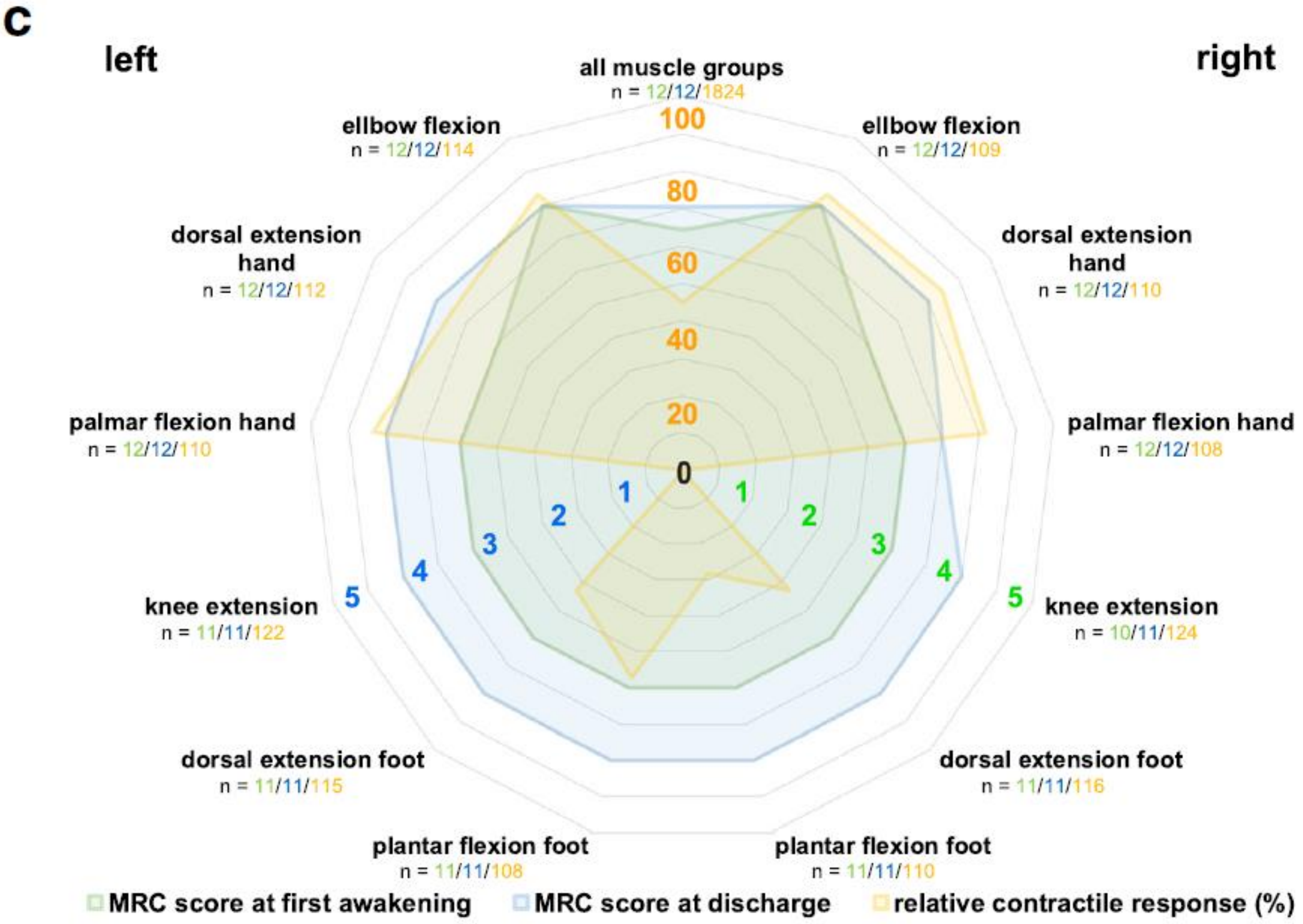
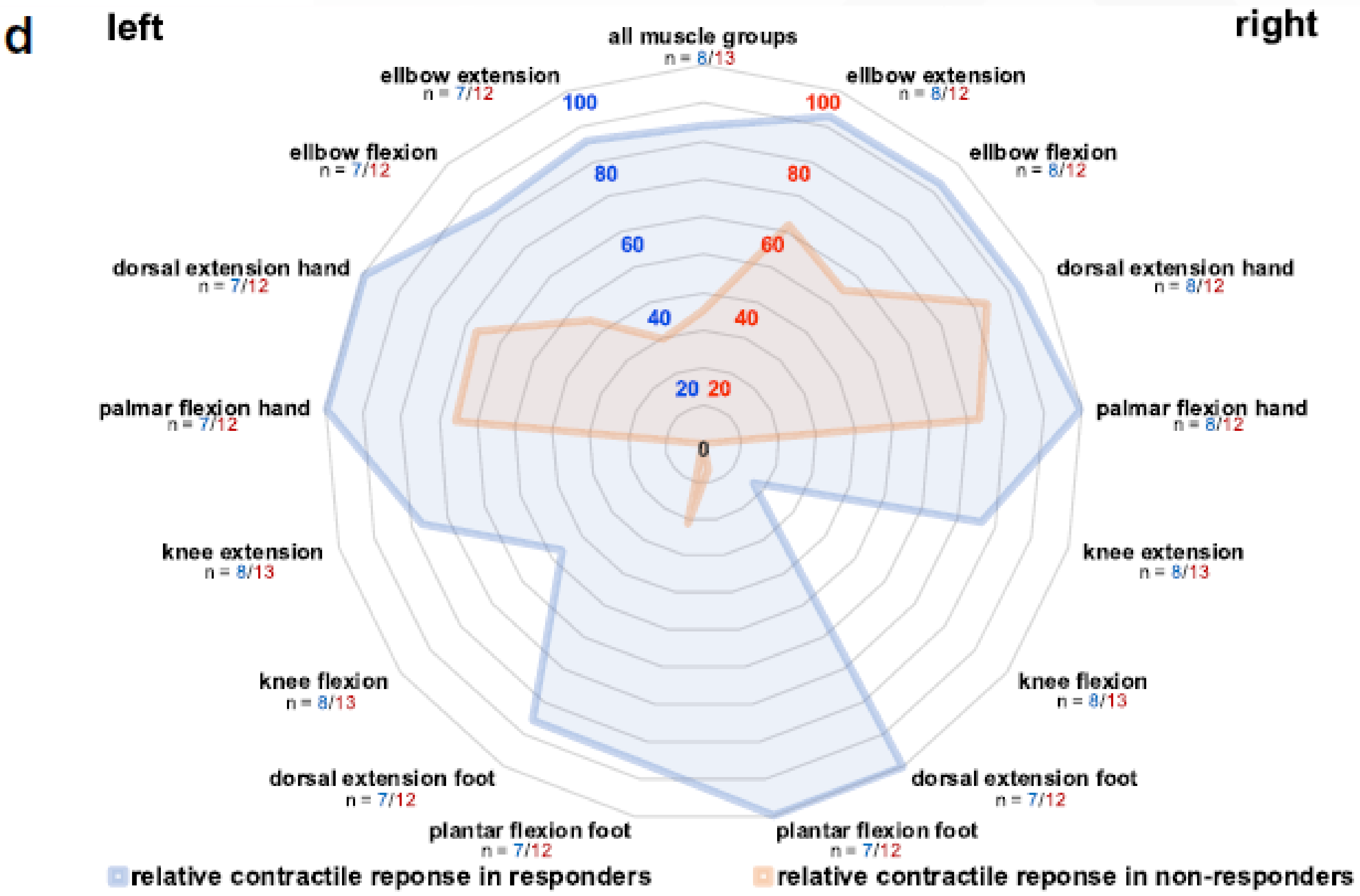
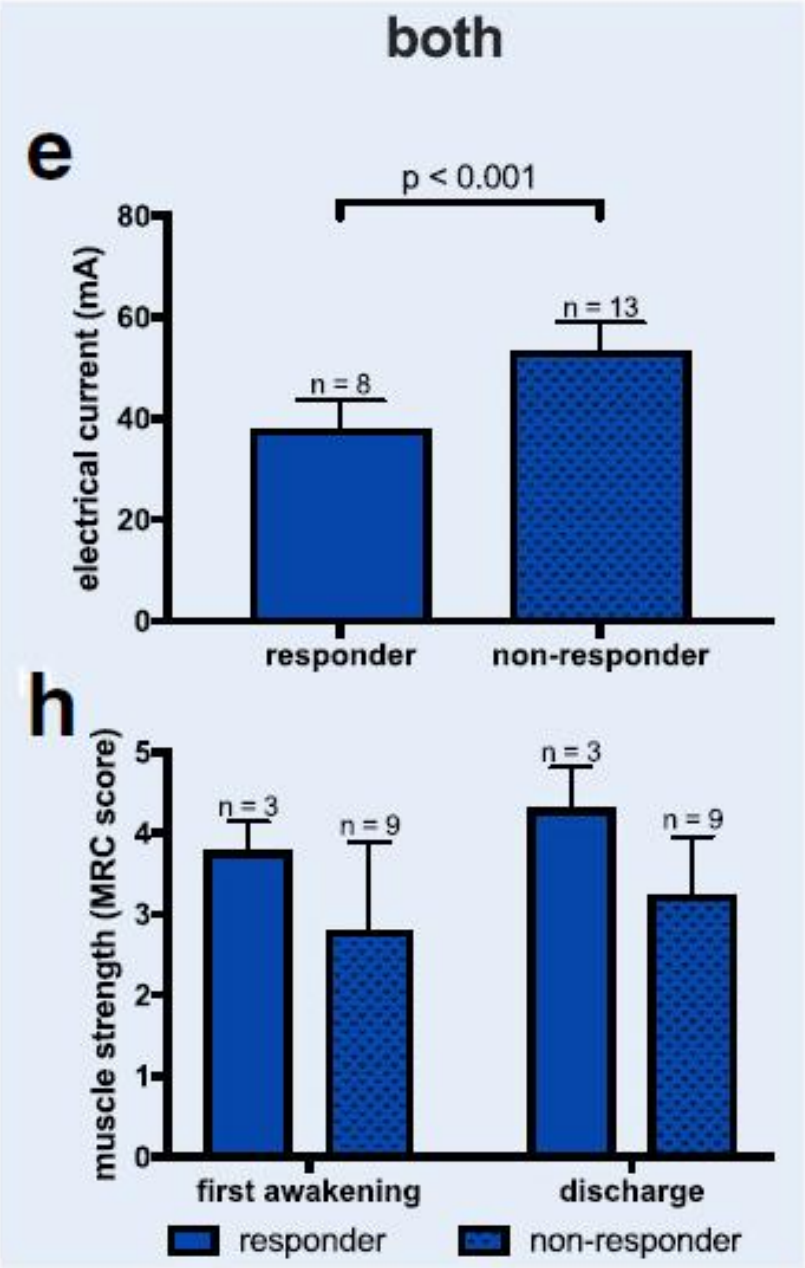
Patients

Mechanically ventilated patients ≥ 18 years of age were included on the basis of a Sepsis-related Organ Failure Assessment (SOFA) score ≥ 9 within the first 72 h after ICU admission as well as written informed consent by a legal proxy and excluded if any of the following applied: prior hospital treatment for longer than 7 days, illness prohibiting early mobilisation, pre-existing neuromuscular disease, insulin-dependent diabetes mellitus, Body Mass Index > 35 kg/m^2, not ambulating before admission or poor prognosis with a high likelihood of death within the next hours.

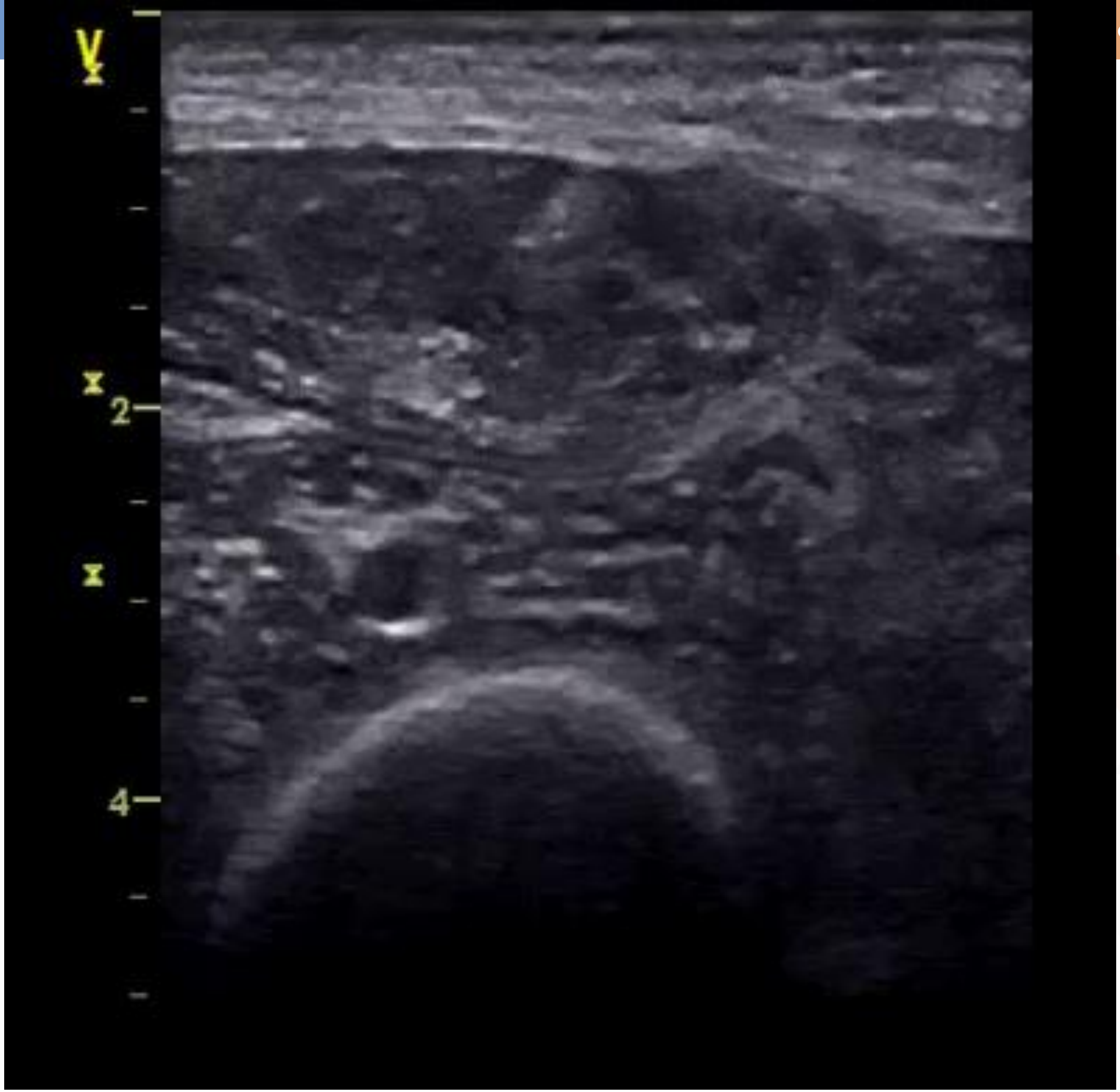


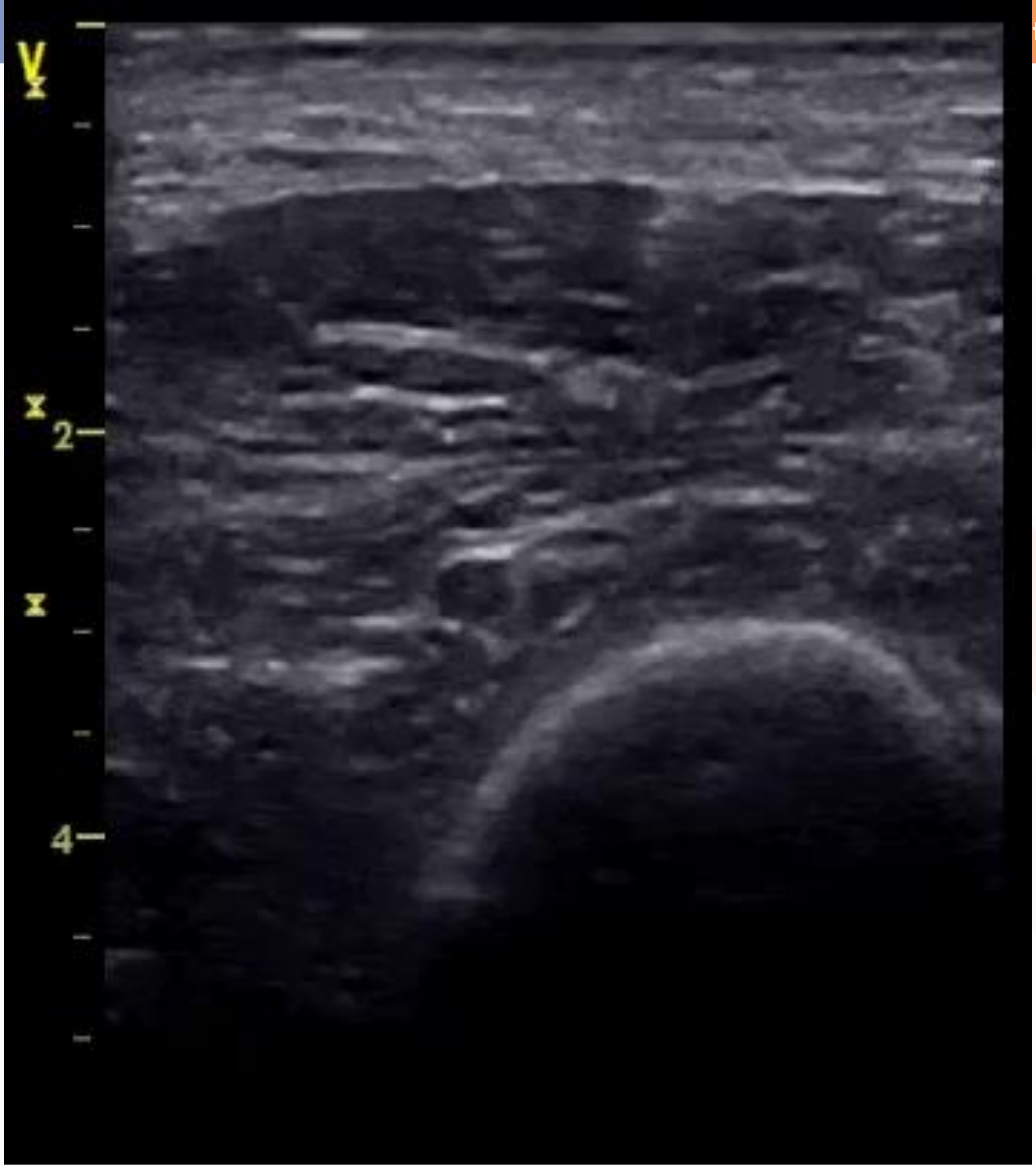

c
left
right
all muscle groups
n = 12/12/1824
ellbow flexion
n = 12/12/114
ellbow flexion
n = 12/12/109
dorsal extension hand
n = 12/12/112
dorsal extension hand
n = 12/12/110
palmar flexion hand
n = 12/12/110
palmar flexion hand
n = 12/12/108
knee extension
n = 11/11/122
knee extension
n = 10/11/124
dorsal extension foot
n = 11/11/115
dorsal extension foot
n = 11/11/116
plantar flexion foot
n = 11/11/108
plantar flexion foot
n = 11/11/110
100
80
60
40
20
0
1
2
3
4
5
1
2
3
4
5
MRC score at first awakening
MRC score at discharge
relative contractile response (%)


d
left
right
all muscle groups
n = 8/13
ellbow extension
n = 7/12
ellbow extension
n = 8/12
ellbow flexion
n = 7/12
ellbow flexion
n = 8/12
dorsal extension hand
n = 7/12
dorsal extension hand
n = 8/12
palmar flexion hand
n = 7/12
palmar flexion hand
n = 8/12
knee extension
n = 8/13
knee extension
n = 8/13
knee flexion
n = 8/13
knee flexion
n = 8/13
dorsal extension foot
n = 7/12
dorsal extension foot
n = 7/12
plantar flexion foot
n = 7/12
plantar flexion foot
n = 7/12
100
80
60
40
20
0
relative contractile reponse in responders
relative contractile reponse in non-responders


both
e
p < 0.001
electrical current (mA)
80
60
40
20
0
n = 8
n = 13
responder
non-responder
h
muscle strength (MRC score)
5
4
3
2
1
0
n = 3
n = 9
n = 3
n = 9
first awakening
discharge
responder
non-responder

En vidéo


2
4


V
2
4

Des preuves hétérogènes

Préservation de la masse musculaire ?

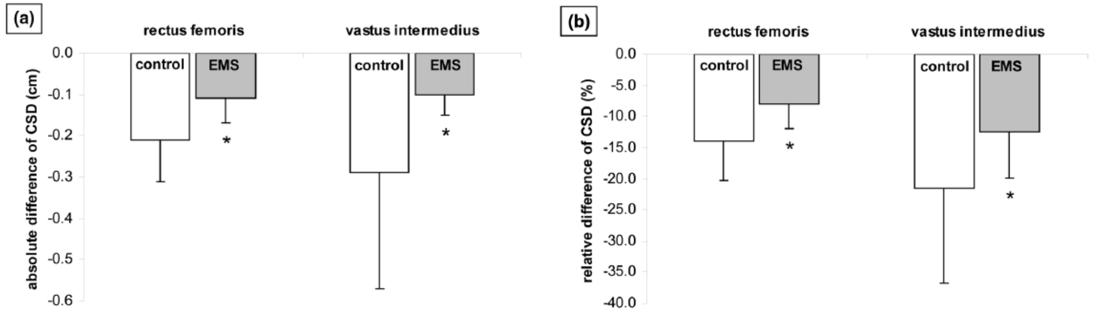
Research

Open Access

Electrical muscle stimulation preserves the muscle mass of critically ill patients: a randomized study

Vasiliki Gerovasili[1], Konstantinos Stefanidis[1], Konstantinos Vitzilaios[1], Eleftherios Karatzanos[1], Panagiotis Politis[1], Apostolos Koroneos[1], Aikaterini Chatzimichail[2], Christina Routsi[1], Charis Roussos[1] and Serafim Nanas[1]

- Evaluation par Echographie
- Stimulation électrique quadriceps + Fibulaires
- J2-J9
- Ondes biphasique 12sec contraction/ 6s repos
- 55 minutes (5 échauffement/5repos)
- 13/13 patients



(a) Absolute difference (cm) and (b) relative difference (%) in cross sectional diameter (CSD) of right rectus femoris and vastus intermedius in the control (n = 13) and EMS (n = 13) groups (mean ± standard deviation). *significant between-group difference ($P < 0.05$). EMS = electrical muscle stimulation.

=>Fonte moins marquée si ESM

Gerovasili V, et al. Crit Care. 2009

JAMA Network

Can early in-bed leg cycling and electrical stimulation of the quadriceps muscles improve muscle function in critically ill adults?

CONCLUSION Early in-bed cycling and electrical stimulation of the quadriceps muscles did not improve muscle strength in critically ill patients

POPULATION

201 Men 111 Women

Patients likely to remain in the ICU for >48 hours and who could ambulate before their ICU admission

Mean age: 66 years

LOCATIONS

1
Single center in France

INTERVENTION

314 Patients randomized
(312 analyzed because 2 patients withdrew consent)

158
Early in-bed cycling
daily 15-minute session
Electrical stimulation
of the quadriceps muscles
In addition to standardized early rehabilitation

154
Standardized early rehabilitation

PRIMARY OUTCOME

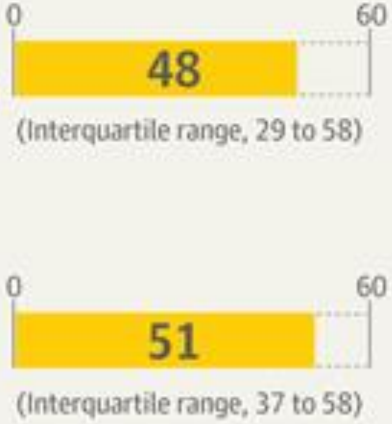
Muscle strength at ICU discharge on a scale of 0-60 (a higher score reflects better strength)

FINDINGS

Muscle strength at ICU discharge (0-60)

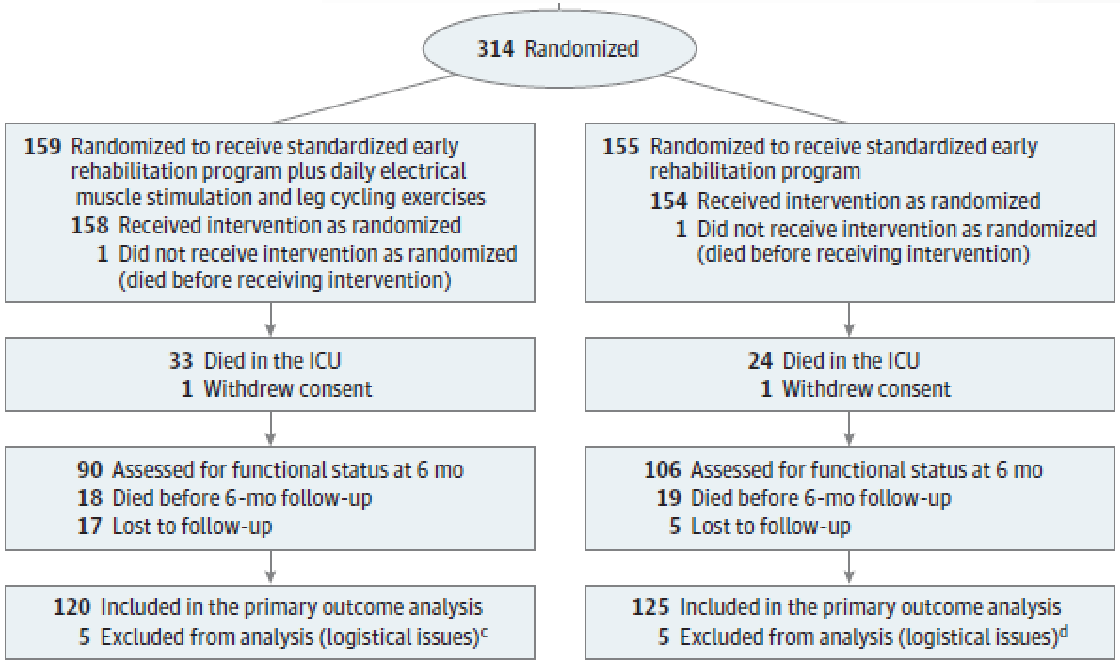
Early in-bed cycling, electrical stimulation, and **standardized early rehabilitation**

Standardized early rehabilitation



Median difference between groups:
-3.0
(95% CI, -7.0 to 2.8)

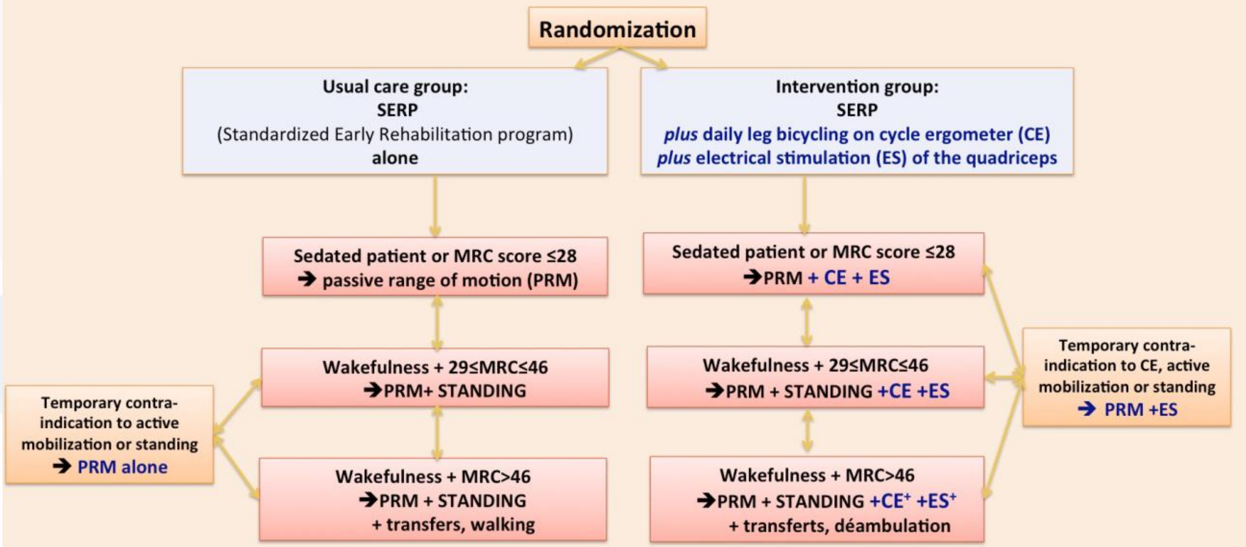
Fossat G, Baudin F, Courtes L, et al. Effect of in-bed leg cycling and electrical stimulation of the quadriceps on global muscle strength in critically ill adults: a randomized clinical trial [published July 24, 2018]. *JAMA*. doi:10.1001/jama.2018.9592



JAMA | Preliminary Communication

Effect of In-Bed Leg Cycling and Electrical Stimulation of the Quadriceps on Global Muscle Strength in Critically Ill Adults
A Randomized Clinical Trial

Guillaume Fossat, PT; Florian Baudin, PT; Léa Courtes, PT; Sabrine Bobet, PT; Arnaud Dupont, PT; Anne Bretagnol, MD; Dalila Benzekri-Lefèvre, MD; Toufik Kamel, MD; Grégoire Muller, MD; Nicolas Bercault, MD; François Barbier, MD, PhD; Isabelle Runge, MD; Mai-Anh Nay, MD; Marie Skarzynski, MD; Armelle Mathonnet, MD; Thierry Boulain, MD



- Electrical stimulation of the quadriceps following the 54-min "atrophy prevention program"
  - *Sedated patient (Ramsay score> 3 and RASS <0) or in awaking phase and MRC≤28*
  - *Patient in the awakening phase and 29≤MRC≤46*
  - *Awake patient and 29≤MRC≤46*
- Electrical stimulation of the quadriceps following the 20-min "muscle building" program
  - *Awake and 47≤MRC*

JAMA | Preliminary Communication

Effect of In-Bed Leg Cycling and Electrical Stimulation of the Quadriceps on Global Muscle Strength in Critically Ill Adults
A Randomized Clinical Trial

Guillaume Fossat, PT; Florian Baudin, PT; Léa Courtes, PT; Sabrine Bobet, PT; Arnaud Dupont, PT; Anne Bretagnol, MD; Dalila Benzekri-Lefèvre, MD; Toufik Kamel, MD; Grégoire Muller, MD; Nicolas Bercault, MD; François Barbier, MD, PhD; Isabelle Runge, MD; Mai-Anh Nay, MD; Marie Skarzynski, MD; Armelle Mathonnet, MD; Thierry Boulain, MD

	Median (IQR)[a]			
	Intervention Group (n = 158)	Usual Care Group (n = 154)	Between-Group Difference (95% CI)[b]	*P* Value
Primary Outcome				
Global MRC score at ICU discharge among ICU survivors[12,c]	48 (29 to 58)	51 (37 to 58)	MD, −3.0 (−7.0 to 2.8)	.28[d]
Change from study inclusion to ICU discharge				
Rectus femoris muscle thickness, mm	−1.9 (−8.0 to 0.2)	−2.4 (−7.1 to −0.3)	MD, −0.5 (−1.0 to 2.4)	.17[d]
Invasive mechanical ventilation, d				
Intention-to-treat population	5 (2 to 10)	5 (2 to 11)	MD, 0 (−2.0 to 1.5)	.69[h]
ICU survivors				
Frequency of reintubation within 48 h after first extubation, No./total (%) [95% CI]	12/131 (9.2)[5.3 to 15.3]	13/133 (9.8)[5.8 to 16.0]	ARR, 0.7 (−6.7 to 7.9)	>.99[g]

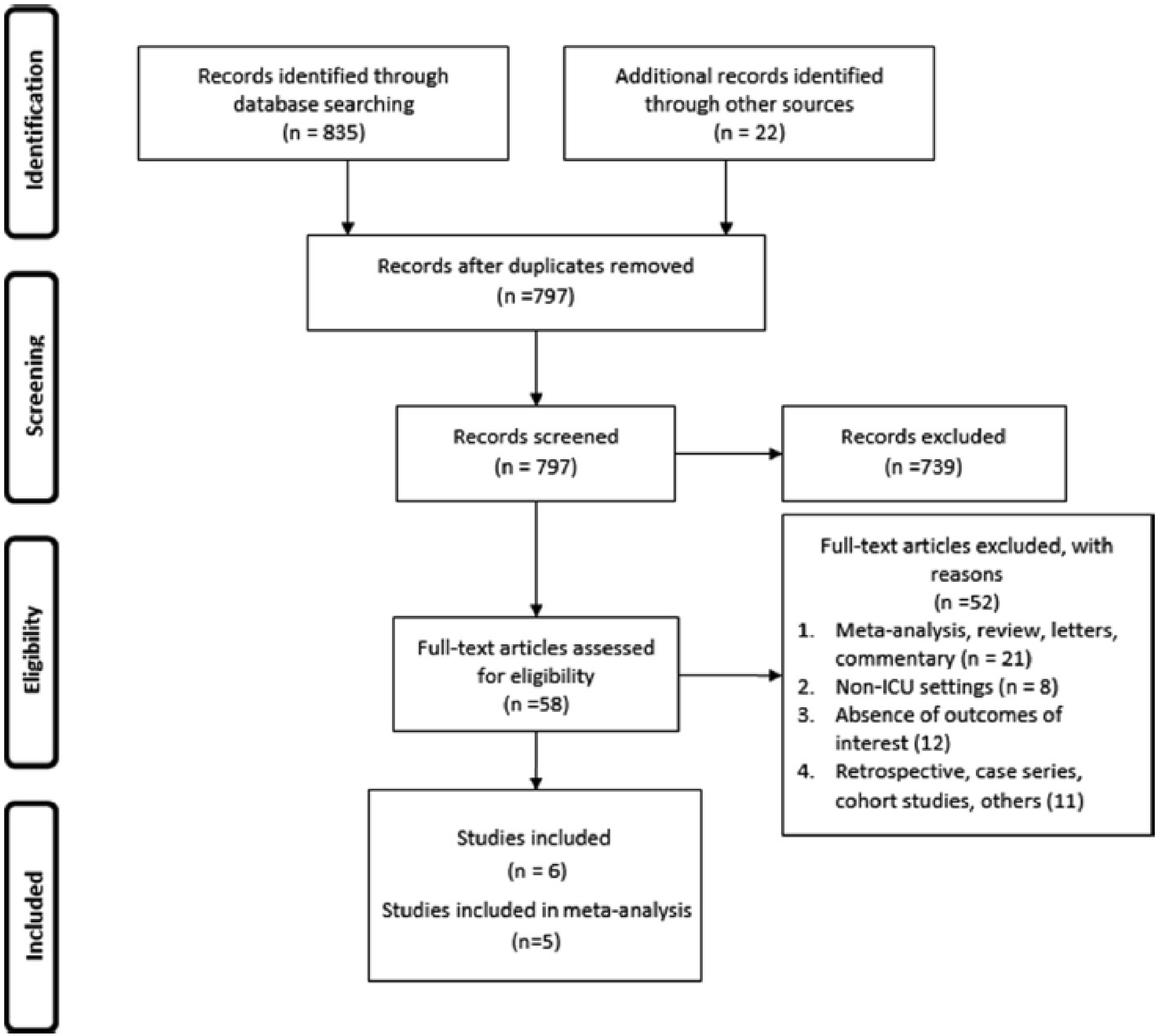


Fig. 1. Flow diagram for literature search and study selection.

Australian Critical Care 33 (2020) 203–210

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ELSEVIER

Review paper

Effects of neuromuscular electrical stimulation in critically ill patients: A systematic review and meta-analysis of randomised controlled trials

Y. Zayed, MD [a,*]
B. Kheiri, MD MRCP [a]
M. Barbarawi, MD [a]
A. Chahine, MD [a]
L. Rashdan, MD [a]
S. Chintalapati, MD [a]
G. Bachuwa, MD MS MHSA [a]
I. Al-Sanouri, MD [b]

[a] Department of Internal Medicine, Hurley Medical Center/Michigan State University, Flint, MI, 48503, USA
[b] Pulmonary and Critical Care Department, Hurley Medical Center/Michigan State University, Flint, MI, 48503, USA

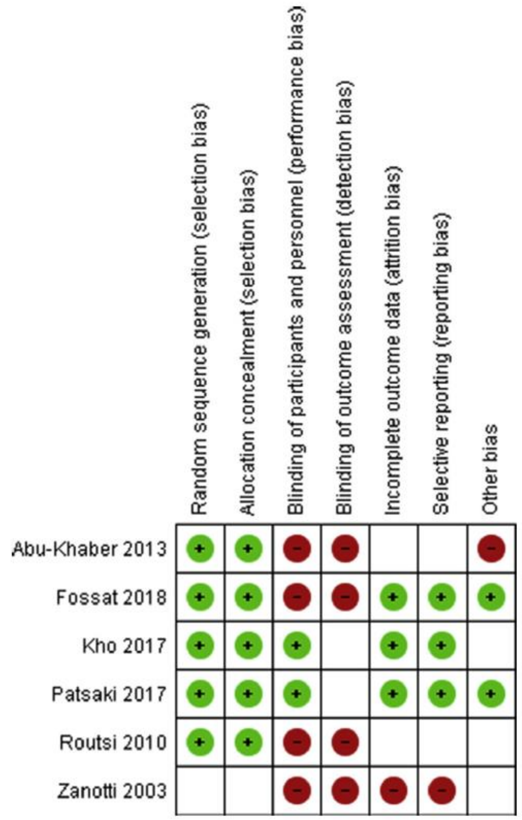

Fig. 2. Risk of bias assessment based on authors' judgement. Blank squares indicate unclear risk of bias.

Study or Subgroup	NES Mean	NES SD	NES Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Routsi 2010	56.75	2.25	24	52	4.5	28	24.7%	4.75 [2.86, 6.64]	2010
Abu-Khaber 2013	20.6	5.68	36	21	9.76	34	20.0%	-0.40 [-4.17, 3.37]	2013
Patsaki 2017	50	13	63	51	10	65	19.3%	-1.00 [-5.03, 3.03]	2017
Kho 2017	49	6	16	48	8	18	17.5%	1.00 [-3.72, 5.72]	2017
Fossat 2018	45.33	22.44	158	48.66	15.71	154	18.6%	-3.33 [-7.62, 0.96]	2018
Total (95% CI)			**297**			**299**	**100.0%**	**0.45 [-2.89, 3.80]**	

Heterogeneity: $Tau^2 = 10.90$; $Chi^2 = 17.84$, df = 4 (P = 0.001); $I^2 = 78\%$
Test for overall effect: Z = 0.27 (P = 0.79)

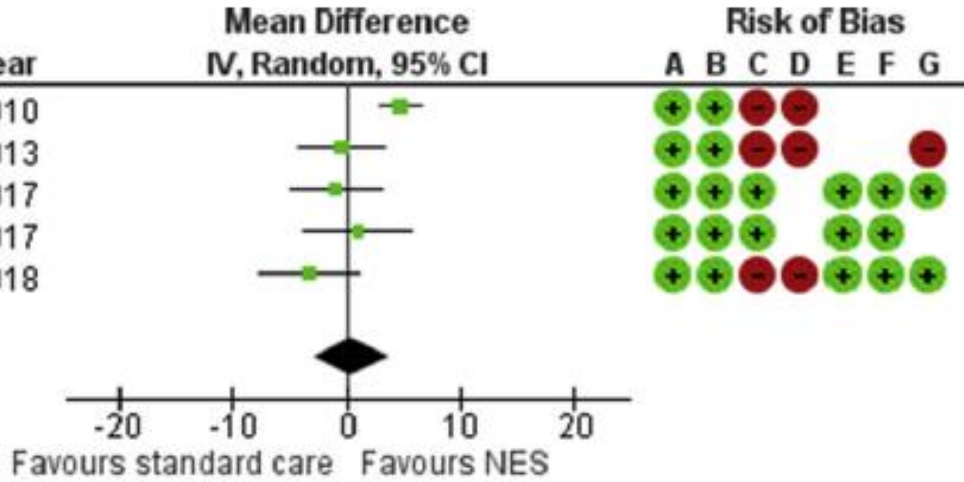

Fig. 3. Forest plots for global muscle strength at ICU discharge measured by modified Medical Research Council (mMRC) grading system.

Study or Subgroup	NES Events	NES Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Routsi 2010	28	68	22	72	48.2%	1.35 [0.86, 2.11]	2010
Abu-Khaber 2013	4	40	6	40	6.9%	0.67 [0.20, 2.18]	2013
Kho 2017	3	16	1	16	2.1%	3.00 [0.35, 25.87]	2017
Fossat 2018	33	158	24	154	42.8%	1.34 [0.83, 2.16]	2018
Total (95% CI)		**282**		**282**	**100.0%**	**1.30 [0.95, 1.78]**	
Total events	68		53				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.84$, df = 3 (P = 0.61); $I^2 = 0\%$
Test for overall effect: Z = 1.66 (P = 0.10)

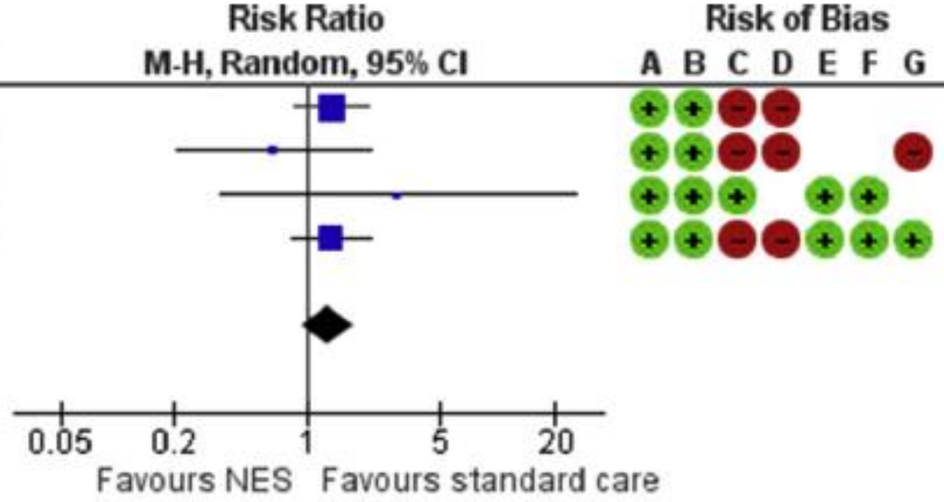

Fig. 4. Forest plot for intensive care unit mortality. NES: neuromuscular electrical stimulation; CI: confidence interval.

Study or Subgroup	NES Mean	NES SD	NES Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Routsi 2010	14.25	10	24	20.75	15	72	19.5%	-6.50 [-11.79, -1.21]	2010
Abu-Khaber 2013	9.01	8.01	40	11.97	8.07	40	29.5%	-2.96 [-6.48, 0.56]	2013
Kho 2017	20	18	16	16	15	18	6.2%	4.00 [-7.22, 15.22]	2017
Fossat 2018	5.6	6	158	6	6.73	154	44.8%	-0.40 [-1.82, 1.02]	2018
Total (95% CI)			**238**			**284**	**100.0%**	**-2.07 [-5.06, 0.92]**	

Heterogeneity: $Tau^2 = 4.67$; $Chi^2 = 6.79$, df = 3 (P = 0.08); $I^2 = 56\%$
Test for overall effect: Z = 1.36 (P = 0.18)

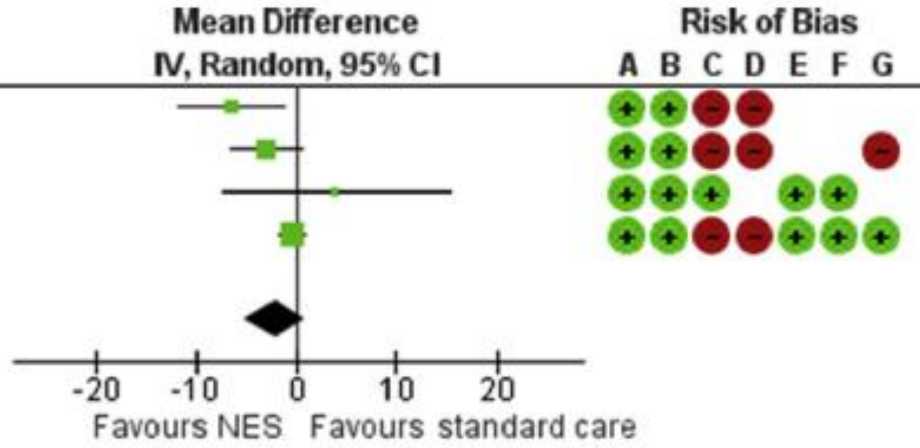

Fig. 5. Forest plot for duration of mechanical ventilation.

Study or Subgroup	NES Mean	NES SD	NES Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Routsi 2010	23	15	24	34	22	28	27.6%	-11.00 [-21.12, -0.88]	2010
Kho 2017	22	17	16	20	17	18	23.5%	2.00 [-9.45, 13.45]	2017
Patsaki 2017	14	14	63	15	18	65	48.8%	-1.00 [-6.58, 4.58]	2017
Total (95% CI)			**103**			**111**	**100.0%**	**-3.06 [-9.79, 3.68]**	

Heterogeneity: $Tau^2 = 16.09$; $Chi^2 = 3.58$, df = 2 (P = 0.17); $I^2 = 44\%$
Test for overall effect: Z = 0.89 (P = 0.37)

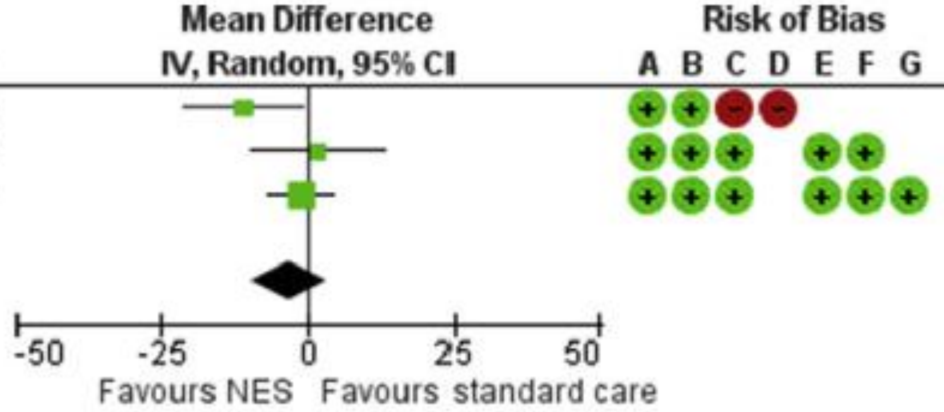

Fig. 6. Forest plot for intensive care unit length of stay.

5. Conclusion

Among critically ill patients, there were no significant differences between NES and the standard-of-care therapy on global muscle strength, ICU mortality, the duration of MV, or ICU length of stay. Further large RCTs are needed to determine which populations may benefit from this modality and to examine its efficacy and safety in adult patients in the ICU.

Peut-on améliorer l'électrostimulation


Resistance
0.00
Power
0.0
Control Speed
23
22
Speed
100%
COOL DOWN
STOP
0:03:45
Left
Right

Functionnal Electrical Stimulation

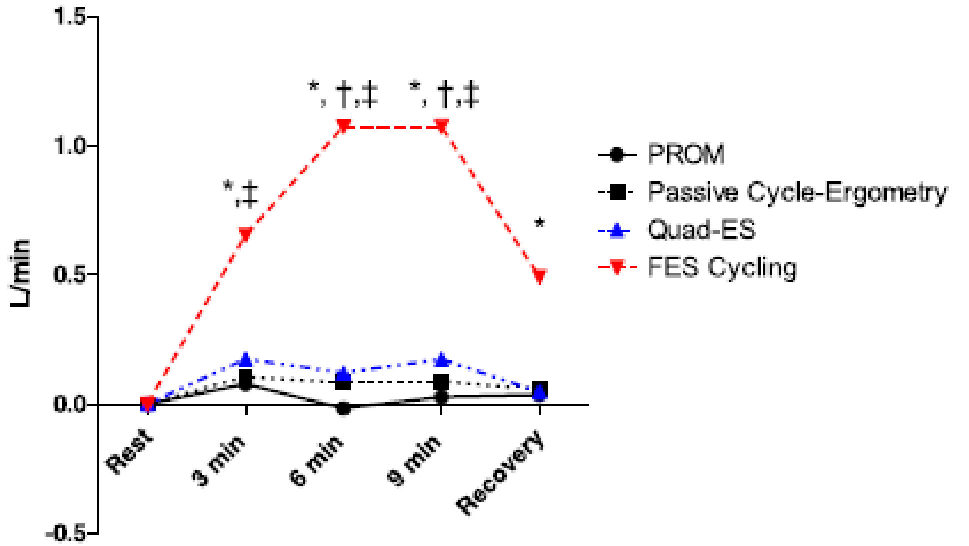

Fig. 2 Cardiac output over time for each exercise. Black circles represent passive range of leg movement (PROM); black squares represent passive cycle-ergometry; blue triangles represent quadriceps electrical stimulation; red triangles represent functional electrical stimulation cycling (FES-Cycling). *Significantly different between PROM and FES-Cycling; †significantly different between passive cycle-ergometery and FES-Cycling; ‡significantly different between quadriceps electrical stimulation and FES-Cycling

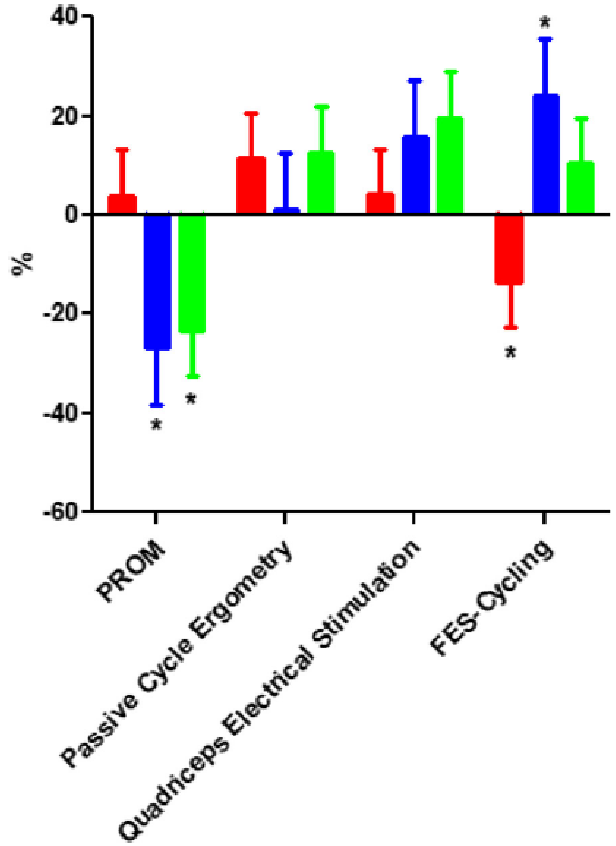

Fig. 3 Relative change in haemoglobin at the end of each exercise. Red bars represent oxyhaemoglobin (HbO_2); blue bars represent deoxyhaemoglobin (HHb); green bars represent total haemoglobin (THb); *$p < 0.05$ for comparison between baseline and the end of the exercise

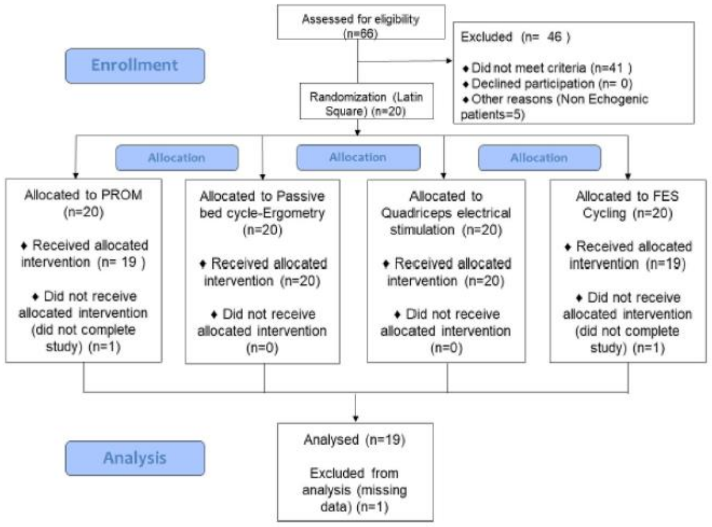

Fig. 1 Study design. PROM, passive range of leg movement; FES, functional electrical stimulation

Privilégier chez le patient conscient?

Patients répondeurs?

Des programmes spécifiques?

Comment optimiser?

FES?

Œdème sous cutané

Quels muscles ?

Quelle intensité?

Video: Valentin Durant
Hopital Ambroise Paré Mons – Belgique

L'EMS peut-elle aider à prédire la faiblesse acquise ?

- Stimulation électrique du quadriceps pour induire une extension du genou avec décollement du talon
- 24 heures après l'initiation de la VM (ou stop curares)
- Pré-test ou intensité max (999 ou 120 mA)
- Contraction 3-5 secondes puis 1 minute repos
- Comparaison de 2 modèles

- Outcome
  - ❖Quel modèle à baseline permet de prédire le mieux la faiblesse acquise
    - ❖A : Intensité/Fraction d'épaississement/Ratio de rigidification
    - ❖B: Facteurs de risque de faiblesse
    - ❖A+B

Model A => AUC 0.87 (95%CI 0.79 to 0.95)
Model B => AUC 0.85 (95%CI 0.76 to 0.93)
Model A+B => AUC of 0.94 (95%CI 0.89 to 0.99)

"The quadriceps response to NMES appears to be a promising predictor of future ICU-AW development"

Combret Y et al. Confidentiel, under review

Merci

CHU Orléans

SRLF
SOCIÉTÉ DE RÉANIMATION DE LANGUE FRANÇAISE

Université de Rouen Normandie

GRHVN

SKR
Société de Kinésithérapie de Réanimation