Early Mobilization of Critically Ill Patient: fact of fantasy?

Matthias Eikermann

Grand Rounds

2014

Content

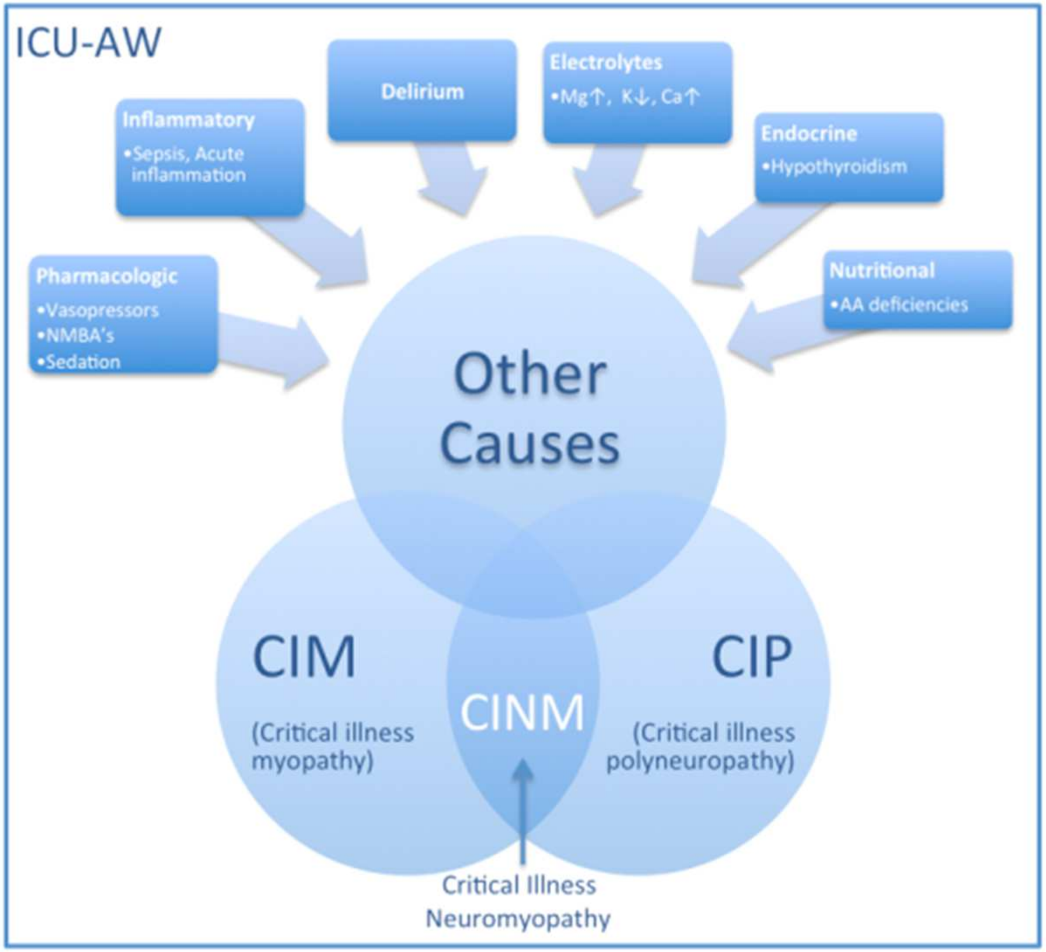
ICU-associated muscle weakness: causes, implications, and mechanisms

Postoperative respiratory complications: impact of respiratory muscle weakness

Benefits of early mobilization in the ICU

The SOMS trial

Mechanisms of ICU acquired muscle weakness



Clinical focus in the ICU contributes to ICU-associated muscle weakness.

Focus on safety and patients' comfort

- Pain, Anxiety
- Devices
- Falls
- Hemodynamics
- Weight bearing restrictions
- CVVH lines / function
- Aspiration

Culture of low-tidal volume ventilation (6 cc/kg)

- ARDS
- Risk of ARDS
- All patients with hypercarbic respiratory failure

Opioids, Propofol, Seroquel, NMBA, Restraints, NG-tube, Bed-rest, Controlled ventilation, day-light

MGH 1811

Content

ICU-associated muscle weakness: causes and implications

Overview of respiratory muscle weakness and respiratory arousal

Benefits of early mobilization in the ICU

Barriers to mobilizing patients in the ICU

The SOMS trial

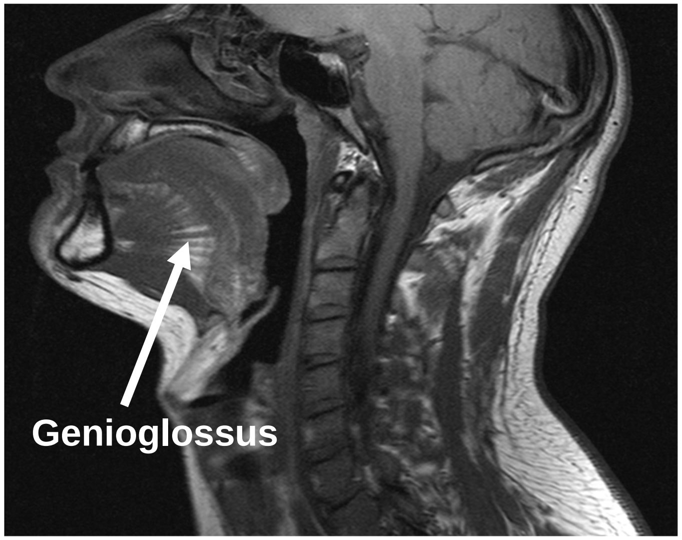
Respiratory muscles include upper airway dilators and diaphragmatic pump muscles

Respiratory pump muscles

- Weaning failure (rapid shallow breathing)
- Extubation failure (cough)

Upper airway muscles

- Aspiration
- Airway collapse



Respiratory arousal: neural activation of pump muscles & upper-airway dilatory muscles

Cortical function
Wakefulness

Respiratory arousal

Anesthetics
Opioids
Endogenous impairment of consciousness
[Sleep, stroke, delirium]

Brain stem

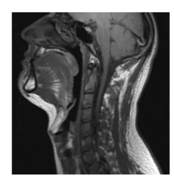
Chemoreceptors (PO_2, PCO_2, pH) → **Central respiratory pattern generator**

Negative pressure reflex

Motor Neurons

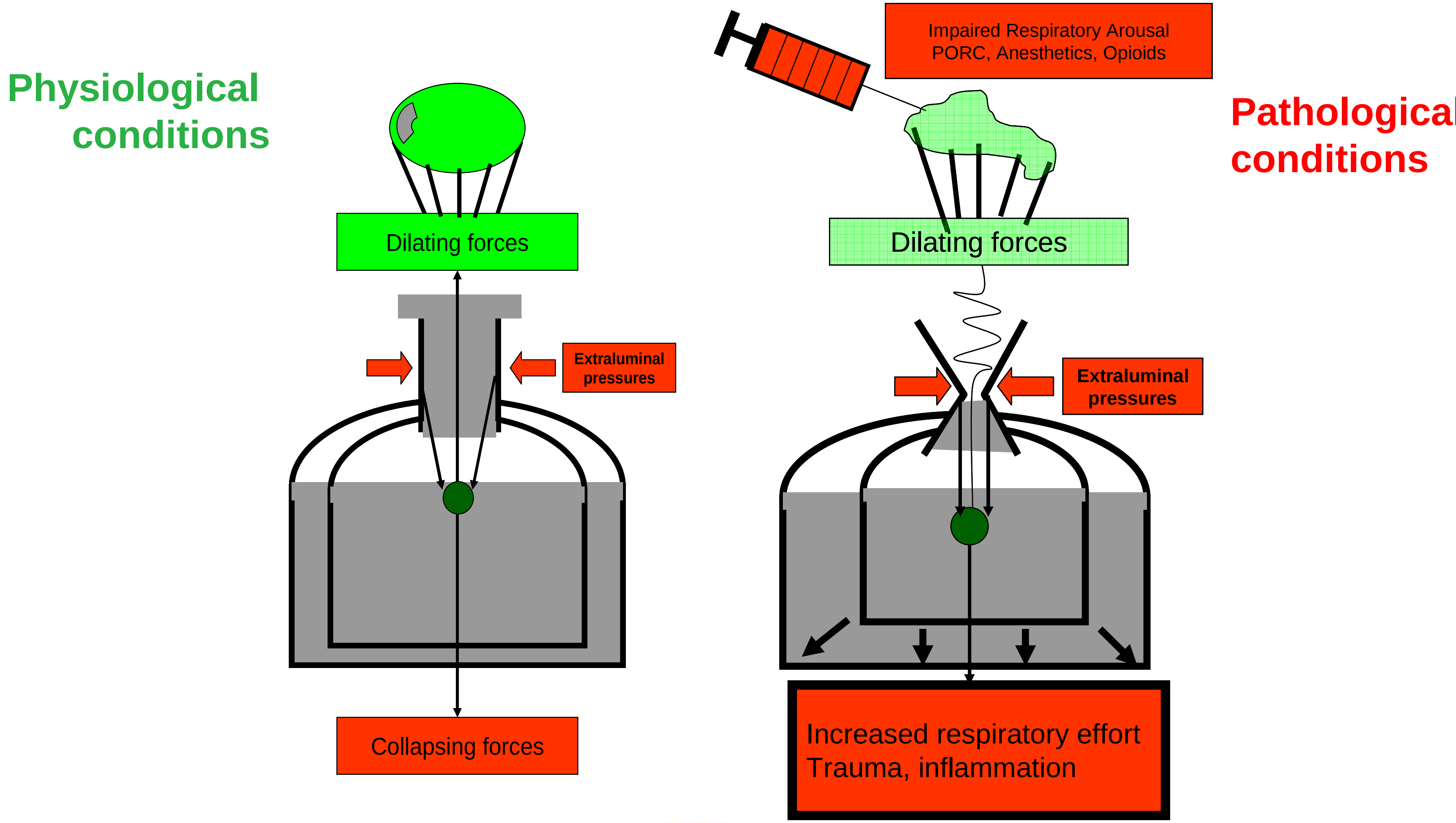
Opioids
Anesthetics

Respiratory pump muscles
Diaphragm, Intercostals



Upper airway dilator muscles
Genioglossus, tensor palatine

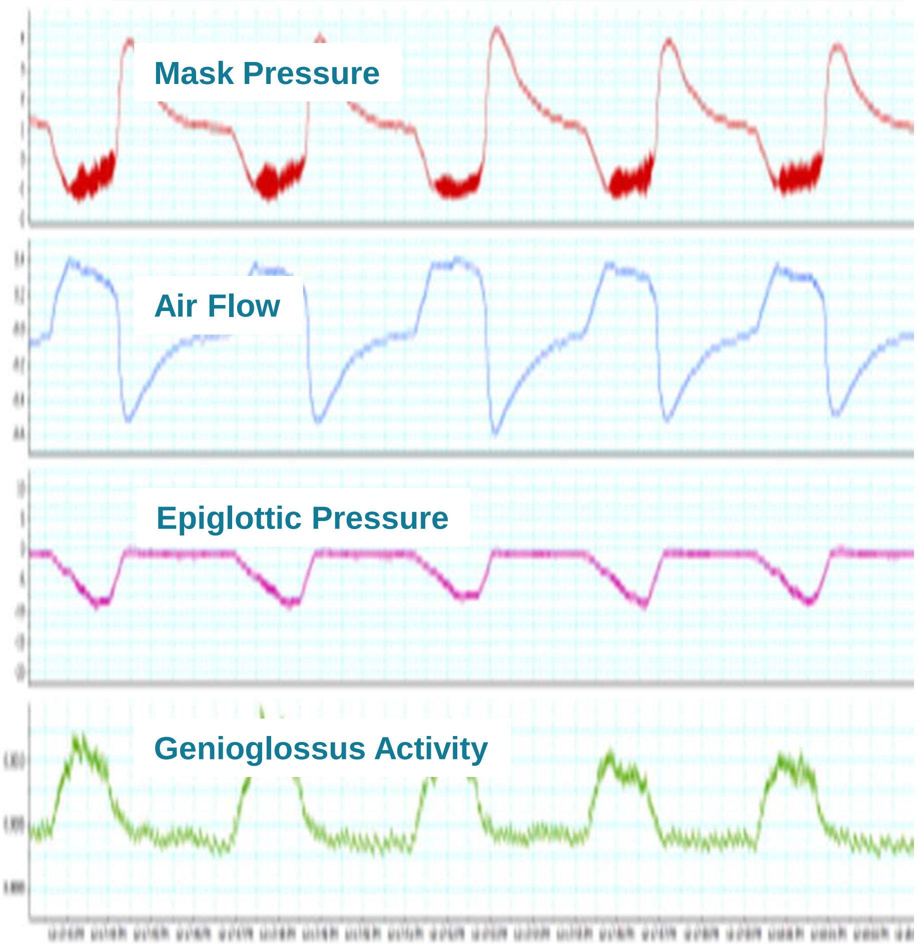
Anesthetics, NMBA and cognitive dysfunction can impair balance between dilating upper airway dilator & pump muscles



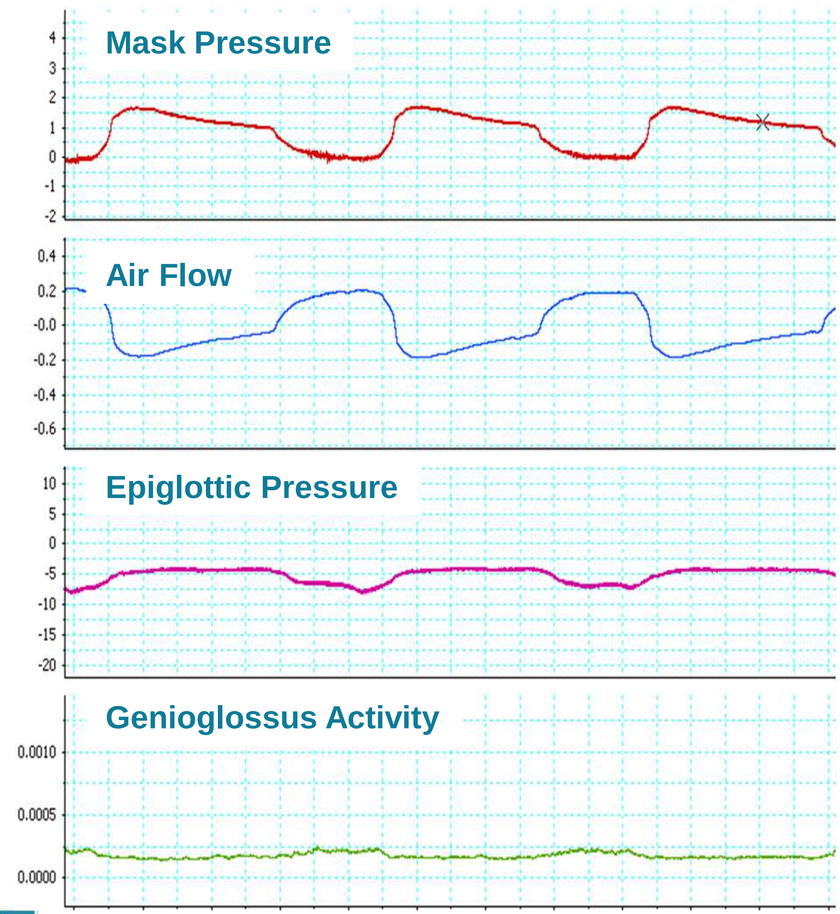

Fabius Tiro

Propofol decreases upper airway muscle activity & diminishes negative pressure from respiratory pump

Shallow

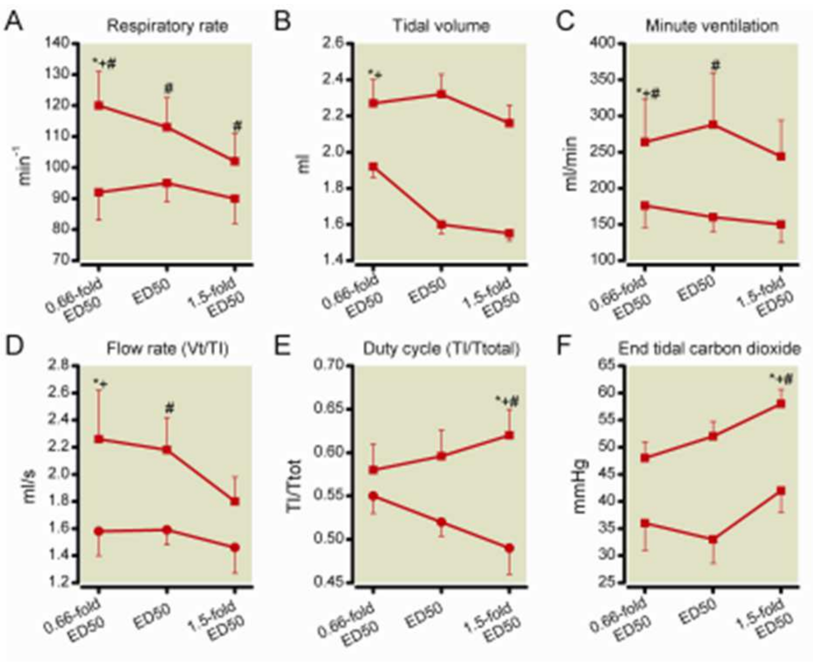


Deep

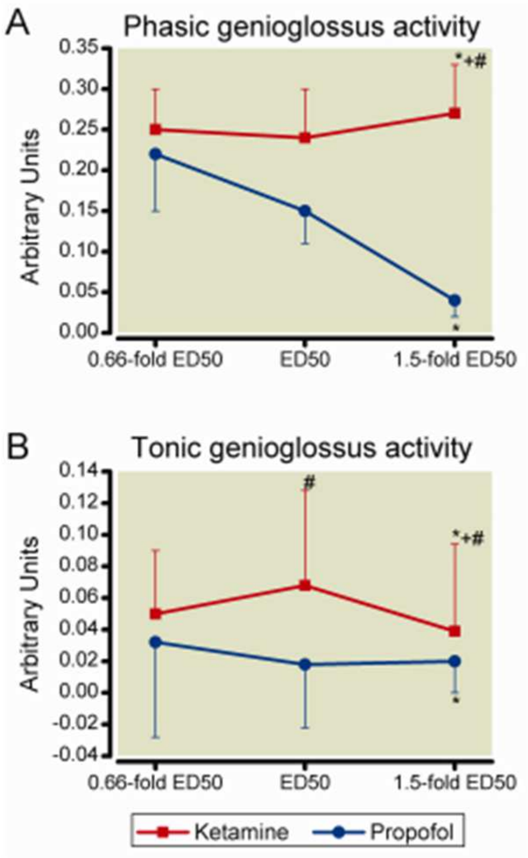


Effects of anesthetics on respiratory muscles: Ketamine compared with propofol is more forgiving

Ketamine: Higher ventilatory drive



No upper airway muscle compromise



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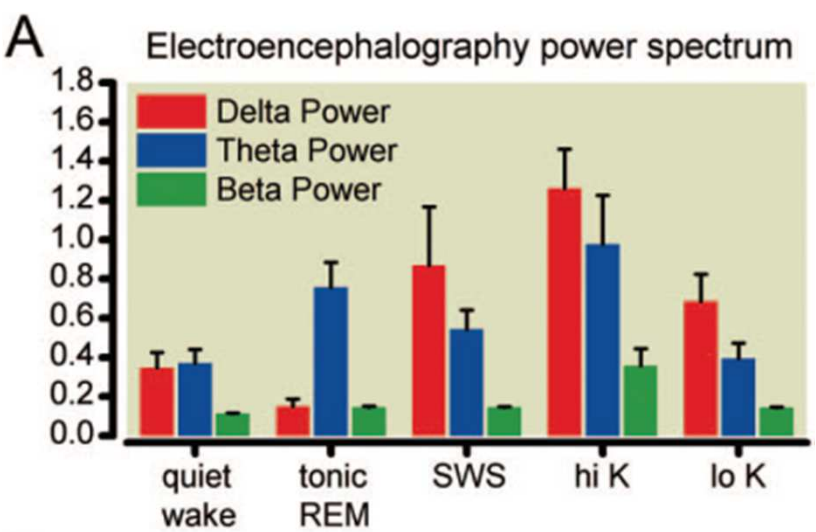
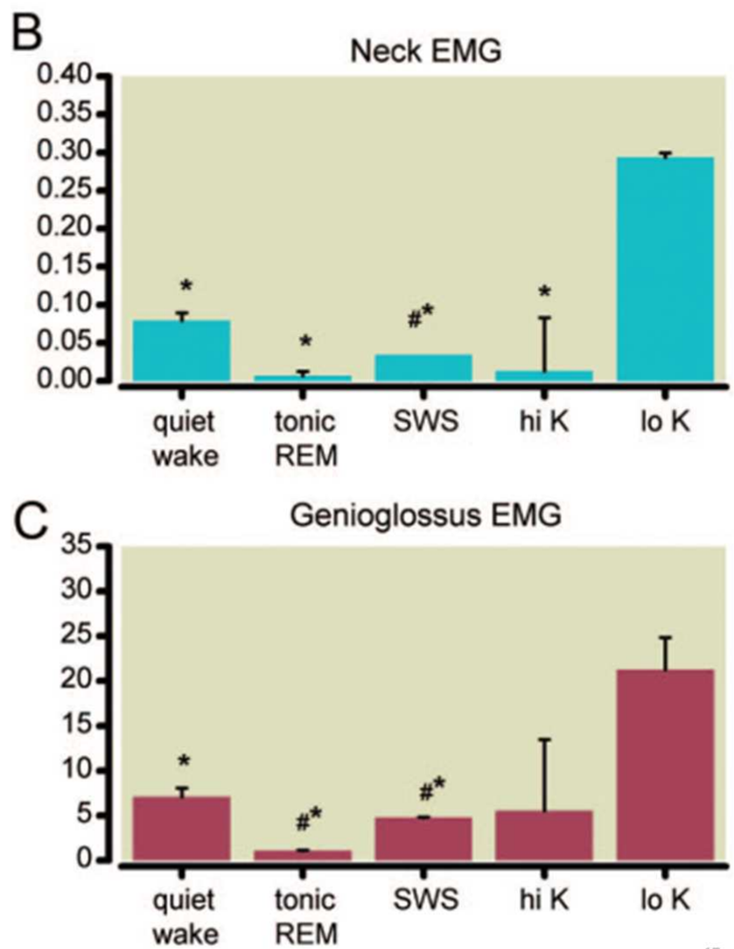
Ketamine: Dissociation between unconsciousness and airway muscle dysfunction

EEG: sleep-like increase in total power



EMG: activation (low-dose range)

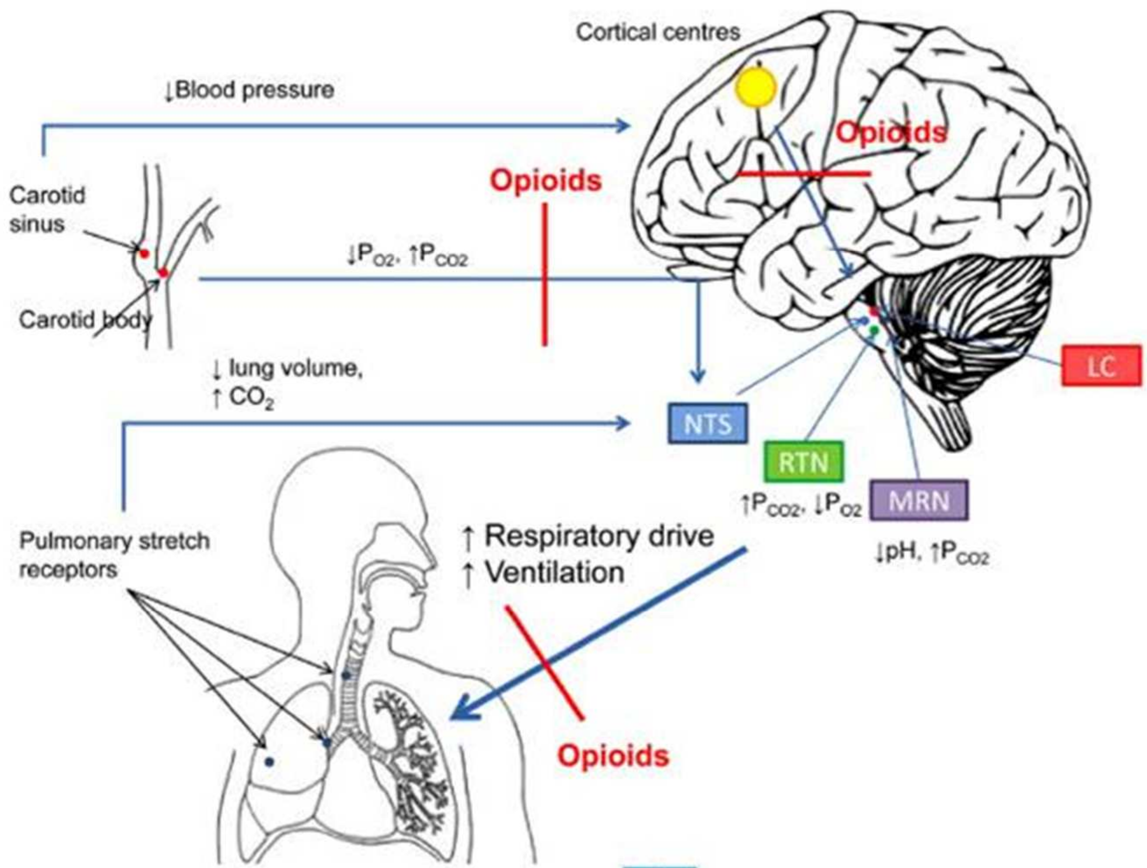


Opioids suppress breathing by multiple mechanisms

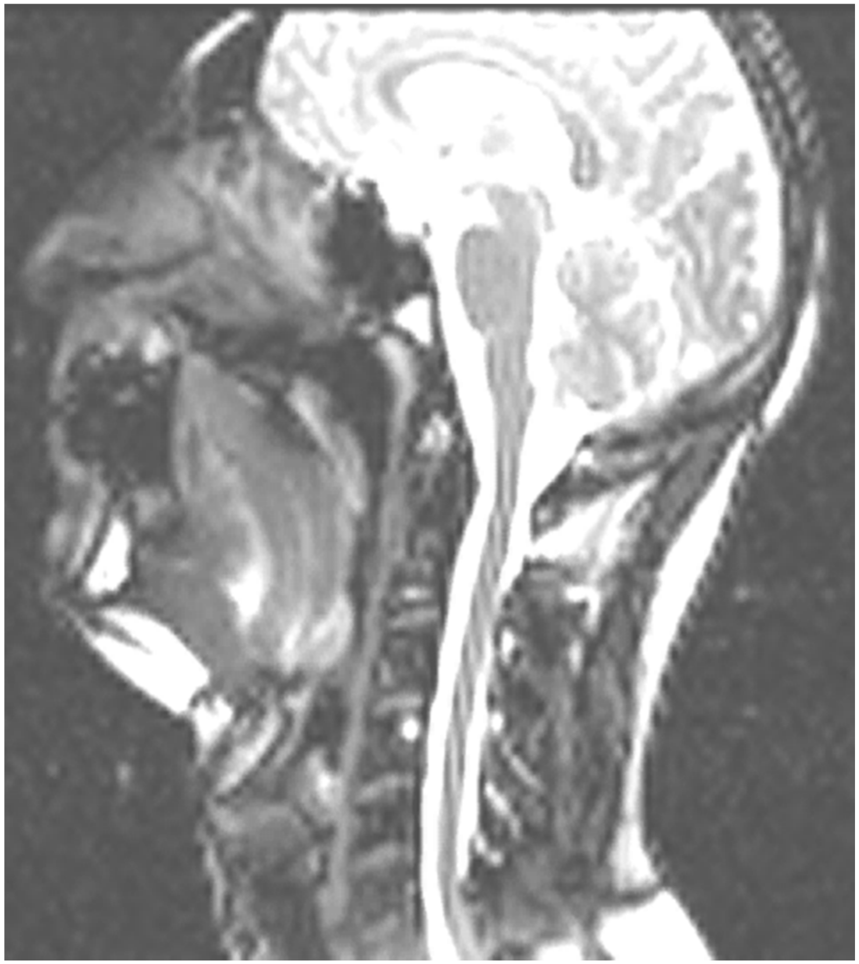
Peripheral and central chemoreception

Respiratory motor neurons, cortical

cough reflex



Subclinical doses of neuromuscular blocking agents decrease pharyngeal airway muscle activity.



Baseline

TOF 80

Pharyngeal muscle weakness:
Association between ICU-acquired muscle weakness and aspiration

RACU: FEES in patients with and without weakness

CRITICAL CARE MEDICINE

Muscle Weakness Predicts Pharyngeal Dysfunction and Symptomatic Aspiration in Long-term Ventilated Patients

Hooman Mirzakhani, M.D.,* June-Noelle Williams, M.S., C.C.C.-S.L.P.,†
Jennifer Mello, M.S., C.C.C.-S.L.P.,† Sharma Joseph, M.D.,‡ Matthew J. Meyer, M.D.,‡
Karen Waak, P.T., D.P.T., C.C.S.,§ Ulrich Schmidt, M.D.,|| Emer Kelly, M.D.,#
Matthias Eikermann, M.D., Ph.D.**

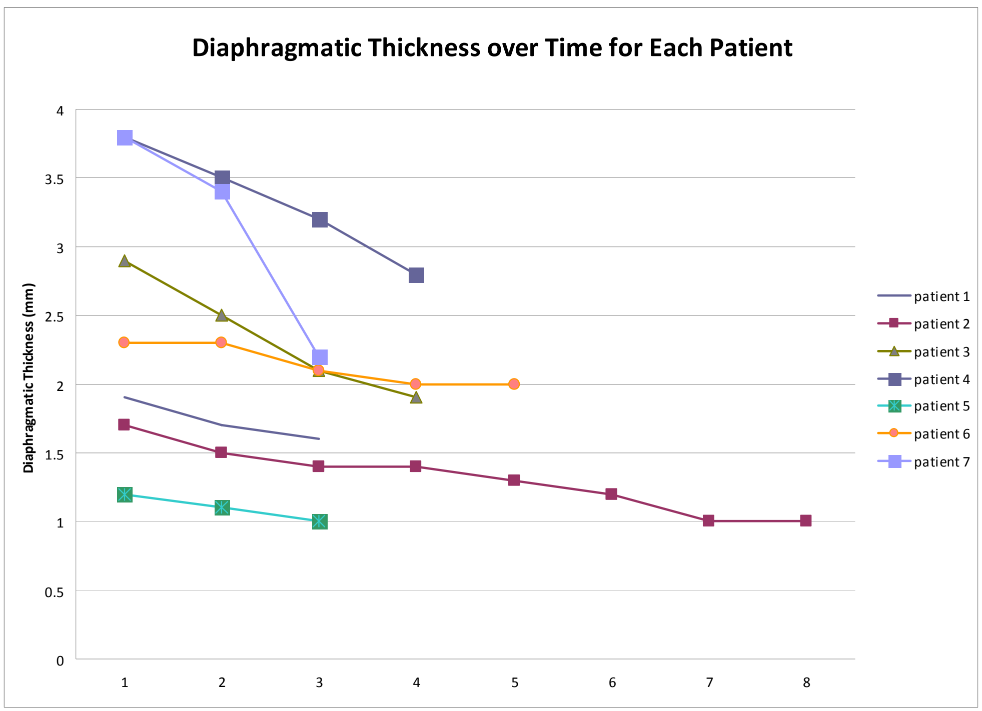
The diaphragm

Immobilization (Ventilator-induced) leads to weakness in respiratory muscles

Ultrasound of diaphragm

Diaphragm Muscle Thinning in Mechanically Ventilated Patients

Horiana B. Grosu, Young Im Lee, Jarone Lee, Edward Eden, Matthias Eikermann and Keith Rose



Evoked airway occlusion pressure

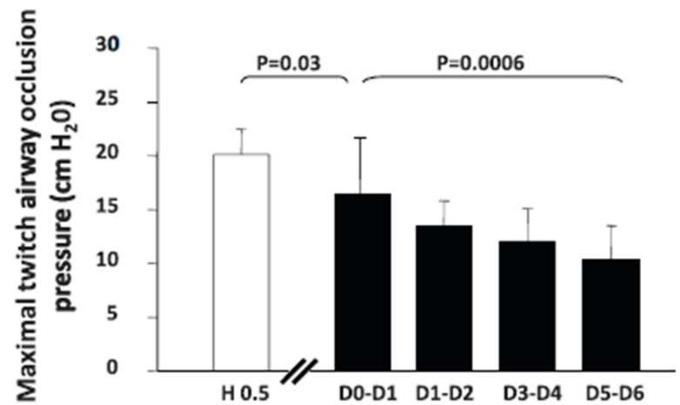


Figure 2. Relationship between duration of mechanical ventilation (MV) and diaphragmatic function. Maximal twitch airway occlusion pressure (TwPtr) generated by magnetic stimulation of the phrenic nerves at different time points in short-term MV (*open bar*; n = 6) and long-term MV (*solid bars*; n = 6) groups. H = number of hours of MV; D = number of days of MV.

Preclinical data show that mechanical ventilation is associated diaphragmatic weakness

Immobilizing ventilator settings

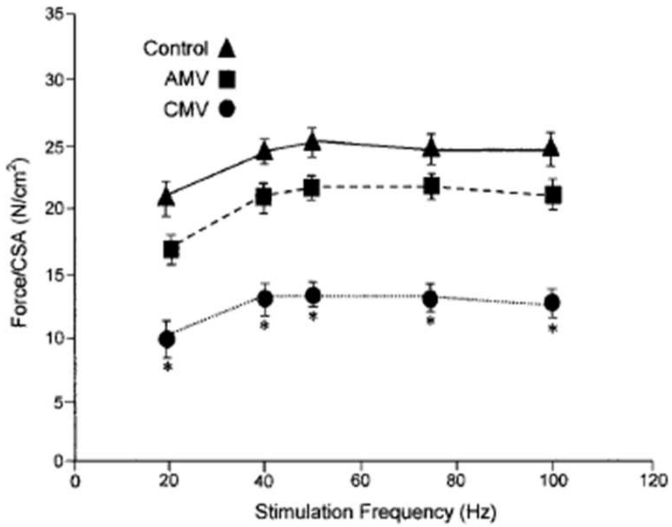
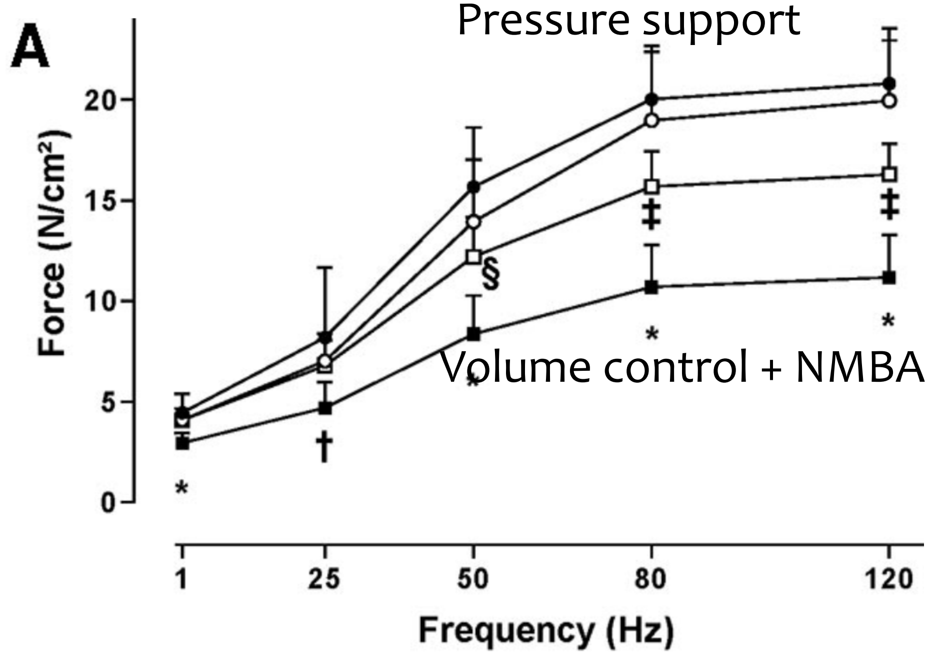


Fig. 5. Diaphragmatic tetanic force (forced divided by cross-sectional area [CSA]) at various stimulation frequencies in control, assist-control mechanical ventilation (AMV), and controlled mechanical ventilation (CMV). * $p < 0.01$ for CMV versus control and AMV. AMV attenuated the force-loss induced by CMV. (From Reference 37, with permission.)

Muscle relaxants make it worse



Spontaneous breathing can improve hemodynamics and O_2-delivery in ARDS with less sedation and shorter ICU LOS

AMERICAN JOURNAL OF
Respiratory and Critical Care Medicine®

Spontaneous Breathing During Ventilatory Support Improves Ventilation–Perfusion Distributions in Patients with Acute Respiratory Distress Syndrome

CHRISTIAN PUTENSEN, NORBERT J. MUTZ, GABRIELE PUTENSEN-HIMMER, and JÖRG ZINSERLING

Department of Anesthesiology and Intensive Care Medicine, University of Bonn, Bonn, Germany; and Division of Intensive Care Medicine, Department of Anesthesia and Intensive Care Medicine, University of Innsbruck, Innsbruck, Austria

Long-Term Effects of Spontaneous Breathing During Ventilatory Support in Patients with Acute Lung Injury

CHRISTIAN PUTENSEN, SABINE ZECH, HERMANN WRIGGE, JÖRG ZINSERLING, FRANK STÜBER, TILMANN VON SPIEGEL, and NORBERT MUTZ

Department of Anesthesiology and Intensive Care Medicine, University of Bonn, Bonn, Germany; and Department of Anesthesia and Intensive Care Medicine, University of Innsbruck, Innsbruck, Austria

Spontaneous breathing :

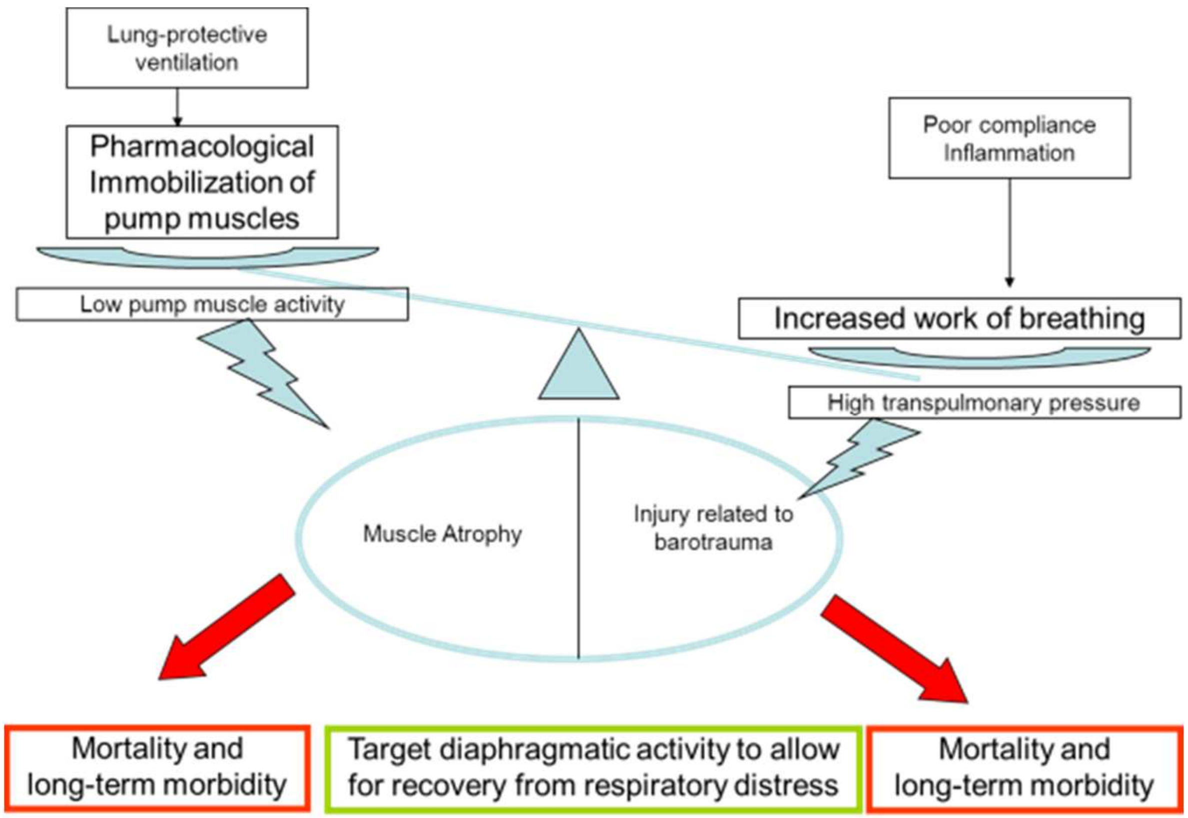
- Right ventricular end-diastolic volume,
- Stroke volume
- Cardiac index (CI)
- PaO2
- Oxygen delivery
- Mixed venous oxygen tension (PvO2)
- Reductions in pulmonary vascular resistance.

Spontaneous breathing :

- Less sedation.
- Improves cardiopulmonary function
- Shorter duration of ventilatory support
- Shorter ICU stay.

Remain within a narrow range of muscle activation to avoid atrophy and protect from labored breathing injury

Optimize delicate balance every day

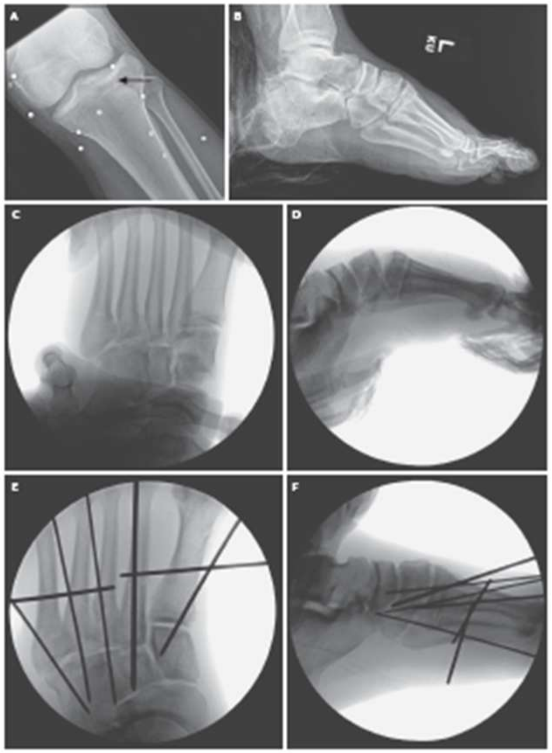


MGH 1811

CASE RECORDS OF THE MASSACHUSETTS GENERAL HOSPITAL

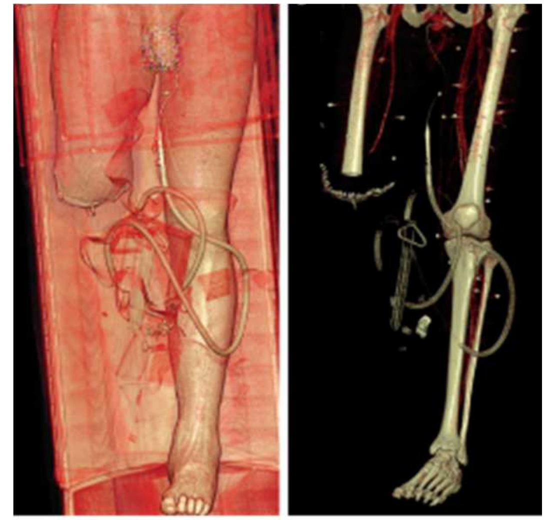
Case 11-2014: A Man with Traumatic Injuries after a Bomb Explosion at the Boston Marathon

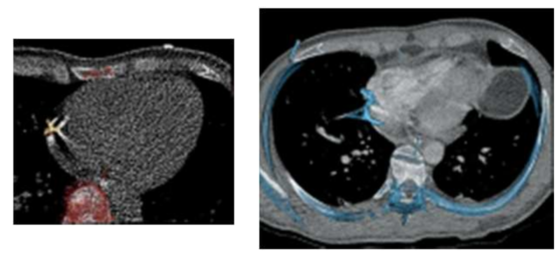
Matthias Eikermann, M.D., George Velmahos, M.D., Suhny Abbara, M.D., Paul L. Huang, M.D., Shawn P. Fagan, M.D., Ronald E. Hirschberg, M.D., John Y. Kwon, M.D., and Vania Nosé, M.D., Ph.D.



Lisfranc fracture

- Spontaneous breathing on the ventilator and early extubation
- Enabling optimal healing of the residual right leg.
- Early treatment and prevention of functional limitations, such as sitting up and standing,
- Positioning and exercise training to preserve joint range of motion and muscle length.
- As the patient improved, his physical therapy progressed to include a focus on aerobic exercise and functional mobility training,





NEJM 2014, April 10th publication date

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The SOMS trial

Early mobilization

World War II

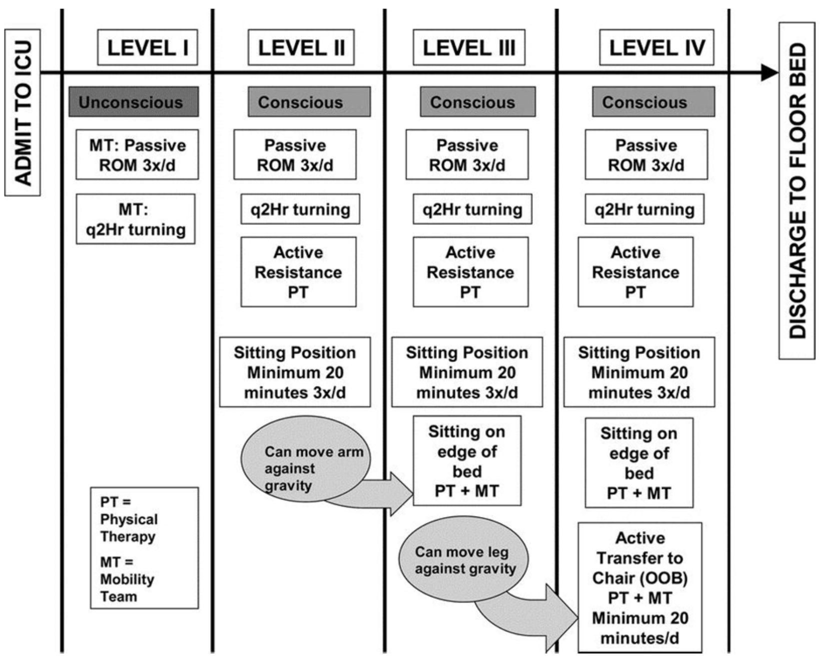
- Effort to expedite the recovery of soldiers for return to the battlefield

Our definition

- In-bed mobility, passive range of motion exercises, edge of bed activities, transfers out of bed to chair, and gait training

Morris et al: showed that early mobilization in the medical ICU accelerates ICU and hospital length of stay

Goal-directed mobility protocol



Results of the trial

Table 3. Outcomes (survivors)

	Usual Care (n = 135)	Protocol (n = 145)	*p*
Days to first out of bed	13.7 (11.7–15.7)	8.5 (6.6–10.5)	<.001
Days to first out of bed (adjusted[a])	11.3 (9.6–13.4)	5.0 (4.3–5.9)	<.001
Ventilator days	9.0 (7.5–10.4)	7.9 (6.4–9.3)	.298
Ventilator days (adjusted[a])	10.2 (8.7–11.7)	8.8 (7.4–10.3)	.163
ICU LOS days	8.1 (7.0–9.3)	7.6 (6.3–8.8)	.084
ICU LOS days (adjusted[a])	6.9 (5.9–8.0)	5.5 (4.7–6.3)	.025
Hospital LOS days	17.2 (14.2–20.2)	14.9 (12.6–17.1)	.048
Hospital LOS days (adjusted[a])	14.5 (12.7–16.7)	11.2 (9.7–12.8)	.006

Data are presented as means (confidence intervals).

Adjusted[a], adjusted for body mass index, Acute Physiology and Chronic Health Evaluation II, and vasopressors.

ICU, intensive care unit; LOS, length of stay.

Schweickert et al show that early mobilization in the Medical ICU improves recovery of functional mobility

Multi-centric RCT

- **Goal-directed early mobility with PT versus standard of care**
- **All patients: weaning protocol, daily d/c of sedation attempts.**
- **Primary: Function mobility at hospital discharge**

Recovery of functional mobility

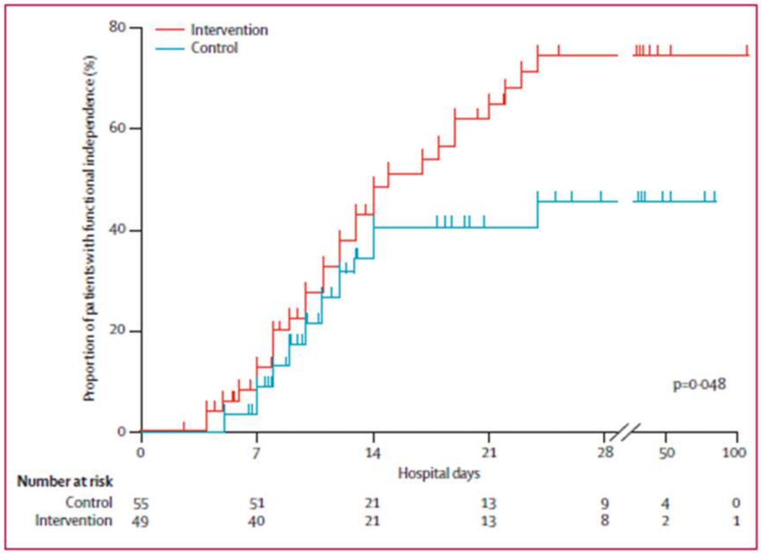


Figure 2: Probability of return to independent functional status in intervention and control groups

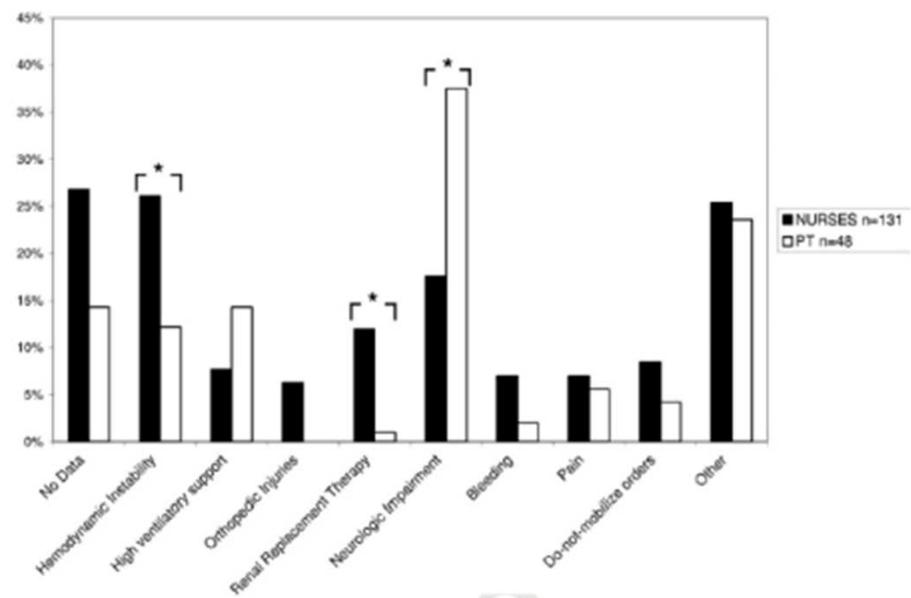
The Lancet 2009

Early mobilization in the Surgical ICU: MGH experience

Potential issues

- Wound pain?
- Inflammation?
- Weight bearing restrictions?
- Drains or other medical devices?
- Open abdomen/chest/fascia?

Survey: Barriers to early mobilization



Orchestrating a culture of change in an interdisciplinary fashion

Identify stakeholders

- Nurses (CNS, Directors, Staff)
- PT
- PM&R
- Surgeons
- Fellows
- Anesthesia & CC-Attendings

Plan, do, check, act:
Design a communication tool

SOMS Algorithm

Safety criteria for advancing mobilisation

No mobilisation (0)	PROM (1)	Sitting (2)	Standing (3)	Ambulation (4)
1) Stable spine 2) No excessive predicted mortality in next 24 hours 3) ICP < 20 cm H2O	→			
	1) Follows 1-step commands 2) Volitional movement 3) No SCI, open lumbar drains, open EVD, femoral vein access for CVVH	→		
		1) ≥3/5 bilateral quadriceps strength 2) Sits with no support 3) No WB restrictions	→	
			1) Stands twice with minimal assist 2) Steps-in-place with minimal assist	→

Attempt to maintain blood pressure and heart rate in clinically appropriate range during mobilisation: consider vasopressors, fluid volume, vasodilators, pain medication and other interventions as indicated. If unsuccessful in achieving hemodynamic stabilization, do not advance.

Orchestrating a culture of change in an interdisciplinary fashion

Validate the communication tool

Use it and spread the word, study

The surgical intensive care unit optimal mobility score predicts mortality and length of stay

George Kasotakis, MD; Ulrich Schmidt, MD, PhD; Dana Perry, RN; Martina Grosse-Sundrup, MD; John Benjamin, MD; Cheryl Ryan, RN; Susan Tully, RN; Ronald Hirschberg, MD; Karen Waak, DPT; George Velmahos, MD, PhD; Edward A. Bittner, MD, PhD; Ross Zafonte, DO; J. Perren Cobb, MD; Matthias Eikermann, MD, PhD

Open Access Protocol

BMJ open

Surgical Intensive Care Unit Optimal Mobilisation Score (SOMS) trial: a protocol for an international, multicentre, randomised controlled trial focused on goal-directed early mobilisation of surgical ICU patients

Matthew J Meyer,[1] Anne B Stanislaus,[1] Jarone Lee,[2] Karen Waak,[3] Cheryl Ryan,[4] Richa Saxena,[1] Stephanie Ball,[4] Ulrich Schmidt,[1] Trudy Poon,[1] Simone Piva,[5] Matthias Walz,[6] Daniel S Talmor,[7] Manfred Blobner,[8] Nicola Latronico,[5] Matthias Eikermann[1,9]

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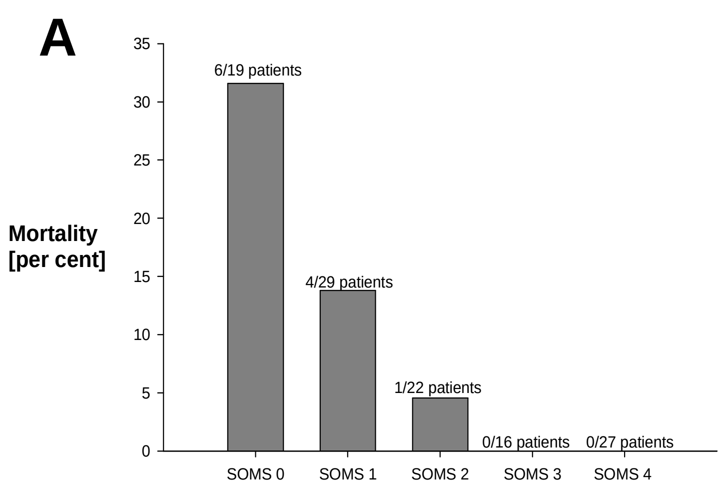
SICU Optimal Mobilization Score (SOMS) predicts morbidity and mortality in the ICU (CCM 2012)

The surgical intensive care unit optimal mobility score predicts mortality and length of stay

George Kasotakis, MD; Ulrich Schmidt, MD, PhD; Dana Perry, RN; Martina Grosse-Sundrup, MD; John Benjamin, MD; Cheryl Ryan, RN; Susan Tully, RN; Ronald Hirschberg, MD; Karen Waak, DPT; George Velmahos, MD, PhD; Edward A. Bittner, MD, PhD; Ross Zafonte, DO; J. Perren Cobb, MD; Matthias Eikermann, MD, PhD

Table 1. Patient demographics (during the first full day in the surgical intensive care unit) and outcome variables taken on day 1 after admission to the intensive care unit

Variable	Measure (Mean ± SD)	Range
Age	60.2 ± 18.1	18–93
Male:female ratio	58.4 (n = 66):41.6 (n = 47)	Not available
Acute Physiology and Chronic Health Evaluation II score	15.68 ± 6.9	3–32
Comorbidity index	2.29 ± 1.85	0–10
Vasopressor therapy	49.6% (n=56)	Not available
Ventilator days	3.19 ± 2.48	0–10
Renal replacement therapy	2.7% (n= 3)	Not available
Delirium	18.9% (n=21)	Not available
Achieved surgical intensive care unit optimal mobilization scale	2 ± 1.46	1–4
Surgical intensive care unit length of stay	5.21 ± 5.26	1–31
Hospital length of stay	14.1 ± 11.31	1–61
Mortality	9.7% (n=11)	N/A



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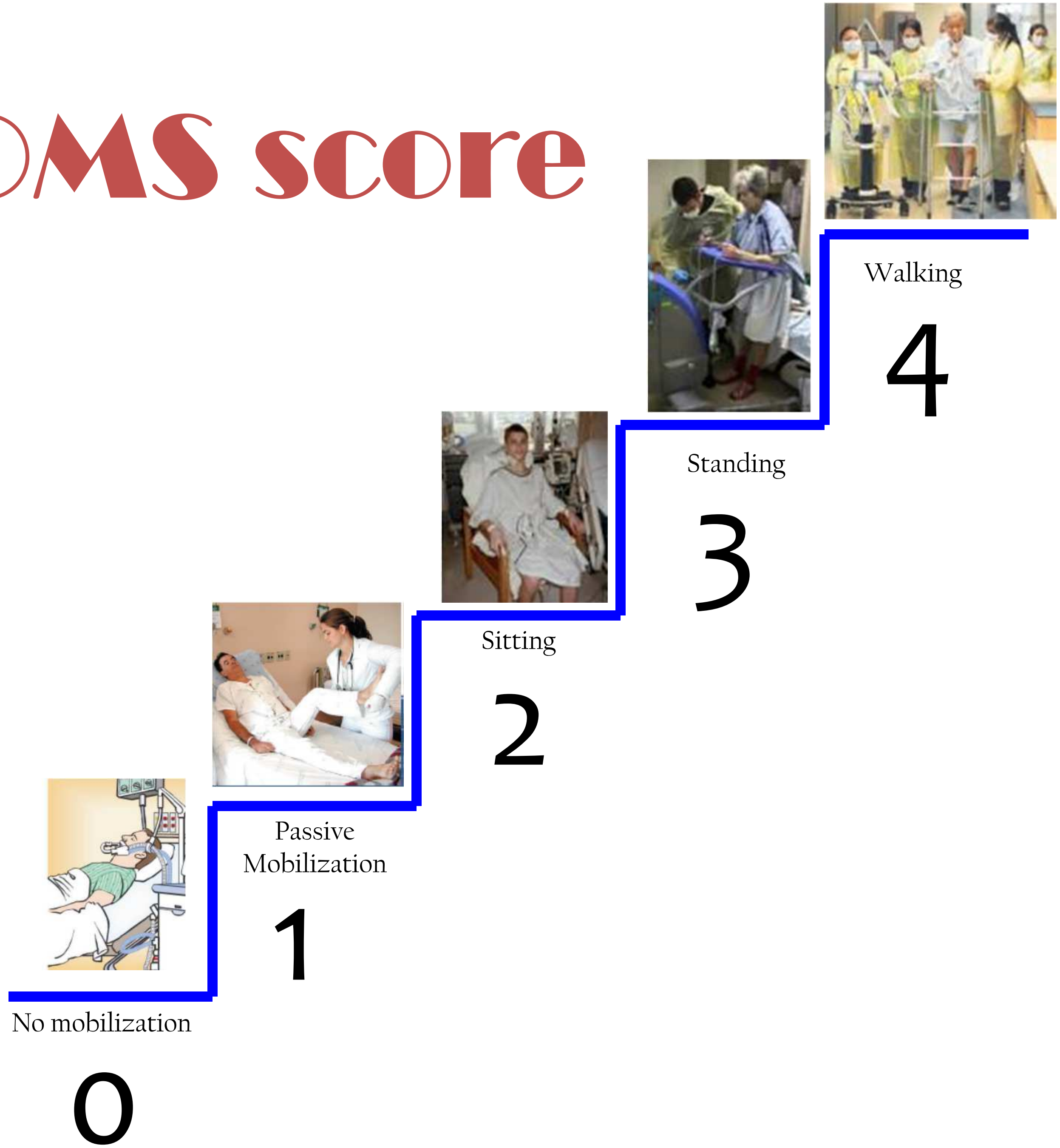
SOMS score



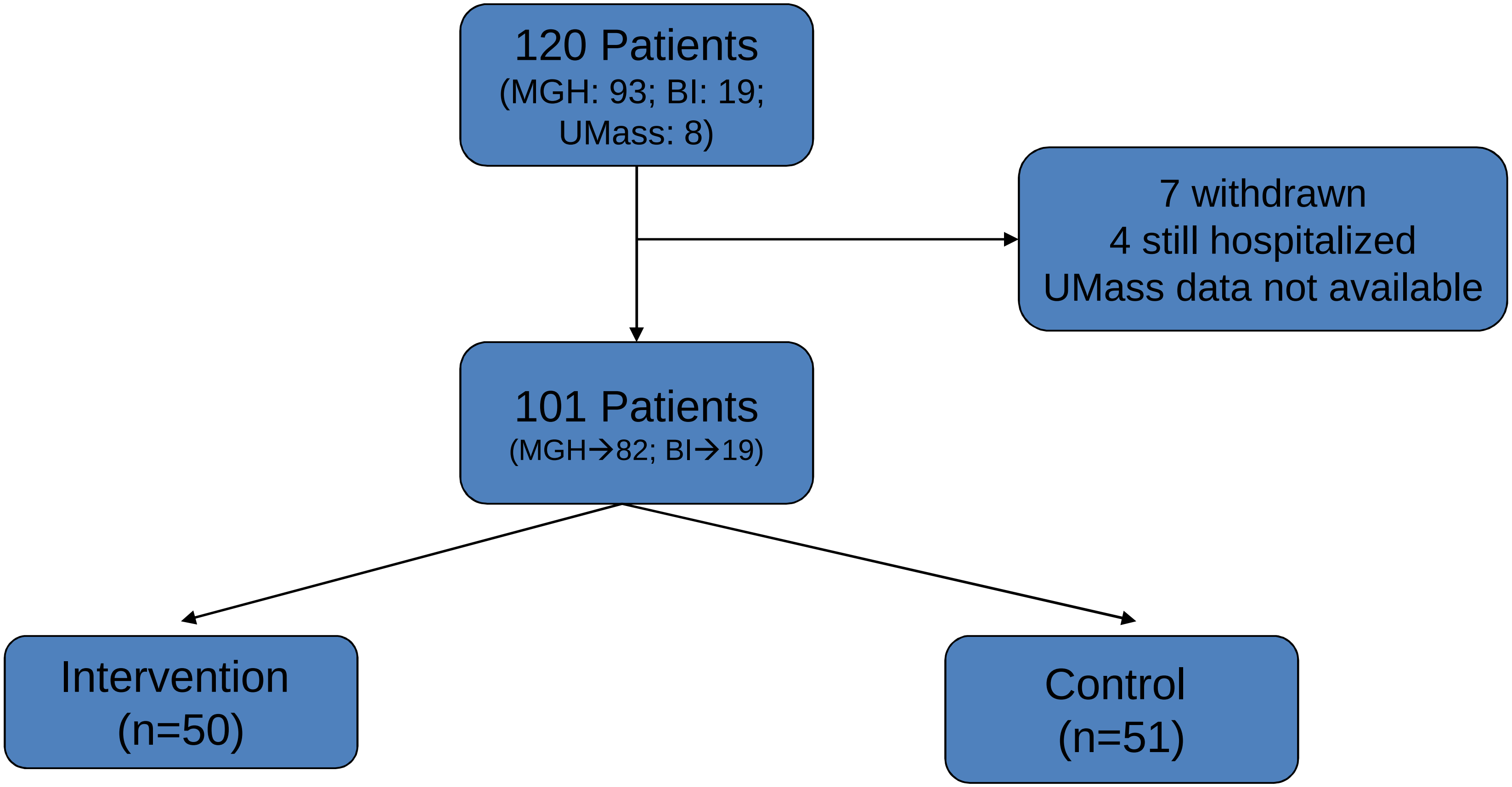
No mobilization
0
Passive Mobilization
1
Sitting
2
Standing
3
Walking
4

Intervention

- Multidisciplinary team
  - Nursing, clinicians, PT (when consulted), study staff
- Daily Work
  - Rounding tool: SOMS goal set in AM by multidisciplinary team and plan created to achieve goal
  - Work towards goal throughout day
  - Identify barriers and work around ('sedation')
  - Score SOMS in PM by day RN
    - List barriers on score sheet if goal not met

Study Population

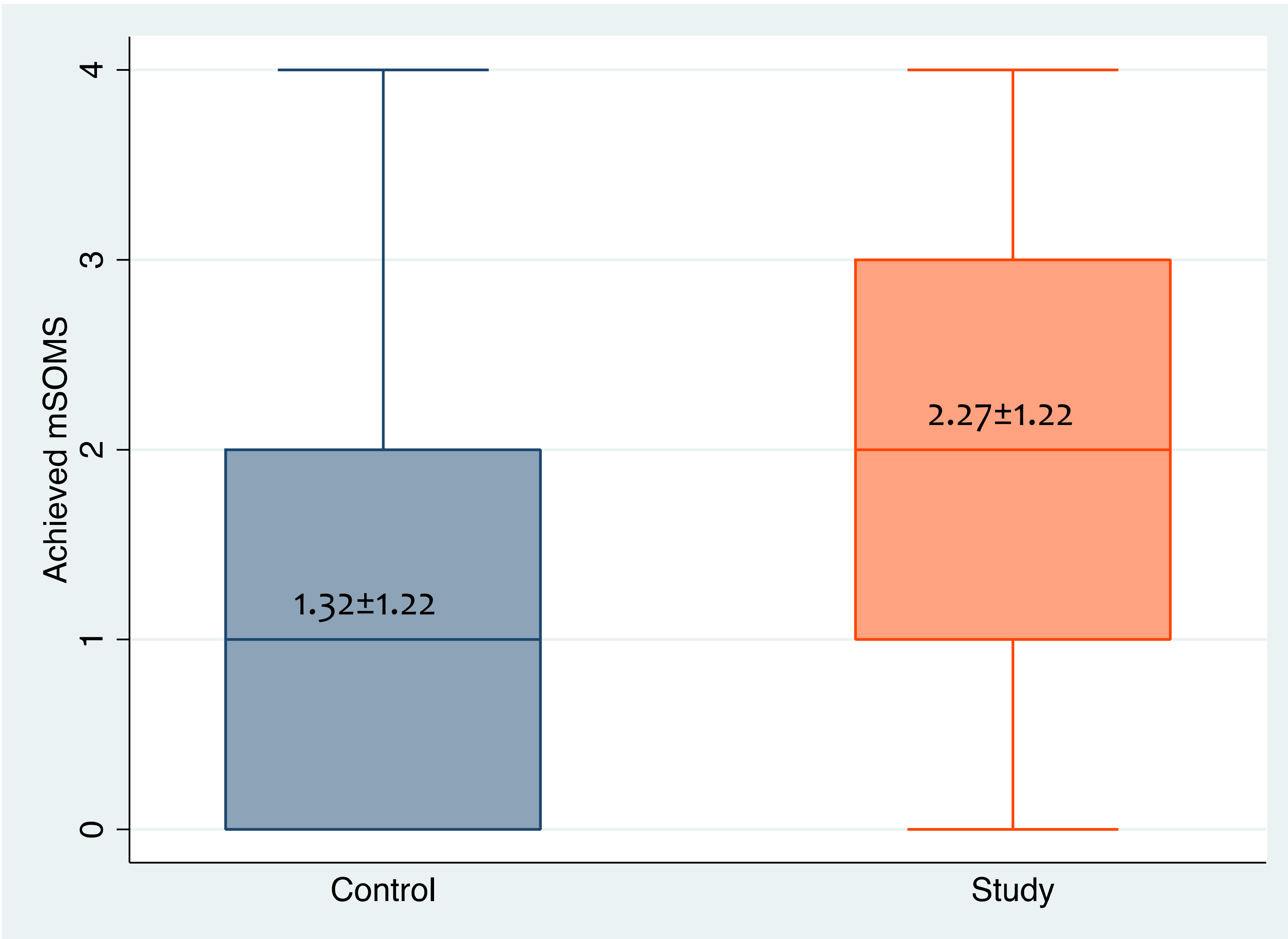
- $\geq$18 years old
- <48hrs of mechanical ventilation with likely continued mechanical ventilation >24hrs
- Baseline functional independence (Barthel ≥ 70)
  - Determined at time of consent from patient's health care proxy; frame of reference 2wks prior to hospital admission


120 Patients
(MGH: 93; BI: 19;
UMass: 8)
7 withdrawn
4 still hospitalized
UMass data not available
101 Patients
(MGH→82; BI→19)
Intervention
(n=50)
Control
(n=51)

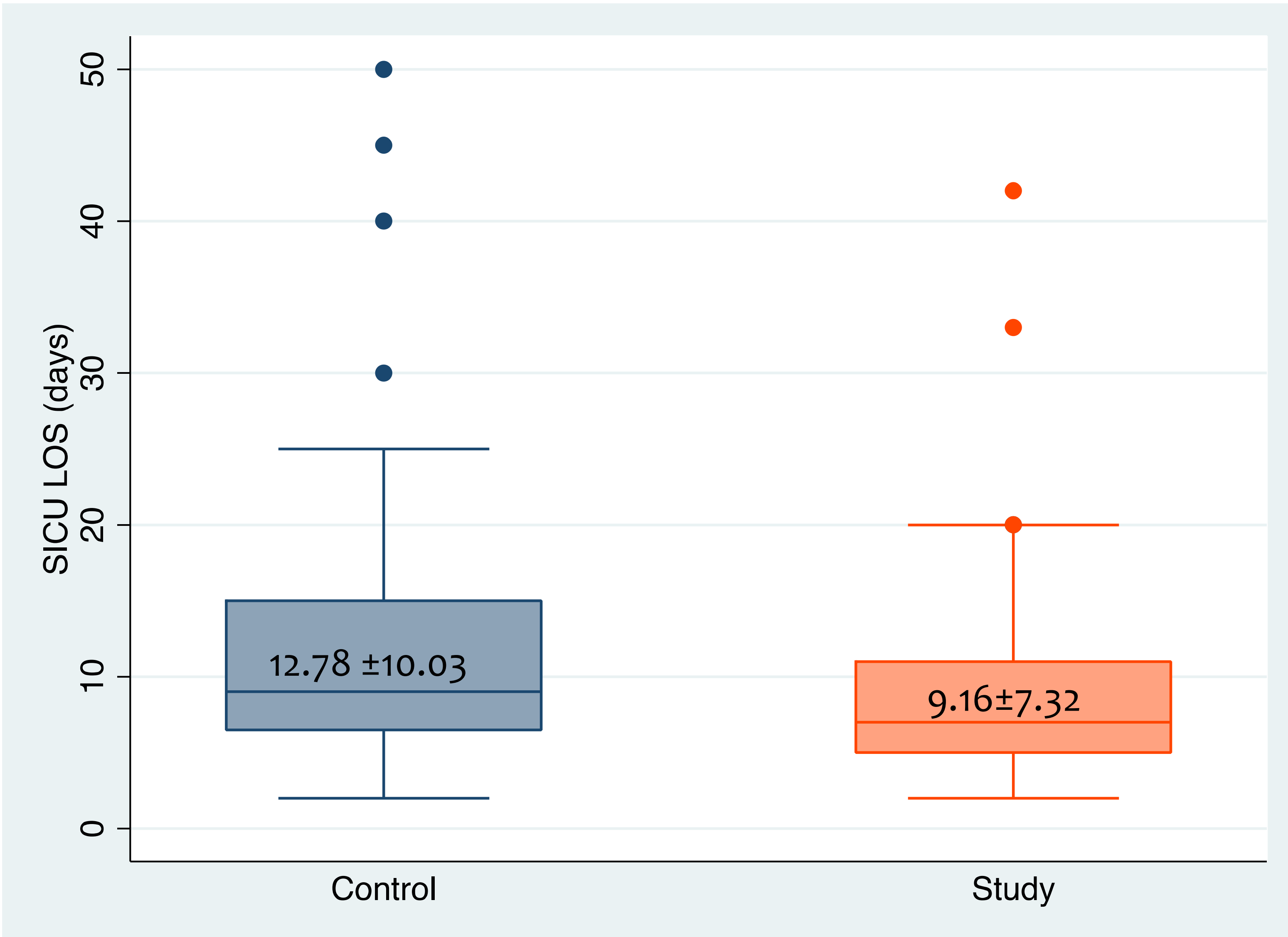
Baseline Data

	STUDY	CONTROL
Age (years)	60.21±17.35	58.78±17.46
Gender	M 60.8%	M 62.7%
	F 39.2%	F 37.3%
Race	White 78.4%	White 78.4%
	African American 3.9%	African American 7.8%
	Asian 2%	Asian 2%
Ethnicity	Other 15.7%	Other 11.8%
Height (inches)	66.24±4.61	67.51±6.74
Weight	171.51±41.88	179.76±60.53
Glasgow Coma Scale	10.1±2.08	9.66±2.63
Pre-enrolment mSOMS	0.22±0.47	0.36±0.8
Admission hemoglobin (g/dL)	11.27±2.16	11.82±2.42
Admission serum creatinine (mg/dL)	1.52±1.60	1.51±1.26
Admission INR	1.26±0.35	1.29±0.34
Admission serum albumin (g/dL)	3.13±0.78	3.20±0.76
Total APACHE II Score	16.9±8.42	17.58±7.72
Total Barthel Score	98.33±6.29	98.43±5.04

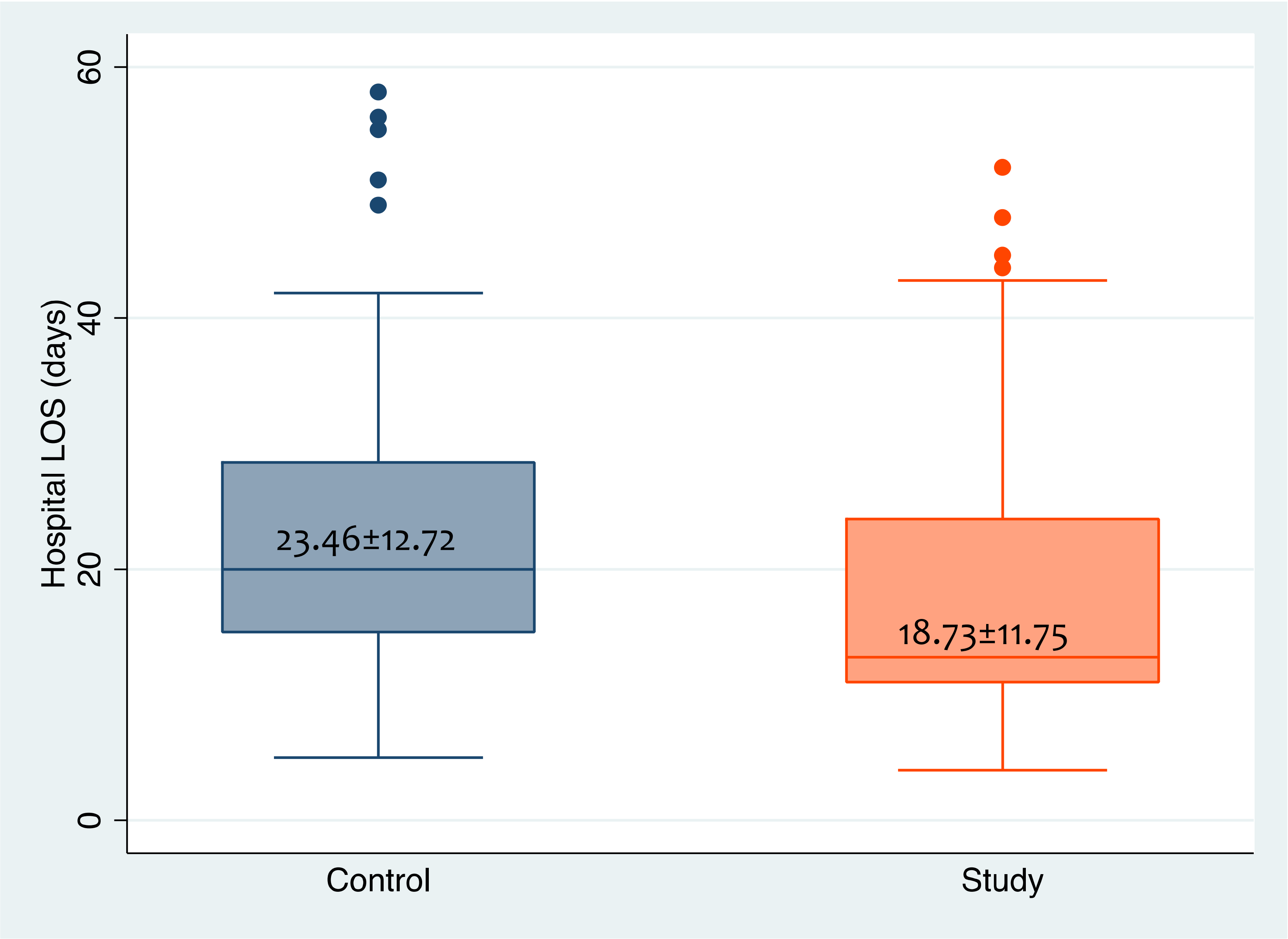
Mean achieved SOMS



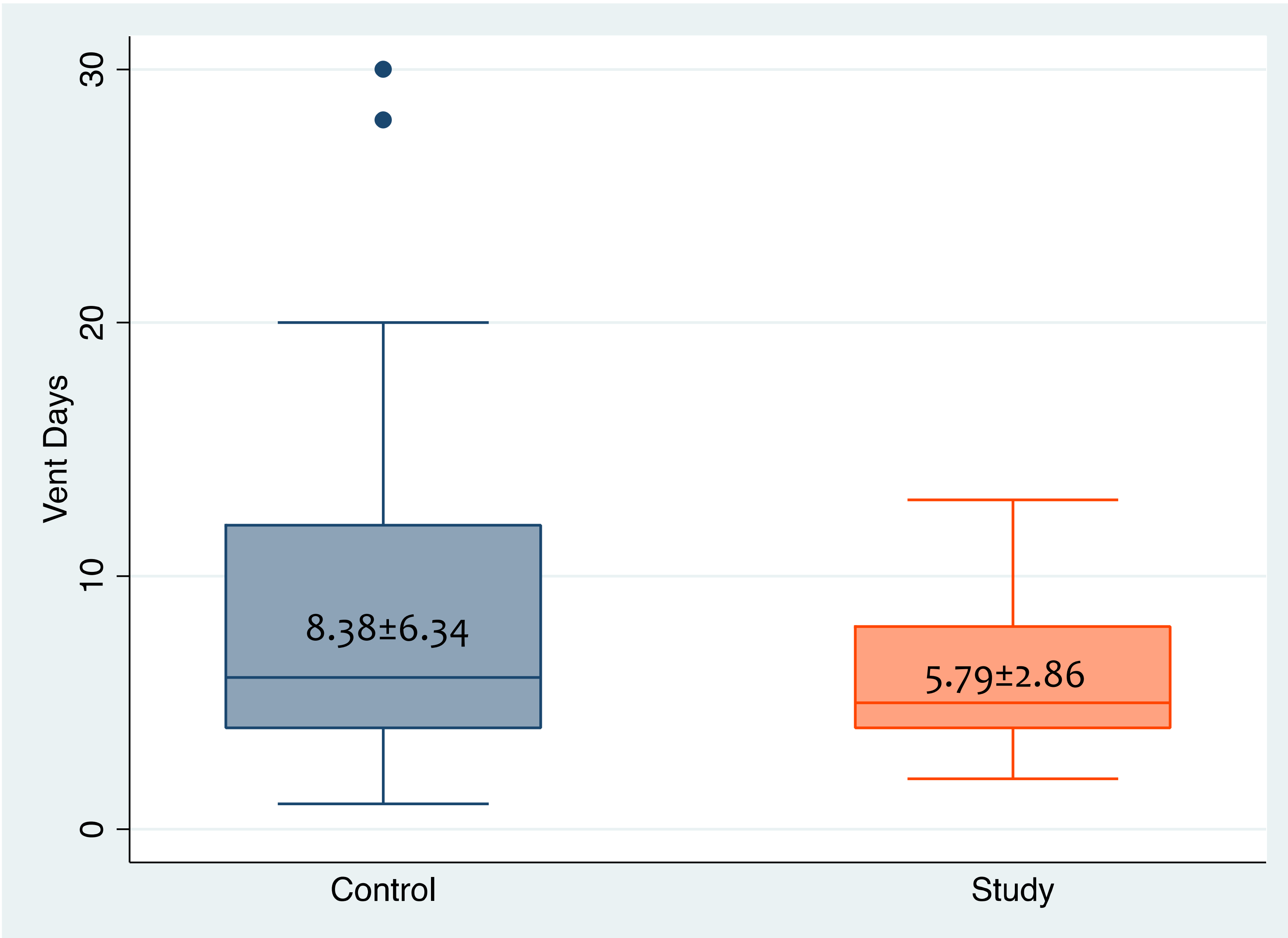
SICU Length of stay



Hospital Length of Stay



Days with mechanical ventilation



Medical Research Council (MRC) Evaluation

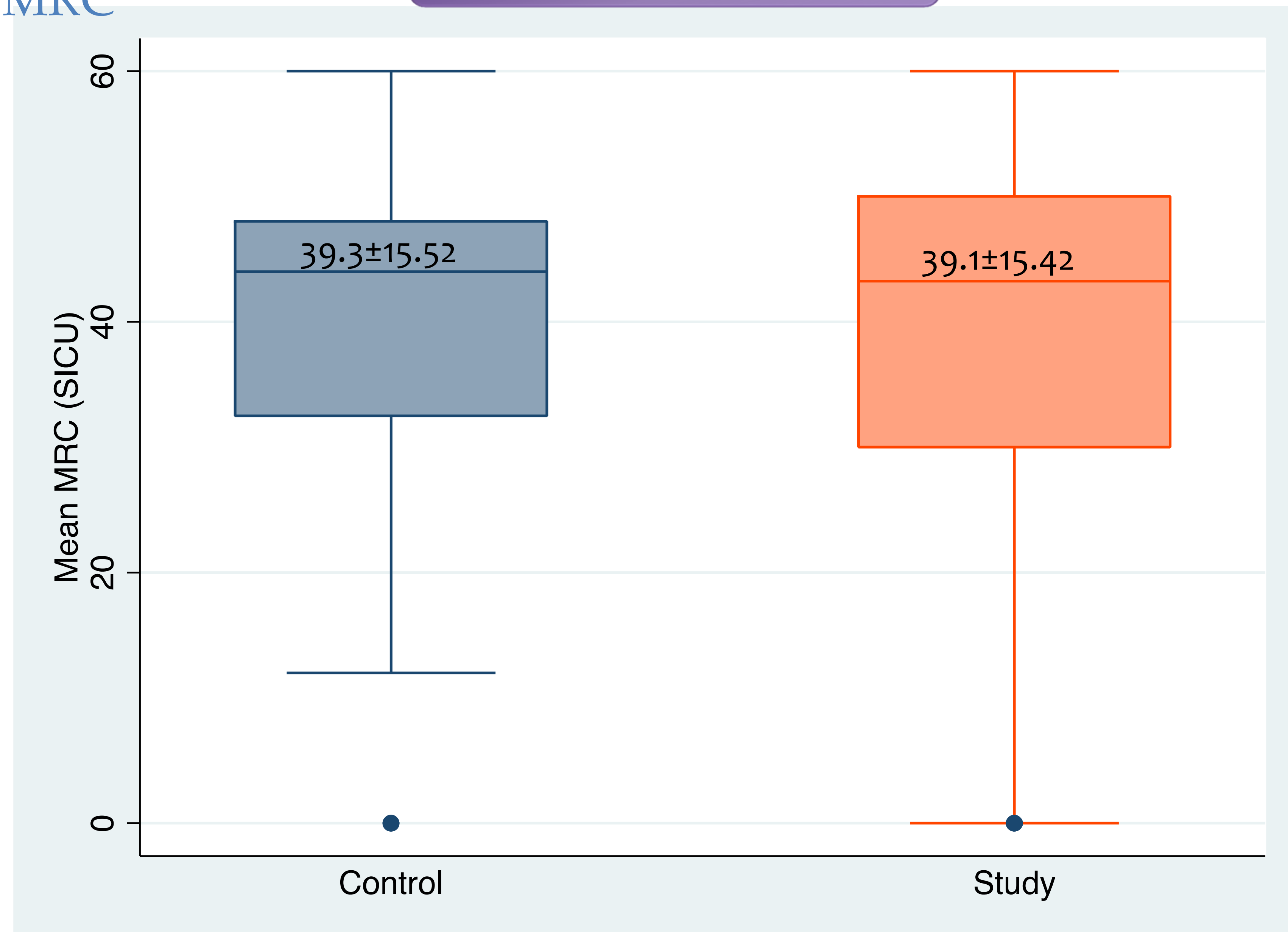
0. No contraction
1. Contraction, no active movement .
2. Active movement that cannot overcome gravity
3. Active movement that can overcome gravity
4. Active movement against gravity and resistance
5. Normal muscle strength

MRC: Medical Research Council.

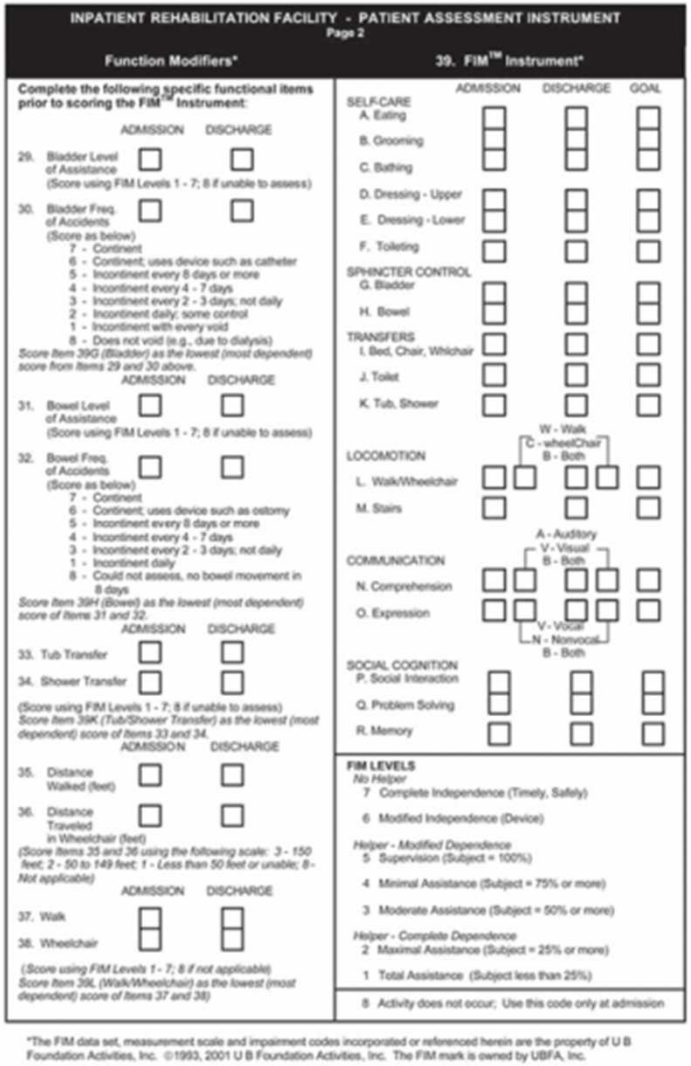
Arm Abduction	Wrist Flexion	Wrist Extension	Leg Flexion	Knee Extension	Dorsal Foot Flexion	SUM

MRC

Missings or Unable to test: almost 50% in both groups



Functional Independence Measure (FIM)



INPATIENT REHABILITATION FACILITY - PATIENT ASSESSMENT INSTRUMENT
Page 2

Function Modifiers*

Complete the following specific functional items prior to scoring the FIM™ Instrument:

ADMISSION DISCHARGE

29. Bladder Level of Assistance ☐ ☐
(Score using FIM Levels 1 - 7; 8 if unable to assess)

30. Bladder Freq. of Accidents ☐ ☐
(Score as below)
7 - Continent
6 - Continent; uses device such as catheter
5 - Incontinent every 8 days or more
4 - Incontinent every 4 - 7 days
3 - Incontinent every 2 - 3 days; not daily
2 - Incontinent daily; some control
1 - Incontinent with every void
8 - Does not void (e.g., due to dialysis)

Score Item 39G (Bladder) as the lowest (most dependent) score from Items 29 and 30 above.

ADMISSION DISCHARGE

31. Bowel Level of Assistance ☐ ☐
(Score using FIM Levels 1 - 7; 8 if unable to assess)

32. Bowel Freq. of Accidents ☐ ☐
(Score as below)
7 - Continent
6 - Continent; uses device such as ostomy
5 - Incontinent every 8 days or more
4 - Incontinent every 4 - 7 days
3 - Incontinent every 2 - 3 days; not daily
1 - Incontinent daily
8 - Could not assess, no bowel movement in 8 days

Score Item 39H (Bowel) as the lowest (most dependent) score of Items 31 and 32.

ADMISSION DISCHARGE

33. Tub Transfer ☐ ☐
34. Shower Transfer ☐ ☐

(Score using FIM Levels 1 - 7; 8 if unable to assess)
Score Item 39K (Tub/Shower Transfer) as the lowest (most dependent) score of Items 33 and 34.

ADMISSION DISCHARGE

35. Distance Walked (feet) ☐ ☐
36. Distance Traveled in Wheelchair (feet) ☐ ☐

(Score Items 35 and 36 using the following scale: 3 - 150 feet; 2 - 50 to 149 feet; 1 - Less than 50 feet or unable; 8 - Not applicable)

ADMISSION DISCHARGE

37. Walk ☐ ☐
38. Wheelchair ☐ ☐

*(Score using FIM Levels 1 - 7; 8 if not applicable)
Score Item 39L (Walk/Wheelchair) as the lowest (most dependent) score of Items 37 and 38)*

39. FIM™ Instrument*

ADMISSION DISCHARGE GOAL

SELF-CARE
A. Eating
B. Grooming
C. Bathing
D. Dressing - Upper
E. Dressing - Lower
F. Toileting

SPHINCTER CONTROL
G. Bladder
H. Bowel

TRANSFERS
I. Bed, Chair, Whlchair
J. Toilet
K. Tub, Shower

W - Walk
C - wheelChair
B - Both

LOCOMOTION
L. Walk/Wheelchair
M. Stairs

A - Auditory
V - Visual
B - Both

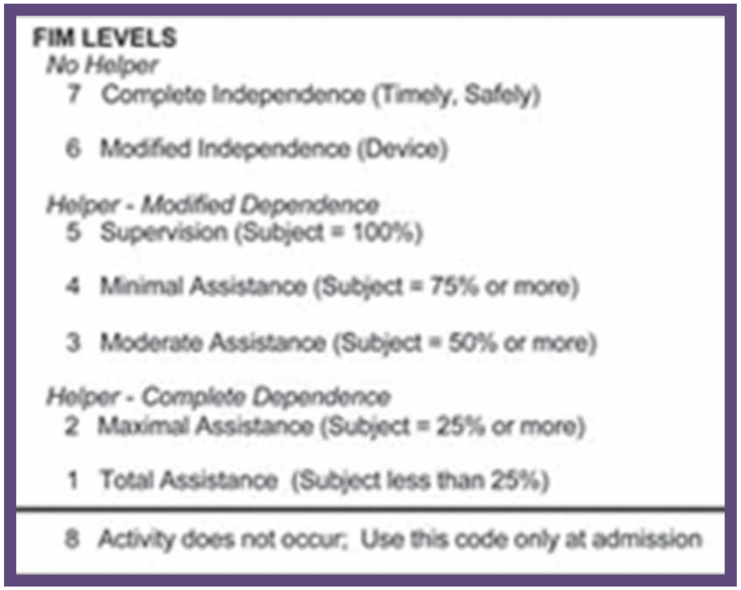
COMMUNICATION
N. Comprehension
O. Expression

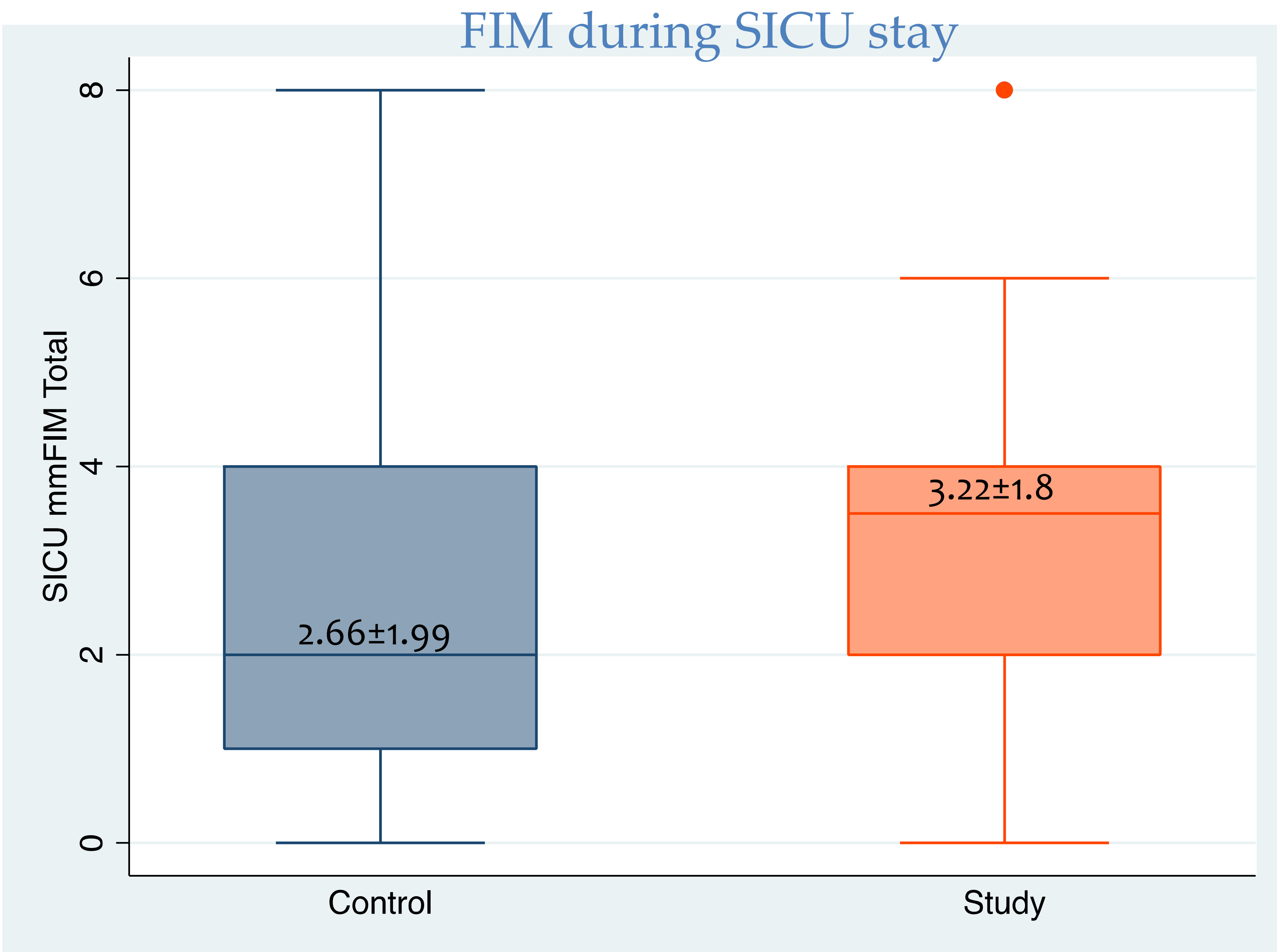
V - Vocal
N - Nonvocal
B - Both

SOCIAL COGNITION
P. Social Interaction
Q. Problem Solving
R. Memory

FIM LEVELS
No Helper
7 Complete Independence (Timely, Safely)
6 Modified Independence (Device)
Helper - Modified Dependence
5 Supervision (Subject = 100%)
4 Minimal Assistance (Subject = 75% or more)
3 Moderate Assistance (Subject = 50% or more)
Helper - Complete Dependence
2 Maximal Assistance (Subject = 25% or more)
1 Total Assistance (Subject less than 25%)
8 Activity does not occur; Use this code only at admission

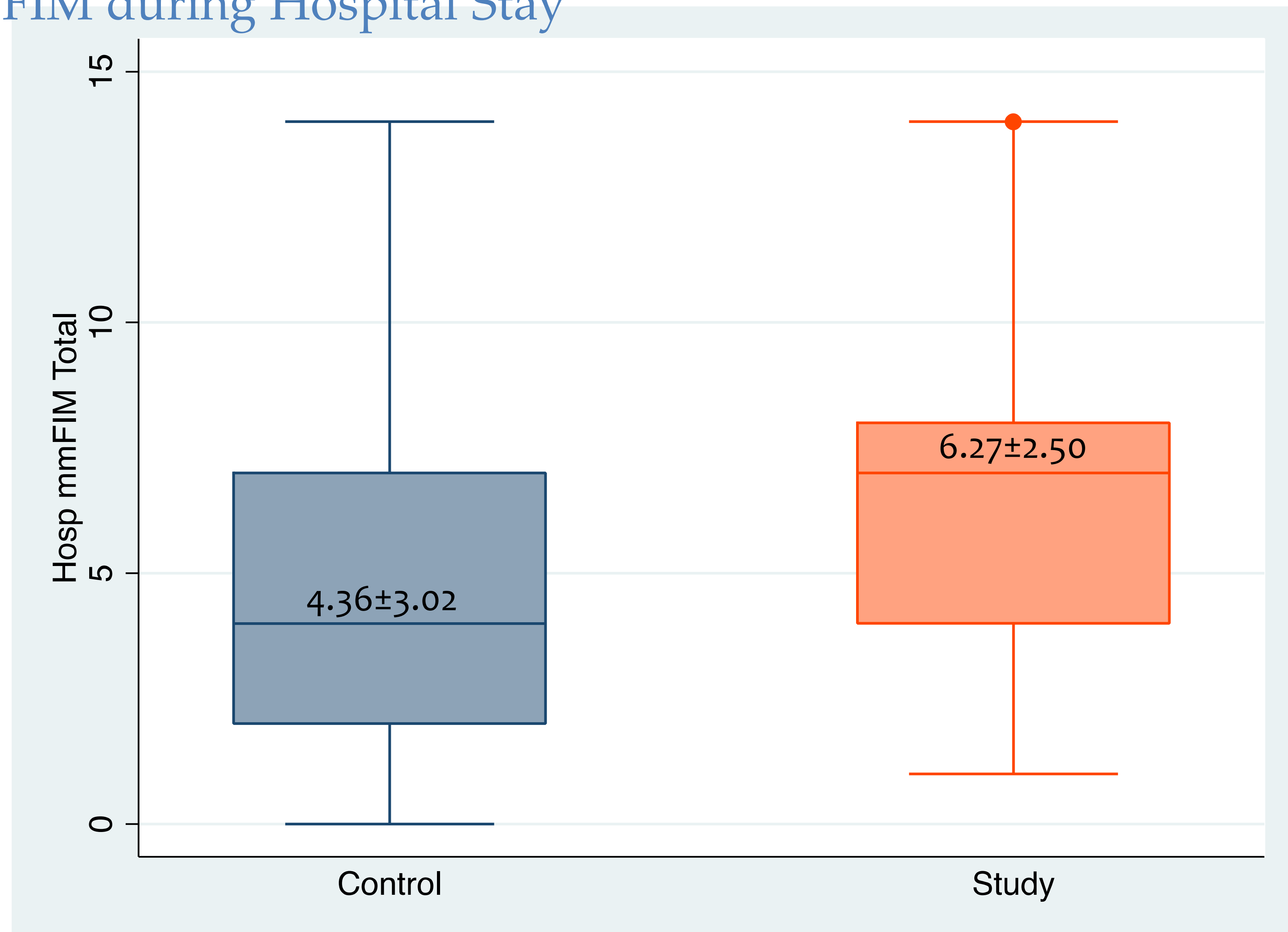
SICU Hospital





FIM during SICU stay
SICU mmFIM Total
0
2
4
6
8
2.66±1.99
3.22±1.8
Control
Study

FIM during Hospital Stay



Other variables: Drugs used in ICU

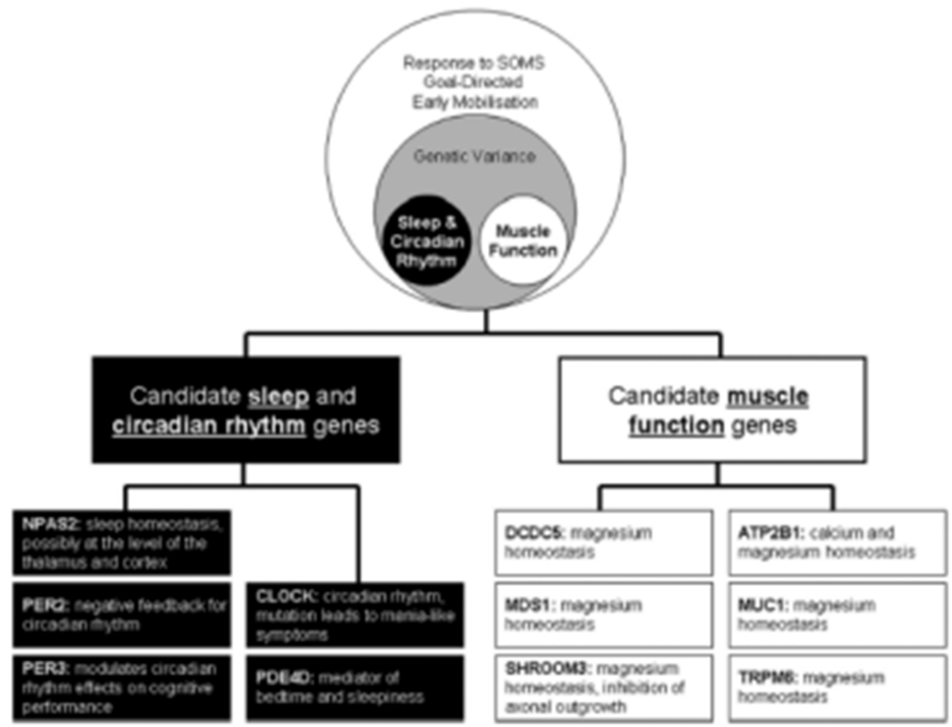
	Opiod Days (SICU)	Benzo-Days (SICU)	Pressor Days (SICU)	Anti-psychotic Days (SICU)	Sedation Days (SICU)	Delirium Days (SICU)
Control	8.565217	0.833333	4.326087	1.851064	6.133333	1.707317
Study	5.744681	0.416667	2.638298	2.0625	4.291667	1.479167

SOMS is an an international, multicentric RCT

Hypothesis generating part

- To get mechanism-based exploratory data

Genetic testing



External centers

Munich

- German validated study completed (n=120)
- IRB for RCT approved (last week)
- Recruitment will start next week

Brescia

- Italian validation study completed
- IRB submitted

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Conclusion

Keep your patients moving

- Bed-rest is associated with morbidity
- Early mobilization improves outcome
- Get the patient out of bed
- Do we need sedation / opioids today?
- Do we need neuromuscular blockade?
- Do we need controlled ventilation today?
- Can we extubate the patient today?

Get more evidence

- Effects of early mobilization on mortality and long-term morbidity.
- Does-response relationship.
- Test effects of different ventilator patterns on ventilator-induced diaphragmatic injury.
- Test sedation protocols.
- Early oral food intake: Network with speech therapists.

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