Published in final edited form as:

Crit Care Med. 2013 October ; 41(10): 2457–2458. doi:10.1097/CCM.0b013e31829824da.

Prevention and Treatment of ICU Acquired Weakness – Is There a Stimulating Answer?

Leigh Ann Callahan, MD¹ and Gerald S. Supinski, MD²

Leigh Ann Callahan: lacall2@email.uky.edu; Gerald S. Supinski: gsupi2@email.uky.edu

¹Department of Internal Medicine, Division of Pulmonary, Critical Care and Sleep Medicine, University of Kentucky, 740 South Limestone Room L-543, Lexington, KY 40536-0284, Phone: 859-323-5045, Fax: 859-257-2418

²Department of Internal Medicine, Division of Pulmonary, Critical Care and Sleep Medicine, University of Kentucky, 740 South Limestone Room L-543, Lexington, KY 40536-0284, Phone: 859-323-5045, Fax: 859-257-2418

ICU acquired weakness (ICUAW) complicates critical illness and is an important determinant of acute and long term outcomes. The consequences of ICUAW are profound. Respiratory muscle weakness prolongs duration of mechanical ventilation, contributes to weaning failure, impacts rates of reintubation after failed extubation, and is associated with poor outcomes including increased transfers to long term acute care facilities and death (1, 2). Likewise, limb muscle weakness limits ambulation, performance of activities of daily living, and impacts patient morbidity for years (3, 4). Survival after the acute episode of critical illness places an enormous burden on patients, families, and healthcare systems (1, 5). As a result, intensivists strive to develop effective rehabilitation strategies to prevent or treat this devastating complication.

In this issue of *Critical Care Medicine*, Parry et al (6) provide an excellent review of previously published randomized controlled trials that examined the use of neuromuscular electrical stimulation (NMES) to treat or attenuate limb muscle weakness in a general population of critically ill patients. Using rigorous predetermined criteria, the authors evaluated studies which included six cohorts of patients (138 total subjects). They provide a detailed analysis and side-by-side comparison of these prior studies, including a well-synthesized and thoughtful discussion that delineates what we have learned thus far from the application of NMES in critical illness.

NMES is one of a number of treatments that might improve muscle function in ICU patients. Since Bailey et al showed that mobilization is safe and feasible in mechanically ventilated patients (7), others have confirmed that early mobilization improves outcomes (8, 9). In addition to early mobilization, more aggressive exercise regimens including cycle ergometry have been used to prevent muscle atrophy and improve strength in critically ill immobilized patients (10). Finally, the institution of sedation protocols and daily interruption of sedation are thought to be essential in facilitating mobilization (11).

Despite the numerous studies promoting early mobilization, implementation of this practice into routine ICU care is limited. While safety and feasibility have been shown, many healthcare providers maintain that sedation interruption and early mobilization places patients at risk for unwanted complications including accidental extubation, dislodgement of catheters, worsening respiratory status and hemodynamic instability. Furthermore, most

research in this area employed multidisciplinary teams (nurses, technicians, respiratory therapists and physicians) and used special equipment to implement early mobilization. Many hospitals may not be willing to support these costs for additional personnel and equipment. Moreover, a recent multicenter trial examining outcomes in ICU patients that received daily sedation interruption showed no benefit compared to patients who did not, challenging the present dogma (12). The reality is that in many critical care units, early mobilization just does not occur. As such, intensivists should consider other approaches to ICU rehabilitation. NMES may offer a viable and practical alternative to ICU rehabilitation.

NMES can be administered very early during the course of critical illness while the patient is in bed, regardless of the level of sedation or analgesia. Caregivers may be more amenable to this intervention, since the risks of accidental extubation, dislodgement of catheters, worsening respiratory status and hemodynamic instability are almost nonexistent. This therapy provides a non-volitional training regimen that does not require a multidisciplinary team of healthcare workers and numerous, relatively inexpensive stimulators are commercially available, suggesting that NMES may be less costly than early mobilization.

Despite the potential benefits of NMES, several issues need consideration. Effective delivery of NMES is limited in obese patients and in those with significant limb edema. Additionally, NMES can only target a limited number of muscle groups. For example, respiratory muscle weakness is an important manifestation of ICUAW, but stimulation of limb muscles does not directly target these muscles. This is important because liberation from mechanical ventilation is arguably the most practical way to improve mobility in ICU patients. Furthermore, some patients may be non-responders as reports indicate that NMES results in only weakly palpable or no contractions, observations that are consistent with ICUAW-induced muscle inexcitability. In these individuals, NMES may not generate sufficient levels of muscle force generation to achieve a beneficial effect and further efforts to increase current density to achieve contractions may produce unwanted side effects including pain or burns.

In view of these concerns, it is reasonable to speculate that methodological refinement of NMES could improve the application of this modality in ICUAW. One alternative approach would be to target the key muscle groups that are needed to perform a specific task, rather than limiting NMES to a single muscle. Theoretically, this could be achieved by alternate stimulation of synergistic muscle groups. In addition, the use of NMES in combination with other interventions, such as anabolic therapies or volitional tasks (functional electrical stimulation) could augment its efficacy. Moreover, while commercially available stimulators with preprogrammed stimulation protocols simplify the application of NMES in clinical settings, these protocols may not be optimal for use in ICUAW. Stimulation protocols that achieve muscle activation similar to what occurs during voluntary contraction where asynchronous motor unit discharge produces steady forces with relatively low neural firing rates might produce more robust and physiologically relevant outcomes. Theoretically, stimulation protocols could be graded based on individual responsiveness and used to achieve an aerobic training effect as has been reported in some patient populations. If this is possible, NMES could preserve muscle mass, improve muscle quality and function, and restore muscle endurance in patients with ICUAW.

Although the data supporting the use of NMES in ICUAW is limited, this form of rehabilitation in critically ill patients holds great potential. Future studies with NMES, however, need to be carefully designed with attention to the aforementioned issues. Investigations should be scientifically rigorous with objective and well-defined physiologically relevant outcome measures, realizing that muscle performance is not merely a function of muscle quantity (size) (13). Functional capacity is critically dependent upon

muscle quality (force generating capacity) and muscle endurance. We must also reassess the emerging notion that ICU rehabilitation should be reserved for select groups, excluding those with pre-existing functional derangements or co-morbidities (14), since NMES has been shown to improve functional capacity in a wide range of chronic diseases.

Acknowledgments

Drs. Callahan and Supinski's institution received grant support from the National Institutes of Health. Drs. Callahan and Supinski received article research support from NIH.

References

1. Cox CE, Carson SS. Medical and economic implications of prolonged mechanical ventilation and expedited post-acute care. *Semin Respir Crit Care Med*. 2012; 33(4):357–361. [PubMed: 22875381]
2. Nelson JE, Cox CE, Hope AA, et al. Chronic critical illness. *Am J Respir Crit Care Med*. 2010; 182(4):446–454. [PubMed: 20448093]
3. Herridge MS. Recovery and long-term outcome in acute respiratory distress syndrome. *Crit Care Clin*. 2011; 27(3):685–704. [PubMed: 21742223]
4. Herridge MS, Tansey CM, Matte A, et al. Functional disability 5 years after acute respiratory distress syndrome. *N Engl J Med*. 2011; 364(14):1293–1304. [PubMed: 21470008]
5. Kress JP, Herridge MS. Medical and economic implications of physical disability of survivorship. *Semin Respir Crit Care Med*. 2012; 33(4):339–347. [PubMed: 22875379]
6. Parry SM, Berney S, Granger CL, Koopman R, El-Ansary D, Denehy L. Electrical muscle stimulation in the intensive care setting: A systematic review. *Crit Care Med*. 2013
7. Bailey P, Thomsen GE, Spuhler VJ, et al. Early activity is feasible and safe in respiratory failure patients. *Crit Care Med*. 2007; 35(1):139–145. [PubMed: 17133183]
8. Morris PE, Griffin L, Berry M, et al. Receiving early mobility during an intensive care unit admission is a predictor of improved outcomes in acute respiratory failure. *Am J Med Sci*. 2011; 341(5):373–377. [PubMed: 21358312]
9. Schweickert WD, Pohlman MC, Pohlman AS, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. *Lancet*. 2009; 373(9678):1874–1882. [PubMed: 19446324]
10. Burtin C, Clerckx B, Robbeets C, et al. Early exercise in critically ill patients enhances short-term functional recovery. *Crit Care Med*. 2009; 37(9):2499–2505. [PubMed: 19623052]
11. Kress JP. Sedation and mobility: changing the paradigm. *Crit Care Clin*. 2013; 29(1):67–75. [PubMed: 23182528]
12. Mehta S, Burry L, Cook D, et al. Daily sedation interruption in mechanically ventilated critically ill patients cared for with a sedation protocol: a randomized controlled trial. *JAMA*. 2012; 308(19):1985–1992. [PubMed: 23180503]
13. Cartwright MS, Kwayisi G, Griffin LP, et al. Quantitative neuromuscular ultrasound in the intensive care unit. *Muscle Nerve*. 2013; 47(2):255–259. [PubMed: 23041986]
14. Batt J, dos Santos CC, Cameron JI, et al. Intensive care unit-acquired weakness: clinical phenotypes and molecular mechanisms. *Am J Respir Crit Care Med*. 2013; 187(3):238–246. [PubMed: 23204256]