ISSN 1949-8462 (online)

World Journal of *Cardiology*

World J Cardiol 2024 October 26; 16(10): 550-618

Published by Baishideng Publishing Group Inc

World Journal of Cardiology

Contents

Monthly Volume 16 Number 10 October 26, 2024

MINIREVIEWS

ORIGINAL ARTICLE

Case Control Study

Retrospective Cohort Study

Observational Study

CASE REPORT

LETTER TO THE EDITOR

World Journal of Cardiology

Monthly Volume 16 Number 10 October 26, 2024

Contents

ABOUT COVER

Editorial Board Member of *World Journal of Cardiology*, Akshyaya Pradhan, MD, DM, FACC, FSCAI, FESC, FAPSIC, Professor (Jr), Department of Cardiology, King George's Medical University, Lucknow, Uttar Pradesh 226003, India. akshyaya33@gmail.com

AIMS AND SCOPE

The primary aim of *World Journal of Cardiology* (*WJC*, *World J Cardiol*) is to provide scholars and readers from various fields of cardiology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJC mainly publishes articles reporting research results and findings obtained in the field of cardiology and covering a wide range of topics including acute coronary syndromes, aneurysm, angina, arrhythmias, atherosclerosis, atrial fibrillation, cardiomyopathy, congenital heart disease, coronary artery disease, heart failure, hypertension, imaging, infection, myocardial infarction, pathology, peripheral vessels, public health, Raynaud's syndrome, stroke, thrombosis, and valvular disease.

INDEXING/ABSTRACTING

The *WJC* is now abstracted and indexed in Emerging Sources Citation Index (Web of Science), PubMed, PubMed Central, Scopus, Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2024 Edition of Journal Citation Reports® cites the 2023 journal impact factor (JIF) for *WJC* as 1.9; JIF without journal self cites: 1.9; 5-year JIF: 2.3; JIF Rank: 123/220 in cardiac and cardiovascular systems; JIF Quartile: Q3; and 5-year JIF Quartile: Q2. The *WJC*'s CiteScore for 2023 is 3.3 and Scopus CiteScore rank 2023: Cardiology and cardiovascular medicine is 189/387.

RESPONSIBLE EDITORS FOR THIS ISSUE

NAME OF JOURNAL
World Journal of Cardiology

ISSN
ISSN 1949-8462 (online)

LAUNCH DATE
December 31, 2009

FREQUENCY
Monthly

EDITORS-IN-CHIEF
Ramdas G Pai, Dimitrios Tousoulis, Marco Matteo Ciccone, Pal Pacher

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/1949-8462/editorialboard.htm

PUBLICATION DATE
October 26, 2024

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

World Journal of Cardiology

Submit a Manuscript: https://www.f6publishing.com

World J Cardiol 2024 October 26; 16(10): 604-607

DOI: 10.4330/wjc.v16.i10.604

ISSN 1949-8462 (online)

LETTER TO THE EDITOR

Evaluating neuromuscular electrical stimulation for preventing and managing intensive care unit-acquired weakness: Current evidence and future directions

Annu Lisa Kurian, Brandon Lucke-Wold

Specialty type: Critical care medicine

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification
Scientific Quality: Grade B
Novelty: Grade B
Creativity or Innovation: Grade B
Scientific Significance: Grade B

P-Reviewer: Ong H

Received: April 19, 2024
Revised: September 3, 2024
Accepted: September 20, 2024
Published online: October 26, 2024
Processing time: 180 Days and 15.9 Hours

Annu Lisa Kurian, College of Medicine, Florida State University, Tallahassee, FL 32304, United States

Brandon Lucke-Wold, Department of Neurosurgery, University of Florida, Gainesville, FL 32611, United States

Corresponding author: Brandon Lucke-Wold, MD, PhD, Doctor, Neurosurgeon, Research Scientist, Department of Neurosurgery, University of Florida, 1505 SW Archer Road, Gainesville, FL 32611, United States. brandon.lucke-wold@neurosurgery.ufl.edu

Abstract

Intensive care unit-acquired weakness (ICU-AW) is a prevalent issue in critical care, leading to significant muscle atrophy and functional impairment. Aiming to address this, Neuromuscular Electrical Stimulation (NMES) has been explored as a therapy. This systematic review assesses NMES's safety and effectiveness in enhancing functional capacity and mobility in pre- and post-cardiac surgery patients. NMES was generally safe and feasible, with intervention sessions varying in frequency and duration. Improvements in muscle strength and 6-minute walking test distances were observed, particularly in preoperative settings, but postoperative benefits were inconsistent. NMES showed promise in preventing muscle loss and improving strength, although its impact on overall functional capacity remained uncertain. Challenges such as short ICU stays and body composition affecting NMES efficacy were noted. NMES also holds potential for other conditions like cerebral palsy and stroke. Further research is needed to optimize NMES protocols and better understand its full benefits in preventing ICU-AW and improving patient outcomes.

Key Words: Neuromuscular electrical stimulation; Intensive care unit-acquired weakness; Cardiac surgery; Muscle atrophy; Functional capacity

Core Tip: Muscle weakness, termed intensive care unit-acquired weakness (ICU-AW), commonly affects limb and respiratory muscles, causing severe atrophy and functional impairment. Neuromuscular Electrical Stimulation (NMES) is a promising therapy that induces muscle contractions without patient effort. While NMES is safe and feasible, its effectiveness in improving post-surgery functional capacity is limited. It shows potential in preventing neuromyopathy and enhancing muscle strength, especially when used preoperatively. NMES may also benefit conditions beyond cardiac surgery, such as cerebral palsy and stroke. Further research is needed to fully understand and optimize NMES for preventing ICU-AW and improving outcomes in critical care settings.

Citation: Kurian AL, Lucke-Wold B. Evaluating neuromuscular electrical stimulation for preventing and managing intensive care unit-acquired weakness: Current evidence and future directions. *World J Cardiol* 2024; 16(10): 604-607
URL: https://www.wjgnet.com/1949-8462/full/v16/i10/604.htm
DOI: https://dx.doi.org/10.4330/wjc.v16.i10.604

TO THE EDITOR

As emphasized by Kourek *et al*[1], to tackle the issues of diminished functional capacity and muscle function in patients recovering from cardiac surgery, and to counteract complications such as intensive care unit-acquired weakness (ICU-AW) and polyneuromyopathy, neuromuscular electrical stimulation (NMES) is advised. NMES has proven to be both safe and practical, even in high-risk patients, with a low incidence of severe complications or adverse effects. Implementing NMES as a prehabilitation strategy before cardiac surgery and continuing its use until discharge can lead to notable improvements in muscle strength, exercise tolerance, and overall mobility. This method also holds potential for reducing the length of intensive care unit (ICU) stays and minimizing complications. Nevertheless, while NMES shows considerable promise, further research with large-scale randomized controlled trials is needed to fully understand its benefits and refine its application.

WHY OPT FOR NEUROMUSCULAR ELECTRICAL STIMULATION?

Muscle weakness is a common issue in the ICU, often arising as a secondary disorder during treatment for life-threatening conditions. This condition, termed ICU-AW, primarily affects limb and respiratory muscles, with reduced muscle tone and reflexes. It can result from neurogenic or myogenic disturbances, or a combination of both known as critical illness neuromyopathy[2]. Severe muscle atrophy may occur, contributing to functional impairment. In some studies, it was shown that ICU-AW caused more than 10% loss of muscle mass, just in the first week of stay in the ICU[3]. ICU-AW stands out as the predominant neuromuscular issue encountered in patients facing critical illness in hospitals and it has been estimated to affect approximately 43% of ICU patients[4]. As this is such a common occurrence, a few therapies have emerged as possible treatments, with NMES being one of the most promising[1].

The study outlines that ICU-AW is exacerbated by prolonged ICU stays and lack of mobilization, impacting patient quality of life and mortality rates. Therapeutic strategies focus on preventing muscle atrophy and degeneration, with early mobilization showing promise but facing challenges due to patient limitations. As such, NMES has emerged as a viable alternative, promoting muscle contraction without patient effort, showing benefits in preventing neuromyopathy progression, shortening ICU stays, and improving muscle strength and functional capacity. Their systematic review aims to evaluate NMES's safety and effectiveness in improving functional capacity and mobility in pre- and post-cardiac surgery patients, with potential implications for improving patient outcomes and quality of life.

After their literature review, the study ended up looking at 10 randomized control trials with a total of 703 patients, most of them being male patients, who had undergone surgeries ranging from valve replacements to heart transplants. In these patients, NMES was consistently applied to the intervention group across all studies, with variations in intensity and session duration noted. In three studies, electrodes were placed on the control group without electricity delivery, while in seven studies, the control group received usual care post-surgery. Most studies involved at least five NMES sessions and session frequency ranged from 2 to 5 times weekly, with durations spanning from 30 to 90 minutes. Functional capacity was evaluated in nine out of ten studies on NMES. However, only two recent studies demonstrated improvement in functional capacity. One study also observed a significant increase in distance measured on the 6-Minute Walking Test (6MWT) within the NMES group as compared to the control group when it came to prehabilitation before cardiac surgery. Additionally, some studies reported significant improvements in muscle strength with NMES, while others did not find significant differences compared to controls.

Overall, NMES appears safe and feasible for pre- and post-cardiac surgery patients, potentially benefiting muscle strength to prevent ICU-AW However, its impact on functional capacity post-surgery seems limited, particularly compared to its effectiveness as prehabilitation before surgery. Muscle atrophy, a key component of ICU-AW, is influenced by various factors including age and inactivity-induced oxidative stress. NMES offers a safe alternative exercise method, potentially reducing ICU stays and improving muscle strength, particularly in the limbs, though its impact on overall functional capacity remains uncertain.

The effectiveness of NMES may be hindered by the short duration of ICU stays and limited sessions. Preoperative NMES as a form of prehabilitation shows promise in enhancing functional capacity and muscle strength, yet data on this approach are still scarce. Mechanistically, NMES activates muscle fibers directly, potentially inducing muscle growth and modulating catabolic processes. By potentially preventing ICU-AW and polyneuromyopathy, NMES could lead to better outcomes, shorter ICU stays, fewer complications, and improved exercise tolerance and mobility for cardiac surgery patients. Additionally, NMES may offer further benefits such as enhancing quality of life and improving hemodynamic and respiratory responses.

In addition to those mentioned in the paper, another limiting factor is that the review was only done on those with a body mass index (BMI) ranging from 19.3 to 29.1 kg/m^2. Obese patients, or patients with a BMI > 30.0 kg/m^2, face challenges in utilizing NMES due to their body composition[5]. The presence of excess subcutaneous fat can hinder NMES effectiveness by increasing the distance between the stimulating electrode and the axon terminals[5]. Additionally, body fat's poor conductivity means higher current intensities are needed to produce muscle contractions in obese individuals[5]. Furthermore, this heightened intensity may inadvertently activate nociceptors along with muscle fibers, which may lead to poorer outcomes[5]. Obese individuals, especially women, have also showed a lower tolerance to motor stimulation compared to non-obese individuals so this is another limiting factor to consider[6]. Furthermore, studies have shown that 4 months post-discharge from the intensive care unit, the 6MWT provided a moderately accurate prediction of long-term physical functional status after the ICU[7]. Therefore, to truly see the validity of NMES, we would need to compare the postoperative 6MWT distance with the participant's baseline 6MWT distance.

CONCLUSION

Be that as it may, NMES has a broad range of applications. There is mounting evidence that NMES can have a beneficial effect by increasing muscle strength, range of motion, and muscle function in patients with diseases such as cerebral palsy [8] or after surgeries such as total knee arthroplasties[9]. NMES has also been shown to be an excellent treatment choice in conditions such as oropharyngeal dysphagia or even stroke[10,11]. Studies have shown that NMES can have peripheral effects of boosting muscle contractility and resilience to fatigue, as well as increasing muscle mass and reducing swelling, effectively reversing muscle atrophy due to inactivity[11,12]. Certain NMES techniques may influence the central nervous system's regulation of movement, fostering motor relearning by facilitating synchronized activity between nerve endings [11]. Moreover, studies have shown that NMES-induced isometric contractions can lead to extensive brain activation patterns, similar to those observed during voluntary movements[13]. Despite discomfort being a significant constraint on NMES efficacy[13], these findings and others like it suggest the potential of NMES for developing customized stimulation protocols to target specific or impaired cerebral brain regions in future research endeavors. However, further research, particularly larger randomized controlled trials, is needed to fully understand NMES's benefits, optimize its application, and explore its potential in preventing ICU-AW after cardiac surgery.

FOOTNOTES

Author contributions: Kurian AL collaborated with the other author in conceptualization of the paper; She designed the structure of the paper, crafted the first draft, and was the primary editor; Lucke-Wold B also contributed to the conceptualization, assisted in organizing the project, provided senior oversight, and conducted quality review of the paper; He is also the co-corresponding author.

Conflict-of-interest statement: All authors have no conflicts of interest to disclose.

Country of origin: United States

ORCID number: Annu Lisa Kurian 0009-0000-4388-246X; Brandon Lucke-Wold 0000-0001-6577-4080.

S-Editor: Liu JH
L-Editor: A
P-Editor: Wang WB

REFERENCES

1 **Kourek C**, Kanellopoulos M, Raidou V, Antonopoulos M, Karatzanos E, Patsaki I, Dimopoulos S. Safety and effectiveness of neuromuscular electrical stimulation in cardiac surgery: A systematic review. *World J Cardiol* 2024; **16**: 27-39 [PMID: 38313389 DOI: 10.4330/wjc.v16.i1.27]

2 **Latronico N**, Bolton CF. Critical illness polyneuropathy and myopathy: a major cause of muscle weakness and paralysis. *Lancet Neurol* 2011;

10: 931-941 [PMID: 21939902 DOI: 10.1016/S1474-4422(11)70178-8]

3 **Puthucheary ZA**, Rawal J, McPhail M, Connolly B, Ratnayake G, Chan P, Hopkinson NS, Phadke R, Dew T, Sidhu PS, Velloso C, Seymour J, Agley CC, Selby A, Limb M, Edwards LM, Smith K, Rowlerson A, Rennie MJ, Moxham J, Harridge SD, Hart N, Montgomery HE. Acute skeletal muscle wasting in critical illness. *JAMA* 2013; **310**: 1591-1600 [PMID: 24108501 DOI: 10.1001/jama.2013.278481]

4 **Fan E**, Cheek F, Chlan L, Gosselink R, Hart N, Herridge MS, Hopkins RO, Hough CL, Kress JP, Latronico N, Moss M, Needham DM, Rich MM, Stevens RD, Wilson KC, Winkelman C, Zochodne DW, Ali NA; ATS Committee on ICU-acquired Weakness in Adults; American Thoracic Society. An official American Thoracic Society Clinical Practice guideline: the diagnosis of intensive care unit-acquired weakness in adults. *Am J Respir Crit Care Med* 2014; **190**: 1437-1446 [PMID: 25496103 DOI: 10.1164/rccm.201411-2011ST]

5 **Vivodtzev I**, Maffiuletti NA, Borel AL, Grangier A, Wuyam B, Tamisier R, Pépin JL. Acute Feasibility of Neuromuscular Electrical Stimulation in Severely Obese Patients with Obstructive Sleep Apnea Syndrome: A Pilot Study. *Biomed Res Int* 2017; **2017**: 3704380 [PMID: 28194410 DOI: 10.1155/2017/3704380]

6 **Maffiuletti NA**, Morelli A, Martin A, Duclay J, Billot M, Jubeau M, Agosti F, Sartorio A. Effect of gender and obesity on electrical current thresholds. *Muscle Nerve* 2011; **44**: 202-207 [PMID: 21698650 DOI: 10.1002/mus.22050]

7 **Rosa RG**, Dietrich C, Valle ELTD, Souza D, Tagliari L, Mattioni M, Tonietto TF, Rosa RD, Barbosa MG, Lovatel GA, Lago PD, Oliveira ES, Sganzerla D, Andrade JMS, Berto P, Cardoso PR, Sanchez EC, Falavigna M, Maccari JG, Rech G, Robinson C, Schneider D, Leon P, Biason L, Teixeira C. The 6-Minute Walk Test predicts long-term physical improvement among intensive care unit survivors: a prospective cohort study. *Rev Bras Ter Intensiva* 2021; **33**: 374-383 [PMID: 35107548 DOI: 10.5935/0103-507X.20210056]

8 **Wright PA**, Durham S, Ewins DJ, Swain ID. Neuromuscular electrical stimulation for children with cerebral palsy: a review. *Arch Dis Child* 2012; **97**: 364-371 [PMID: 22447997 DOI: 10.1136/archdischild-2011-300437]

9 **Klika AK**, Yakubek G, Piuzzi N, Calabrese G, Barsoum WK, Higuera CA. Neuromuscular Electrical Stimulation Use after Total Knee Arthroplasty Improves Early Return to Function: A Randomized Trial. *J Knee Surg* 2022; **35**: 104-111 [PMID: 32610358 DOI: 10.1055/s-0040-1713420]

10 **Miller S**, Peters K, Ptok M. Review of the effectiveness of neuromuscular electrical stimulation in the treatment of dysphagia - an update. *Ger Med Sci* 2022; **20**: Doc08 [PMID: 35875244 DOI: 10.3205/000310]

11 **Knutson JS**, Fu MJ, Sheffler LR, Chae J. Neuromuscular Electrical Stimulation for Motor Restoration in Hemiplegia. *Phys Med Rehabil Clin N Am* 2015; **26**: 729-745 [PMID: 26522909 DOI: 10.1016/j.pmr.2015.06.002]

12 **Carson RG**, Buick AR. Neuromuscular electrical stimulation-promoted plasticity of the human brain. *J Physiol* 2021; **599**: 2375-2399 [PMID: 31495924 DOI: 10.1113/JP278298]

13 **Wegrzyk J**, Ranjeva JP, Fouré A, Kavounoudias A, Vilmen C, Mattei JP, Guye M, Maffiuletti NA, Place N, Bendahan D, Gondin J. Specific brain activation patterns associated with two neuromuscular electrical stimulation protocols. *Sci Rep* 2017; **7**: 2742 [PMID: 28577338 DOI: 10.1038/s41598-017-03188-9]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com