Received: 13 January 2018 | Revised: 10 April 2018 | Accepted: 12 April 2018
DOI: 10.1002/ccr3.1576

CASE REPORT

WILEY Clinical Case Reports Open Access

Recovery of muscle weakness and physical function in a patient with severe ICU-acquired weakness following pulmonary embolism: A case report

Yosuke Morimoto[1] | Motohiro Sekino[2] | Kiyoyuki Eishi[3] | Ryo Kozu[1,4]

[1]Department of Rehabilitation Medicine, Nagasaki University Hospital, Nagasaki, Japan
[2]Department of Intensive Care Unit, Nagasaki University Hospital, Nagasaki, Japan
[3]Department of Cardiovascular Surgery, Nagasaki University Hospital, Nagasaki, Japan
[4]Department of Cardiopulmonary Rehabilitation Science, Nagasaki University Graduate School of Biomedical Sciences, Nagasaki, Japan

Correspondence
Yosuke Morimoto, Department of Rehabilitation Medicine, Nagasaki University Hospital, Nagasaki, Japan.
Email: morimoto@nagasaki-u.ac.jp

Key Clinical Message
Although ICU-AW is a common condition in critically ill, it is unclear which intervention is best to treat. We applied combined exercise training and nutritional supplementation, and these were effective to recover the skeletal muscle function and exercise capacity. We should recognize necessity of nutritional support in ICU-AW patients.

KEYWORDS
early mobilization, intensive care unit-acquired weakness, nutritional intervention, quadriceps muscle thickness, ultrasonographic evaluation

1 | INTRODUCTION

A 53-year-old woman who underwent thrombus removal surgery had an extubation failure and severe quadriceps muscle weakness while in the ICU. She received nutritional supplements, which eventually resulted in increased muscle thickness. The program, consisting of exercises and nutritional supplementation, was feasible and appeared to expedite physical function recovery.

Although advances in intensive care have helped reduce mortality, several critical illness survivors suffer from severe disease symptoms acquired or aggravated during their ICU stay. ICU-acquired weakness (ICU-AW) may occur several hours after ICU admission and could lead to functional disability and impaired health status in the long term. Increasing frequency of physiotherapy may facilitate the initial recovery process in patients who suffer from ICU-AW.[1] Although physiotherapy has a greater role in the management of ICU-AW, it is difficult to completely prevent actually. The prognosis is poor, and complete functional recovery, with patients regaining the ability to breathe spontaneously and walk independently, has been reported at 68.4%.[2] However, the time course of recovery from ICU-AW remains unclear.

In this report, a patient with ICU-AW-induced tetraplegia after severe pulmonary embolism underwent an early mobilization (EM) program and was finally able to walk independently. Progress in peripheral muscle function, especially in quadriceps muscle thickness, which is an important outcome for muscle wasting after ICU-AW-induced tetraplegia,[3] functional exercise capacity during 3 months of intervention, was evaluated.

2 | CASE PRESENTATION

A 53-year-old woman was referred to Nagasaki University Hospital for renal arterial embolization to treat bleeding around the kidney. Her general condition was stable after the treatment, and she could ambulate. On her first postoperative day (POD), 18 days after admission, she required mechanical ventilation (MV) and percutaneous cardiopulmonary support (PCPS) for severe respiratory and cardiac failure because of acute pulmonary thromboembolism due to deep venous thrombosis; consequently, she underwent thrombus removal surgery in the emergency room. After the surgery, she was admitted in the ICU with MV and PCPS.

On POD 2, we, rehabilitation team including physiotherapists, commenced passive limb exercises, such as stretching to prevent joint contracture, with the patient in bed, as the first part of the EM program. Quadriceps muscle thickness was 23.1 mm as measured 15 cm above the patella by B mode ultrasonography (ProSound 2, Hitachi, Ltd., Japan).[4] During the evaluation, as lower limbs are extension position, and the prove was pressed manually. Images were stored and measured thickness on the ProSound2. Every evaluation, the same observer was measured. On POD 3, weaning from PCPS was successful and an inferior vena cava filter was inserted. On POD 8, MV was replaced with nasal high-flow oxygen therapy. We began active-assistive limb exercises; however, she presented with tachypnea and could not keep normal oxygen saturation (SpO_2), thus requiring MV again for 5 hours. On POD 9, she was drowsy and could only slightly move her eyeball and neck. MV was used for almost 48 hours, and she exhibited severe muscle weakness similar to that in tetraplegia. The Medical Research Council sum score (MRC-SS) was 4 (each bilateral ankle and wrist of 1) and handgrip force (HF) was 0 kg, meeting the diagnostic criteria for ICU-AW. A previous report showed that MRC-SS <36/48 indicates severe weakness, and HF scores <7 (interquartile range, 0-7.3) kg in females define ICU-AW.[5] Her quadriceps muscle thickness decreased to 14.8 mm (−35.9%). On POD 10, she was trained to sit on the edge of the bed with maximal assistance by three physiotherapists for 10-20 minutes but could not maintain even the positioning of her head. She had been successfully weaned and extubated from MV on POD 15.

She was discharged from the ICU. Physical function gradually improved, and capacity for activity had progressed such that she was already sitting and standing with supervision on POD28. We started moderate intensity (about borg scale of 13 or 10-20 Repetition Maximum) resistance training of the limbs, 20 minutes 5 times/wk. On POD 44, physical functions were improved, but no remarkable change in quadriceps muscle thickness was noted (17.5 mm, 75.8%). Thereafter, we prescribed resistance training with low-to-moderate intensity only, such as leg press of 30-50 times or training with original Borg Scale of Perceived Exertion (6-20 scale) of 11-13, because her nutritional condition worsened, as evidenced by decrease in total protein and albumin from 7.3 to 5.7 g/dL and 3.5 to 2.9 g/dL, respectively. Then, nutritional supplements rich in branched-chain amino acids (BCAA) (1000 mg) (Calorie Mate Jelly, Otsuka Pharmaceutical Co., Ltd., Japan) were administered, once a day, until discharge. Generally, BCAA was given within 90 minutes after exercise. At first, we tried to administer the supplements after exercise. However, the patient offered that it was difficult to take the supplements after exercise because of exercised-induced tired. Then, we administered that just before exercise. On POD 58, quadriceps muscle thickness finally recovered to 23.4 mm (101.3%), and MRC-SS, HF, isometric quadriceps force (QF), and 6-min walk distance (6MWD) were more improved (total of 59, 15 kg, 9.3kgf, and 313 m).

Radiation therapy for uterine cervical cancer once a week started on POD 55 because of the patient with untreated uterine cervical cancer and bleeding from vagina continued. She had difficulty eating because of nausea and physical fatigue due to radiation therapy. Hence, we reduced the exercise training frequency, 2-3 times/wk, and limited the exercise program to lower limb resistance training which intensity was Borg scale of under 11. QF was not increased, and HF, quadriceps muscle thickness, and 6MWD were all reduced on POD 79. When the side effects of the radiation therapy subsided, she resumed participation in the exercise program. After radiation therapy was completed, she could perform moderate intensity resistance (about Borg scale of 13 or 10-20 RM) and 20-minute aerobic trainings daily. Finally, on POD 108, a day before hospital discharge, her physical function improved, and MRC-SS, HF, and QF were 60, 17 kg, and 21.1 kgf, respectively. Quadriceps muscle thickness improved to 24.9 mm (107.8%) and the 6MWD and BI to 371 m and 95, respectively. She was discharged home on POD 109 (Figures 1 and 2).

3 | DISCUSSION

Previous reports showed functional outcome. However, these outcomes are few, and the interval of time point for assessment is long. This report showed multiple evaluations and short-term interval (per a week) compared to previous studies. To our knowledge, this is the first case report demonstrating multiple evaluations, including quadriceps muscle thickness and the clinical course of physical function in a patient with severe ICU-AW. In this case, we discussed

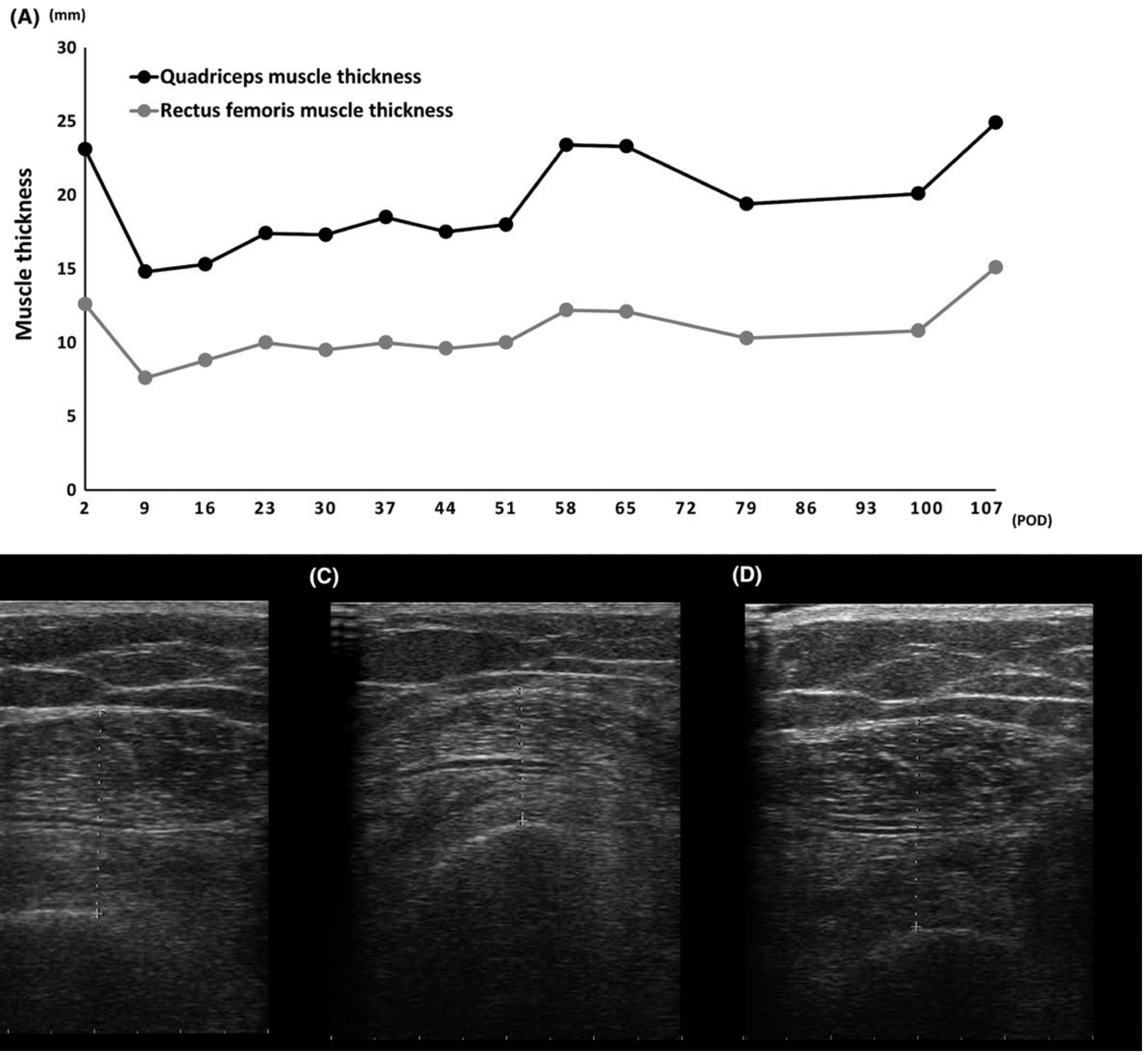

FIGURE 1 Changes in Muscle Thickness: A, Changes in quadriceps and rectus femoris muscle thickness. B-D, The images of femoral cross-sectional region of 15 cm above the patella using ultrasonography (B, POD2; C, POD9; D, POD108)

three major clinical problems: extubation failure, severe muscle weakness, and radiation therapy side effects.

The first problem in this case was due to extubation failure. In a previous study, diaphragm dysfunction in ICU-AW patients was observed in 80% of patients, and 50% had a failed extubation and died during the ICU stay.[6] A range of 18-69 hours of complete diaphragmatic inactivity and MV support results in marked diaphragm myofiber atrophy.[7] In our patient, the diaphragm dysfunction might be due to ICU-AW, which in turn led to extubation failure. Thus, evaluation of respiratory function, including maximal inspiratory pressure and diaphragm thickness, during weaning from MV is essential to monitor for extubation failure. Subsequently, we applied an exercise load to not only limb muscles but also respiratory muscles. EM, such as anti-gravity position, induces increasing respiratory rate and deep inspiration. These respirations need respiratory muscle contracture quickly and strongly. We observed these respirations in this case during EM. The intervention possibly improved her respiratory function; nevertheless, no consensus whether these training approaches are effective for respiratory muscle function exists.[8]

The second problem was her severe muscle weakness, tetraplegia. Here, the first MRC-SS measured was 4 and HF was 0 kg, suggesting severe tetraplegia and risk of mortality. However, not only MRC-SS but also skeletal muscle strength, functional exercise capacity, and ADL gradually improved in 2 months. An increased awareness on the potential influence and benefit of early rehabilitation in the ICU has been noted worldwide, and previous reports support EM and physical therapy as safe and effective interventions with a potential significant effect on functional outcomes.[9] Despite physiotherapy in the ICU appears to contribute significant benefit, its effect in patients with ICU-AW remain unclear. [10]

Interestingly, in this case, quadriceps muscle thickness needed a long time for recovery, while muscle strengths gradually improved. A previous study showed that a 30% reduction in rectus femoris thickness was noted within 10 days

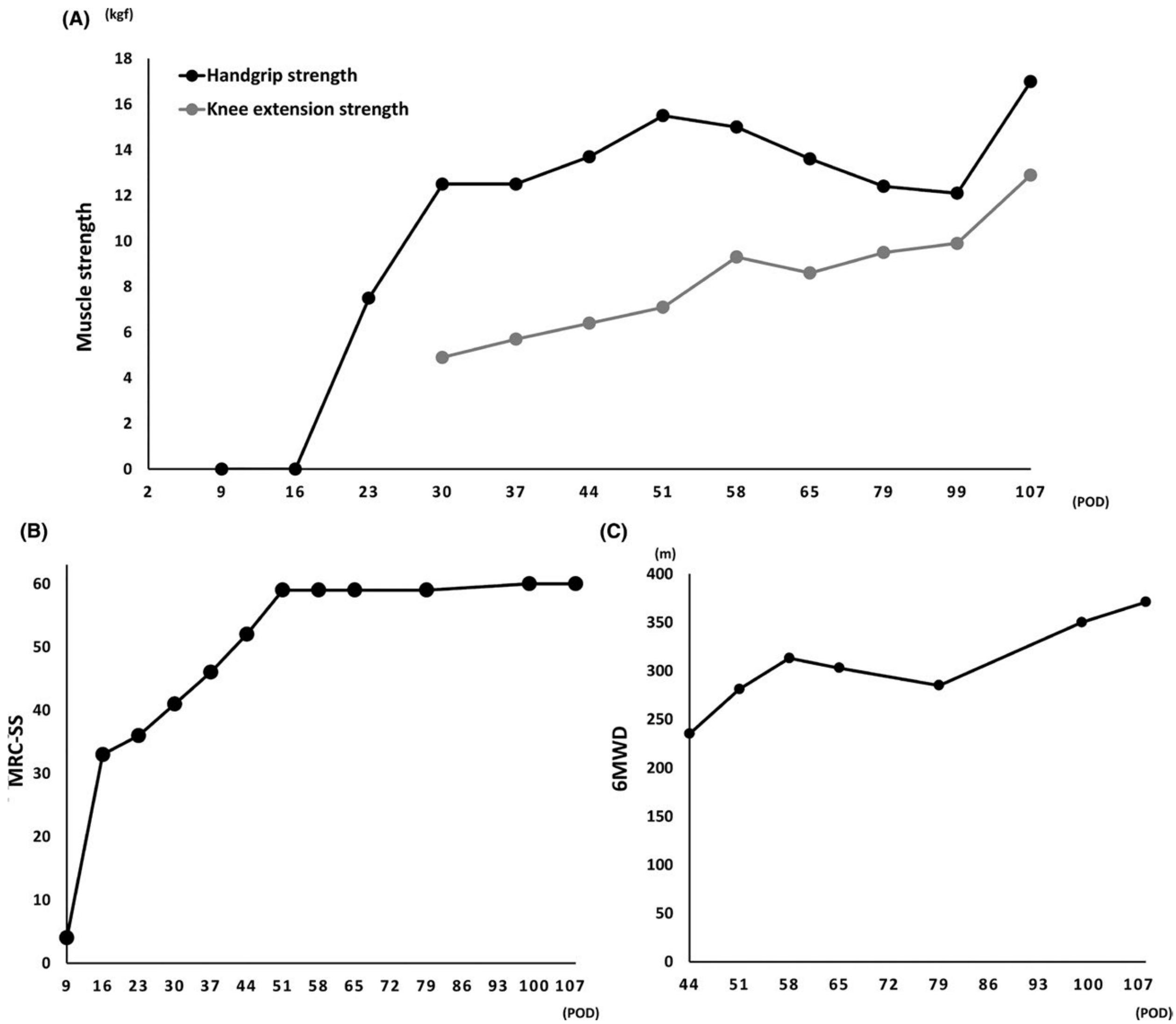

FIGURE 2 Changes in physical function: A, handgrip force and isometric quadriceps force. B, Medical Research Council-sum score. C, Six-minute walk distance

of ICU admission, showing the same time course as that of quadriceps muscle thickness,[4] which is consistent with this study. Because there is a possibility that decreasing muscle mass may precede the muscle strength, the disuse muscle atrophy proceeds to the muscle strength. It is important that the muscle strength is induced muscle contractions commanded from the motor area of the cerebral cortex to muscle via complex nerves after sensory receptors stimulated from EM, such as anti-gravity posture.[11] In this case, we tried to produce her active muscle contractions by sitting and standing with assistance due to EM. We considered that EM, especially promoting muscle strength, prevented impairment of the muscle strength exerted system regardless of muscle atrophy. Hence, QF recovered earlier than quadriceps muscle thickness. Recently, neuromuscular electrical stimulation and functional electrical stimulation have been effective in preventing or treating ICU-AW; however, their use is controversial. These interventions were not applied in this case, because she was diagnosed with deep venous thrombosis. However, the possibility of using such interventions when an inferior vena cava filter is inserted should be reexamined.

Moreover, we considered that malnutrition influences the recovery of skeletal muscle function. Heyland [12] reported that the combination of nutritional support and exercise may have the greatest effect on physical recovery of critical illness survivors. This case showed that quadriceps muscle thickness increased after nutritional supplements rich in BCAA were administered. Identifying whether the progression of resistance training intensity or nutritional supplementation should be prioritized must be considered.

The third problem was reduced EM and exercise frequency because of radiation therapy side effects. Although radiation therapy for pelvic cancers has detrimental effects on both pelvic floor muscle structure and function,[13] no report showed that it affects limb skeletal muscles. In this case, there were no metastasis, diabetes, and metabolic diseases, but HF and 6MWD were decreased; however, QF has been maintained and increased gradually after radiation therapy. During radiation therapy, we considered the side effects, limited the resistance training to low-to-moderate intensity, and prescribed the training only to the lower limbs. This strategy possibly provided optimal intensity for QF recovery considering the patient's general status. Thus, modifying EM with high frequency is important in treating patients with severe ICU-AW who are undergoing radiation therapy.

In conclusion, we considered combining nutritional supplements rich in BCAA and exercise as an important strategy for skeletal muscle function recovery. In addition, the general approach of daily exercise might prevent skeletal muscle atrophy recurrence. The present case suggests that early rehabilitation that includes nutritional intervention and continuation of exercise training are effective strategies for recovery from severe ICU-AW.

CONSENT

Patient's written informed consent was obtained for publication of this case report and any accompanying images.

AUTHORSHIP

YM: were physiotherapists in charge of the patient. KE: operated the patient, and MS provided the medicine in the intensive care unit for the patient after the operation. YM and RK: were wrote the manuscript. All authors performed the literature review and approved the manuscript for submission.

CONFLICT OF INTEREST

The authors state that they have no conflict of interest.

ORCID

Yosuke Morimoto http://orcid.org/0000-0002-8944-1720

REFERENCES

1. Yosef-Brauner O, Andi N, Ben Shahar T, Yehezkel E, Carmeli E. Effect of physical therapy on muscle strength, respiratory muscles and functional parameters in patients with intensive care unit-acquired weakness. *Clin Respir J*. 2015;9:1-6.
2. Osias J, Manno E. Neuromuscular complications of critical illness. *Crit Care Clin*. 2014;30:785-794.
3. Gruther W, Benesch T, Zorn C, et al. Muscle wasting in intensive care patients: ultrasound observation of the M. quadriceps femoris muscle layer. *J Rehabil Med*. 2008;40:185-189.
4. Parry SM, El-Ansary D, Cartwright MS, et al. Ultrasonography in the intensive care setting can be used to detect changes in the quality and quantity of muscle and is related to muscle strength and function. *J Crit Care*. 2015;30:1151. e9-1151.e14.
5. Laghi F, D'Alfonso N, Tobin MJ. Pattern of recovery from diaphragmatic fatigue over 24 hours. *J Appl Physiol (1985)*. 1995;79:539-546.
6. Jung B, Moury PH, Mahul M, et al. Diaphragmatic dysfunction in patients with ICU-acquired weakness and its impact on extubation failure. *Intensive Care Med*. 2016;42:853-861.
7. Levine S, Nguyen T, Taylor N, et al. Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. *N Engl J Med*. 2008;358:1327-1335.
8. Latronico N, Gosselink R. A guided approach to diagnose severe muscle weakness in the intensive care unit. *Rev Bras Ter Intensiva*. 2015;27:199-201.
9. Kayambu G, Boots R, Paratz J. Physical therapy for the critically ill in the ICU: a systematic review and meta-analysis. *Crit Care Med*. 2013;41:1543-1554.
10. Mehrholz J, Pohl M, Kugler J, Burridge J, Mückel S, Elsner B. Physical rehabilitation for critical illness myopathy and neuropathy. *Cochrane Database Syst Rev*. 2015;4:CD010942.
11. Ohira T, Terada M, Kawano F, Nakai N, Ogura A, Ohira Y. Region-specific responses of adductor longus muscle to gravitational load-dependent activity in wistar hannover rats. *PLoS ONE*. 2011;6:e21044.
12. Heyland DK, Stapleton RD, Mourtzakis M, et al. Combining nutrition and exercise to optimize survival and recovery from critical illness: Conceptual and methodological issues. *Clin Nutr*. 2016;35:1196-1206.
13. Bernard S, Ouellet MP, Moffet H, Roy JS, Dumoulin C. Effects of radiation therapy on the structure and function of the pelvic floor muscles of patients with cancer in the pelvic area: a systematic review. *J Cancer Surviv*. 2016;10:351-362.

How to cite this article: Morimoto Y, Sekino M, Eishi K, Kozu R. Recovery of muscle weakness and physical function in a patient with severe ICU-acquired weakness following pulmonary embolism: A case report. *Clin Case Rep*. 2018;6:1214–1218. https://doi.org/10.1002/ccr3.1576