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CASE REPORT

Rehabilitation of a Patient with COVID-19 Who Underwent Right Transfemoral Amputation Due to Acute Limb Ischemia: A Case Report

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Background: Coronavirus disease 2019 (COVID-19) is associated with an increased risk of thrombotic complications. Nonetheless, there is a paucity of clinical knowledge regarding rehabilitation of patients with COVID-19 after lower-limb amputation. **Case:** A 74-year-old woman with COVID-19 was admitted to a university hospital. During hospitalization, she underwent right transfemoral amputation due to acute limb ischemia. Three months after admission, the patient was transferred to a convalescent rehabilitation ward in the same hospital. A femoral prosthesis was prescribed 2 weeks after her transfer to the rehabilitation ward. It featured ischial-ramal containment with a soft liner and belt suspension, 668-g multiple linkage-type safety knee joint (Imasen Engineering; M0781 SwanS), and a solid-ankle cushioned-heel foot. The total rehabilitation time during the patient's stay in the acute-care and rehabilitation wards was 65.5 h (0.99 h/day, 66 days) and 275.0 h (3.02 h/day, 91 days), respectively. In the rehabilitation ward, the patient underwent 54.4 h (19.8%) of muscle strength training, 48.1 h (17.5%) of comprehensive assessments, and 47.1 h (17.1%) of gait training. The patient was discharged home 6 months after admission, with a total Functional Independence Measure score of 120. The patient could walk slowly [44.2 s (0.23 m/s) in the 10 m-walk test] with a femoral prosthesis and a quad cane but exhibited limited endurance (75.0 m in the 6-min walk test). **Discussion:** Following appropriate rehabilitation, a patient was able to walk independently after lower-limb amputation despite the complication of COVID-19, although her walking ability was limited.

Key Words: blood coagulation disorders; convalescent rehabilitation ward; lower-limb amputation; prosthesis; SARS-CoV-2

INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak in December 2019 has led to a massive global pandemic and a major health problem worldwide.[1] It is associated with disseminated intravascular coagulation syndrome and thrombotic microangiography,[2,3] as well as a risk of thrombotic complications, including acute lower-limb ischemia.[4,5]

For patients who underwent lower-limb amputation for COVID-19-associated coagulopathy, there exists only a single report[6] of a case series regarding the rehabilitation of a patient with COVID-19 after lower-limb amputation. This case series[6] included three cases of rehabilitation for amputation because of COVID-19-associated coagulopathy. Nevertheless, this previous study[6] did not specify the type of prostheses or details of the rehabilitation program, and the rehabilitation outcomes were not discussed.

We herein present the details of a rehabilitation program for

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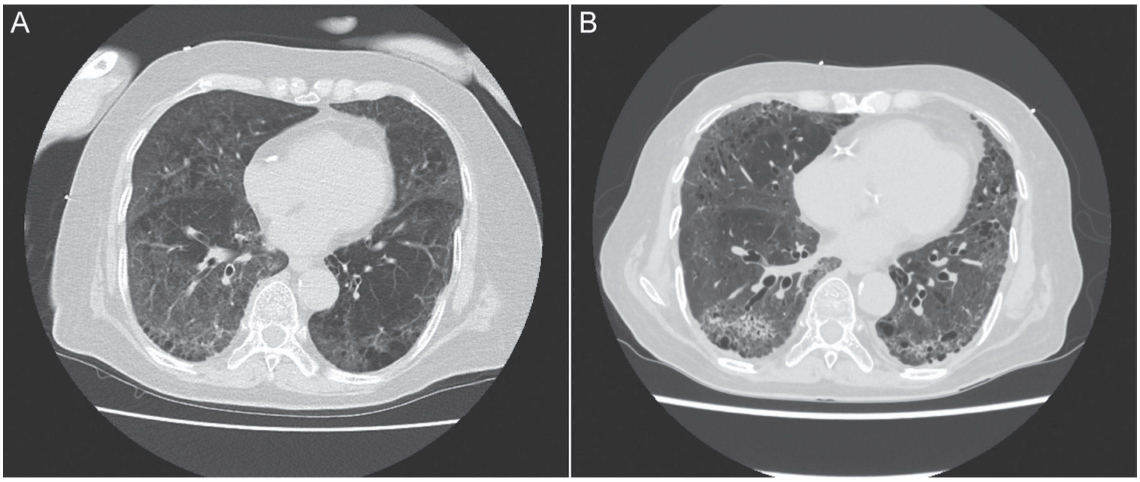

Fig. 1. Chest computed tomography (A) at admission, and (B) at the time of transfer to the convalescent rehabilitation ward.

a patient with COVID-19 who underwent right transfemoral amputation caused by acute limb ischemia. We also describe the corresponding progress in functional status.

CASE

A 74-year-old woman with COVID-19 was admitted to a university hospital. She reported a 32-year history of smoking but had quit smoking 22 years prior to admission. The patient had no comorbidities or past medical history before admission and was fully independent, including instrumental activities of daily living (ADLs). She was not on any medications. On admission, the patient's height and weight were 158 cm and 53.9 kg, with a body mass index of 21.6 kg/m^2. Written informed consent was obtained from the patient for the publication of this case report. This study conformed to the CARE guidelines.[7]

Chest computed tomography (CT) was performed on admission and revealed ground-glass opacity and consolidation in both lungs (**Fig. 1A**). The patient was treated with antiviral and anti-inflammatory drugs, as well as low molecular weight heparin. Two days following admission, melena was observed, and low molecular weight heparin was discontinued. However, blood tests showed rapid increases in levels of D-dimer and fibrin degradation products. As a result, low molecular weight heparin was restarted. Thereafter, no melena was observed. Contrast-enhanced CT showed thrombi in the abdominal aorta, right common iliac artery, right external iliac artery, and right femoral artery (**Fig. 2**). On admission, the patient required 10 L/min of oxygen with a reservoir mask. On the 18th day of hospitalization, the patient was switched to high nasal flow, which was terminated on the 33rd day. Subsequently, the patient required 2–5 L/min of oxygen with nasal flow. Three months following admission, the patient's right leg became dark brown and showed signs of dry gangrene. The patient then underwent right transfemoral amputation due to acute limb ischemia.

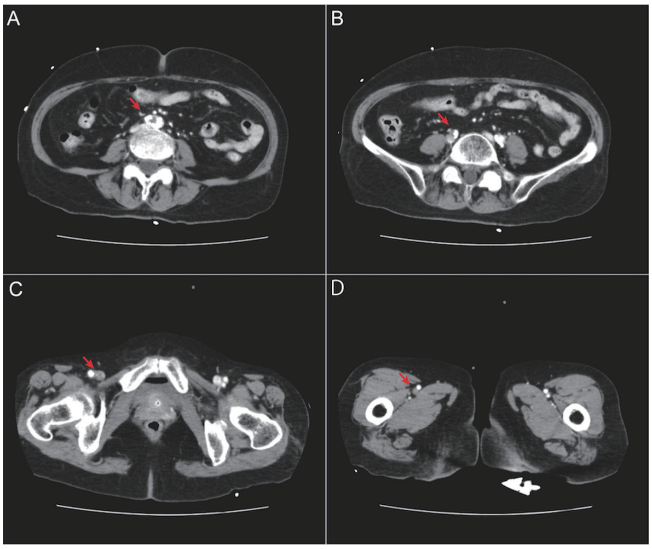

Fig. 2. Contrast-enhanced computed tomography of (A) the abdominal aorta, (B) the right common iliac artery, (C) the right external iliac artery, and (D) the right femoral artery. Red arrows show thromboses.

Following the amputation (3 months after hospital admission), the patient was transferred to a convalescent rehabilitation ward in the same hospital. The patient's weight was 41.8 kg at the time of transfer. Chest CT performed at the time of transfer demonstrated that the ground-glass opacity and consolidation in both lungs remained (**Fig. 1B**). Pulmonary function tests revealed a moderate obstructive pattern [forced expiratory volume in 1 second ($FEV_{1.0}$): 1.68 L, 91.1% predicted; and forced vital capacity (FVC): 2.26 L, 70.4% predicted]. Arterial blood gas analysis in room air indicated the following: pH, 7.47; partial pressure of carbon dioxide, 39.6 mmHg; partial pressure of oxygen, 58.1 mmHg; and type I respiratory failure. The patient required 2–3 L/min of oxygen at rest. The distance from the ischial tuberosity to the end of the residual limb was 26 cm and the stump circumference was 32.5 cm. In the manual muscle test, both upper and both lower extremities were given a grading of 4 (out of 5). The muscle strength for left knee extension was 66 N as measured using a handheld dynamometer. The total functional independence measure (FIM) score at admission to the rehabilitation ward was 73 (subtotal score for motor items, 38; subtotal score for cognitive items, 35).

The patient underwent both physical and occupational therapies for 3 h/day in the rehabilitation ward. The rehabilitation goal was to achieve independence in prosthetic indoor gait and in the ability to perform ADLs. The patient presented with hypoxemia without signs of respiratory distress; hence, exercise therapy was provided together with pulse oximetry monitoring. Exercise therapy was discontinued when percutaneous oxygen saturation fell below 88% or when the respiratory rate became elevated above 30 breaths per minute. Until the prosthesis was prescribed, range of motion (ROM) training, muscle strength training for the trunk and upper/lower limbs, and training for transferring from the bed to the wheelchair or toilet were provided. A femoral prosthesis featuring ischial-ramal containment with soft liner and belt suspension, a 668-g knee joint (M0781 SwanS; Imasen Engineering, Kakamigahara Japan), and a solid-ankle cushioned-heel foot was prescribed 2 weeks after the patient's transfer to the rehabilitation ward (**Fig. 3**). We adopted belt suspension because of the long stump. The SwanS is a multiple-linkage safety knee joint equipped with a stance-phase controller with a bouncing mechanism, a swing-phase controller with a constant-friction mechanism, an extension-assist spring, and a small-capacity pneumatic cylinder. A walker was initially used for gait training with the prosthesis, and the patient was subsequently switched to a quad cane (**Fig. 4**). The patient was allowed to bend her knees during the swing phase as she trained to walk. However, because of decreased muscle strength in the hip joint and increased oxygen demand during walking, we decided to use the prosthetic knee joint under a fixed condition. No oxygen was needed at rest, but 0.5–l L/min of oxygen was administered during exercise.

Fig. 3. Femoral prosthesis as used by the patient in this case study, featuring ischial-ramal containment with soft liner (A), belt suspension (B), M0781 SwanS knee joint (C), and solid-ankle cushioned-heel foot (D).

Fig. 4. Gait training with femoral prosthesis and a quad cane.

Six months after admission, the patient was discharged from the hospital. The results of pulmonary function tests at discharge revealed no abnormalities ($FEV_{1.0}$: 1.60 L, 119.4% predicted; FVC: 2.22 L, 95.0% predicted), and there were no changes in partial blood gas pressures (**Table 1**). The total rehabilitation time during the patient's stay in the acute-care and rehabilitation wards was 65.5 h (0.99 h/day, 66 days;

Table 1. Changes in spirometry and arterial blood gas analysis

	On admission	At discharge
Spirometry		
FVC (L)	2.26	2.22
%FVC (%)	71.7	95.0
$FEV_{1.0}$ (L)	1.68	1.6
$\%FEV_{1.0}$ (%)	91.1	119.4
Arterial blood gas analysis on room air		
PaO_2 (mmHg)	58.1	59.4
$PaCO_2$ (mmHg)	39.6	38.5
HCO_3^- (mmol/L)	28.0	26.2
A-aDO_2 (mmHg)	42.1	42.2

PaO_2, partial pressure of oxygen in arterial blood; $PaCO_2$, partial pressure of carbon dioxide; A-aDO_2, alveolar-arterial oxygen tension difference.

physical therapy, 34.7 h, 55 days; occupational therapy, 30.7 h, 51 days) and 275.0 h (3.02 h/day, 91 days; physical therapy, 162 h; occupational therapy, 113 h), respectively. In the acute-care ward, the patient underwent 22 h (33.1%) of muscle strength training and 13.5 h (20.6%) of comprehensive assessments. In the rehabilitation ward, the patient underwent 54.4 h (19.8%) of muscle strength training, 48.1 h (17.5%) of comprehensive assessments, and 47.1 h (17.1%) of gait training. Details on rehabilitation are presented in **Fig. 5**. Weekly changes of interventions in the acute-care and rehabilitation wards are illustrated in **Fig. 6**. At the time of discharge, both lower extremities scored 4 (out of 5) in the manual muscle test. The muscle strength for left knee extension had increased to 199 N as measured using a handheld dynamometer. The patient was able to walk independently with the prothesis and a quad cane, albeit very slowly [44.2 s (0.23 m/s) in the 10 m-walk test], and her endurance was limited (75.0 m in the 6-min walk test). At the time of discharge, the patient achieved near independence in ADLs, with a total FIM score of 119 (subtotal score for motor items, 84; subtotal score for cognitive items, 35) (see **Fig. 7**).

After discharge from hospital, the patient could use the prosthesis and a quad cane to walk at home and a wheelchair for outdoor activities with home oxygen therapy. At the 3-month follow-up, the patient was performing ADLs and had maintained her walking ability.

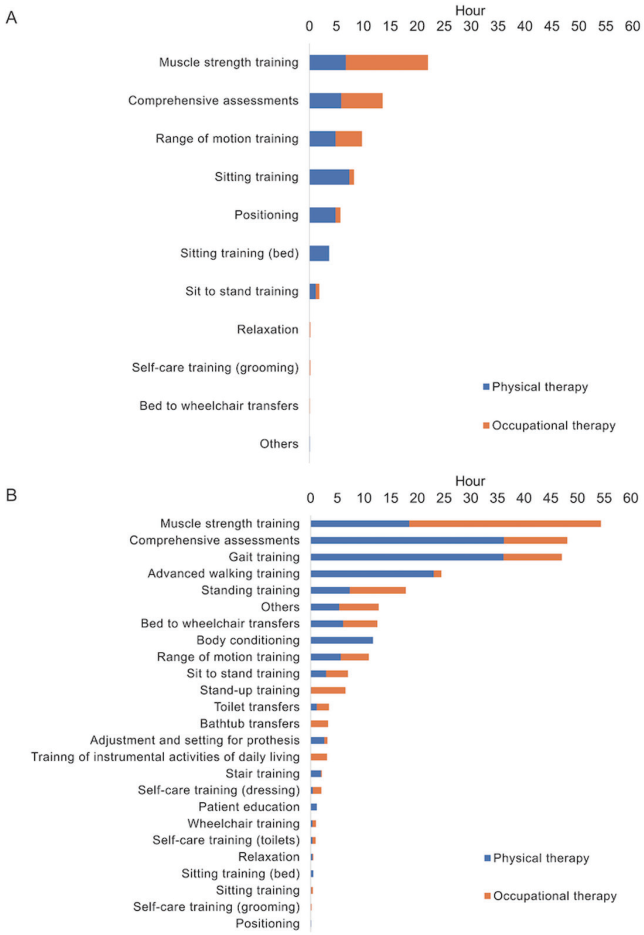

Fig. 5. Details of rehabilitation (A) in the acute-care ward, and (B) the convalescent rehabilitation ward.

DISCUSSION

We report the rehabilitation of a patient with COVID-19 who underwent transfemoral amputation due to acute limb ischemia. To our knowledge, this is the first detailed report of the rehabilitation of a patient with COVID-19 after undergoing lower-limb amputation.

COVID-19 severity is related to ADLs and walking ability. In a systematic review,[8] all of the included studies showed a decline in ADLs among patients with COVID-19 after the acute phase of infection. A Japanese multicenter cohort study[9] of acute COVID-19 cases revealed that only 63% of patients were able to walk independently (FIM items for walking, 6–7 points) at discharge from acute-care hospitals. Therefore, COVID-19 patients with other comorbidities are likely to have poorer ADL and walking ability than similar patients without COVID-19.

The distinguishing feature of the case in this study is

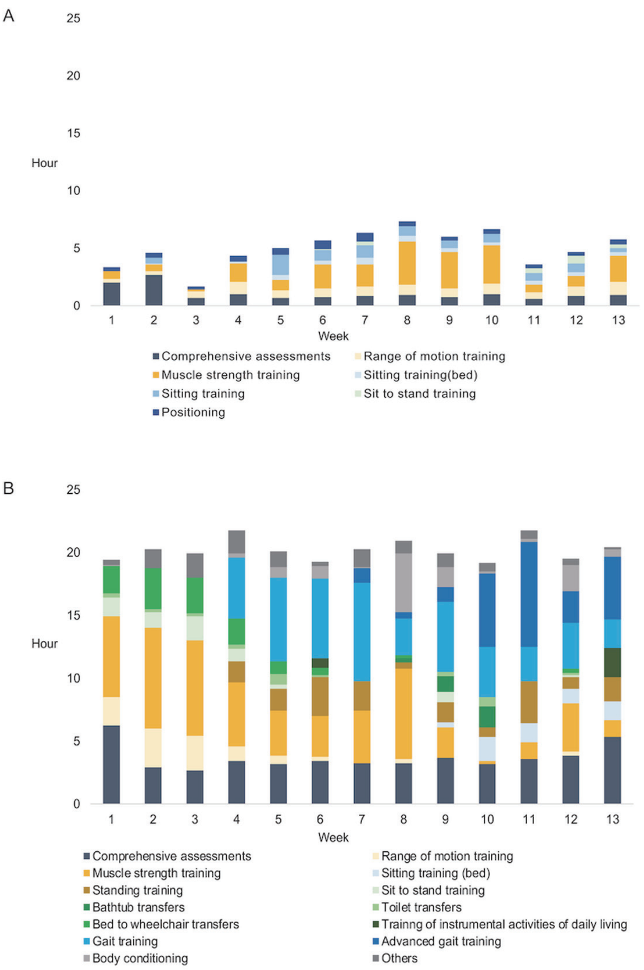

Fig. 6. Weekly changes in interventions (A) in the acute-care ward, and (B) convalescent rehabilitation ward. Figure shows rehabilitation programs in which the patient spent >30 min/week in the acute-care ward and >100 min/week in the convalescent rehabilitation ward.

transfemoral amputation. Patients that undergo lower-limb amputation, especially transfemoral amputations, are known to have difficulty in regaining walking ability similar to that prior to amputation.[10] In particular, the energy consumption during walking in patients who had undergone lower-limb amputation is higher than that in healthy participants.[11] Limited exercise capacity has been reported in patients with COVID-19.[12,13] Therefore, in patients who have undergone lower-limb amputation, the achievement of gait independence is expected to be more difficult in patients that also have COVID-19. However, clinicians should be aware that patients with COVID-19 with associated respiratory dysfunction, as in the present case, may be able to walk independently using a prosthesis if exercise therapy is provided under appropriate

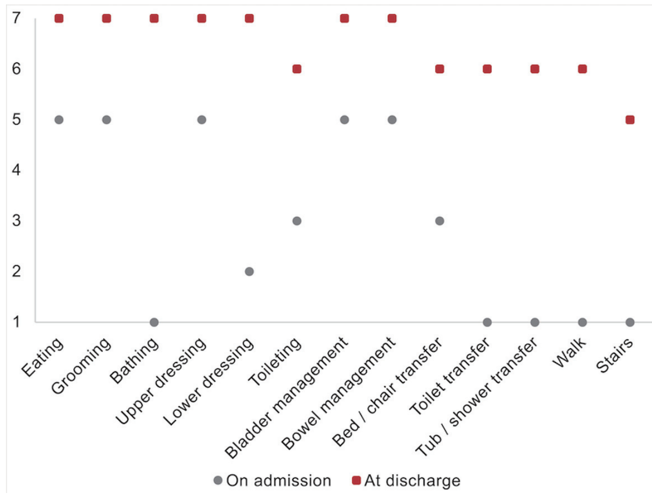

Fig. 7. Changes in the motor items of the functional independence measure score between admission and discharge.

supervision.

In this case study, the patient underwent right transfemoral amputation because of acute limb ischemia, which was complicated by COVID-19 pneumonia. Therefore, the patient also required prolonged bed rest. The infection control measures for COVID-19 may have led to the further isolation and inactivity of the patient. The exercise capacity and muscle strength of the patient in this study decreased more than in other COVID-19 patients without complications. The prosthesis was prescribed approximately 3 months after admission, at which point the percentages of muscle strength training and ROM training were high, suggesting that physical activity remained low for several weeks. After prosthesis prescription, the percentage of gait training increased. However, the time from prosthesis prescription to discharge was another 3 months. Thus, we advocate minimal acute deconditioning in such cases to reduce the length of hospital stay and improve the final functional outcome.

CONCLUSION

With appropriate rehabilitation based on adequate monitoring, a patient was able to walk independently after lower-limb amputation due to lower-limb ischemia, despite the complication of COVID-19. However, her walking ability was relatively limited. Further clinical experiences are warranted to establish a rehabilitation program for patients with lower-limb amputation and COVID-19. Nevertheless, we believe that the clinical course of this case, which eventually achieved independence of gait even with very tough conditions, will help in the planning of rehabilitation goals and programs for future amputees with COVID-19.

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CONFLICTS OF INTEREST

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REFERENCES

1. Wang C, Horby PW, Hayden FG, Gao GF: A novel coronavirus outbreak of global health concern. Lancet 2020;395:470–473. https://doi.org/10.1016/S0140-6736(20)30185-9, PMID:31986257
2. Tang N, Li D, Wang X, Sun Z: Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. J Thromb Haemost 2020;18:844–847. https://doi.org/10.1111/jth.14768, PMID:32073213
3. Gonzalez-Urquijo M, Gonzalez-Rayas JM, Castro-Varela A, Hinojosa-Gonzalez DE, Ramos-Cazares RE, Vazquez-Garza E, Paredes-Vazquez JG, Castillo-Perez M, Jerjes-Sanchez C, Fabiani MA, ARTICO-19 Research Collaborative Group: Unexpected arterial thrombosis and acute limb ischemia in COVID-19 patients. Results from the Ibero-Latin American acute arterial thrombosis registry in COVID-19: (ARTICO-19). Vascular 2021. https://doi.org/10.1177/17085381211052033, PMID:34866506
4. Galyfos G, Sianou A, Frountzas M, Vasilios K, Vouros D, Theodoropoulos C, Michalopoulou V, Sigala F, Filis K: Acute limb ischemia among patients with COVID-19 infection. J Vasc Surg 2022;75:326–342. https://doi.org/10.1016/j.jvs.2021.07.222, PMID:34390791
5. Bellosta R, Luzzani L, Natalini G, Pegorer MA, Attisani L, Cossu LG, Ferrandina C, Fossati A, Conti E, Bush RL, Piffaretti G: Acute limb ischemia in patients with COVID-19 pneumonia. J Vasc Surg 2020;72:1864–1872. https://doi.org/10.1016/j.jvs.2020.04.483, PMID:32360679
6. Brugliera L, Spina A, Castellazzi P, Cimino P, Arcuri P, Deriu M, Zanetta C, Angelone S, Capitanio J, Alemanno F, Meloni C, D'Angelo G, Houdayer E, Abutalebi J, Mortini P, Iannaccone S: Rehabilitation of COVID-19 patients with acute lower extremity ischemia and amputation. J Rehabil Med 2020;52:jrm00094. https://doi.org/10.2340/16501977-2714, PMID:32720698
7. Gagnier JJ, Kienle G, Altman DG, Moher D, Sox H, Riley D, CARE Group: The CARE Guidelines: consensus-based clinical case reporting guideline development. Glob Adv Health Med 2013;2:38–43. https://doi.org/10.7453/gahmj.2013.008, PMID:24416692
8. Pizarro-Pennarolli C, Sánchez-Rojas C, Torres-Castro R, Vera-Uribe R, Sanchez-Ramirez DC, Vasconcello-Castillo L, Solís-Navarro L, Rivera-Lillo G: Assessment of activities of daily living in patients post COVID-19: a systematic review. PeerJ 2021;9:e11026. https://doi.org/10.7717/peerj.11026, PMID:33868804
9. Yamada Y, Kawakami M, Tashiro S, Omori M, Matsuura D, Abe R, Osada M, Tashima H, Shimomura T, Mori N, Wada A, Ishikawa A, Tsuji T: Rehabilitation in acute COVID-19 patients: a Japanese retrospective, observational, multi-institutional survey. Arch Phys Med Rehabil 2022;103:929–936. https://doi.org/10.1016/j.apmr.2021.11.004 , PMID:34896082
10. Silva AM, Furtado G, dos Santos IP, da Silva CB, Caldas LR, Bernardes KO, Ferraz DD: Functional capacity of elderly with lower-limb amputation after prosthesis rehabilitation: a longitudinal study. Disabil Rehabil Assist Technol 2021;16:556–560. https://doi.org/10.1080/17483107.2019.1684581, PMID:31686579
11. Ettema S, Kal E, Houdijk H: General estimates of the energy cost of walking in people with different levels and causes of lower-limb amputation: a systematic review and meta-analysis. Prosthet Orthot Int 2021;45:417–427. https://doi.org/10.1097/PXR.0000000000000035, PMID:34538817
12. Huang Y, Tan C, Wu J, Chen M, Wang Z, Luo L, Zhou X, Liu X, Huang X, Yuan S, Chen C, Gao F, Huang J, Shan H, Liu J: Impact of coronavirus disease 2019 on pulmonary function in early convalescence phase. Respir Res 2020;21:163. https://doi.org/10.1186/s12931-020-01429-6, PMID:32600344

13. González J, Benítez ID, Carmona P, Santisteve S, Monge A, Moncusí-Moix A, Gort-Paniello C, Pinilla L, Carratalá A, Zuil M, Ferrer R, Ceccato A, Fernández L, Motos A, Riera J, Menéndez R, Garcia-Gasulla D, Peñuelas O, Bermejo-Martin JF, Labarca G, Caballero J, Torres G, de Gonzalo-Calvo D, Torres A, Barbé F, Villar RA, Añón JM, Barberà C, Barberán J, Ortiz AB, Bustamante-Munguira E, Caballero J, Carbajales C, Carbonell N, Catalán-González M, Galbán C, Gumucio VD, de la Torre MC, Díaz E, Estella Á, Gallego E, García Garmendia JL, Garnacho-Montero J, Gómez JM, Huerta A, Jorge García RN, Loza-Vázquez A, Marin-Corral J, de la Gándara AM, Varela IM, Messa JL, Albaiceta GM, Novo MA, Peñasco Y, Pozo-Laderas JC, Martí PR, Roche-Campo F, Sánchez-Miralles A, Chinesta SS, Socias L, Solé-Violan J, Sipmann FS, Lomas LT, Trenado J, CIBERESUCICOVID Project (COV20/00110, ISCIII): Pulmonary function and radiologic features in survivors of critical COVID-19: a 3-month prospective cohort. Chest 2021;160:187–198. https://doi.org/10.1016/j.chest.2021.02.062, PMID:33676998