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Outcomes of a functional rehabilitation protocol in chronic critical disease by COVID-19: A case report

Desfechos de um protocolo de reabilitação funcional na doença crítica crônica por COVID-19: Relato de caso

Resultados de un protocolo de rehabilitación funcional en enfermedad crítica crónica por COVID-19: Reporte de caso

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Abstract
The 2019 novel coronavirus *(*SARS-CoV-2*)* is the virus that causes COVID-19. It can cause severe illness, with significant increase in morbidity and mortality rates, requiring the need for hospitalization and mechanical ventilation. This study aims to describe a functional rehabilitation protocol applied to a patient with COVID-19 after 21 days of mechanical ventilation (MV). We report a case of a 56-year-old female patient diagnosed with COVID-19 who presented severe hypoxemic respiratory failure, chronic critical disease, intensive care unit acquired weakness, difficult and prolonged weaning, organ dysfunction, and needed tracheotomy. The patient responded satisfactorily to a late functional rehabilitation protocol showing the importance of well-designed and individualized protocols to achieve maximum functional recovery.
Keywords: Rehabilitation; COVID-19; Muscle weakness.

Resumo
O novo coronavírus (SARS-CoV-2), responsável pela COVID–19 pode ocasionar casos graves, com significativa taxa de morbimortalidade, necessidade de internação hospitalar e ventilação mecânica (VM). Este estudo visa descrever um protocolo de reabilitação funcional aplicado a paciente com COVID-19 após 21 dias de ventilação mecânica (VM). Relato de uma mulher, de 56 anos, com COVID-19, com insuficiência respiratória aguda hipoxêmica, doença crítica crônica (DCC), fraqueza, muscular adquirida na unidade de terapia intensive (UTI), desmame difícil e prolongado, traqueostomia e disfunção de orgãos. A paciente respondeu a um protocolo de reabilitação funcional mesmo que tardio, mostrando a importância de protocolos bem delineados, individualizados para alcance da máxima recuperação funcional.
Palavras-chave: Reabilitação; COVID-19; Fraqueza muscular.

Resumen
El nuevo coronavirus (SARS-CoV-2), responsable de la COVID-19, puede causar casos graves, con una importante morbimortalidad, necesidad de hospitalización y ventilación mecánica (VM). Este estudio tiene como objetivo describir un protocolo de rehabilitación funcional aplicado a un paciente con COVID-19 después de 21 días de ventilación mecánica (VM). Reporte de mujer de 56 años con COVID-19, con insuficiencia respiratoria aguda hipoxémica, enfermedad crítica crónica (CC), debilidad muscular adquirida en la unidad de cuidados intensivos (UCI), destete difícil y prolongado, traqueotomía y disfunción de organos El paciente respondió a un protocolo de rehabilitación funcional, aunque tardíamente, lo que demuestra la importancia de protocolos bien diseñados e individualizados para lograr la máxima recuperación funcional.
Palabras clave: Rehabilitación; COVID-19; Debilidad muscular.

1. Introduction

The 2019 novel coronavirus (SARS-CoV-2) is the virus that causes COVID-19. It can cause severe illnesses, with significant increase in morbidity and mortality rates, requiring the need for hospitalization and mechanical ventilation (MV). The most common symptoms include fever, cough, sore throat, myalgia, weakness, dyspnea, anosmia and odynophagia (World Health Organization, 2020).

Over 17 million cases were reported worldwide, and severe COVID-19 patients had to be admitted to an Intensive Care Unit (ICU) (Yang et al., 2020) and MV with increased risk of developing chronic critical disease (CCD). CCD is a complex pathophysiology syndrome characterized by prolonged MV time and hospitalization, with high morbidity and mortality rates and a strong influence on the socioeconomic status (Leitão et al., 2017). This syndrome contributes to the development of ICU acquired weakness (ICUAW), which may worsen this neuromuscular complication, causing additional deaths per year (Hermes &Van den Berghe.,2015; Biscaro., 2021).

Patients with SARS-CoV-2 on MV require deep sedation, neuromuscular blockage, and prone position for hypoxemia management. All these MV strategies represent significant risk factors for ICUAW (Hermes &Van den Berghe., 2015; Yang et al., 2020;).

Neuromuscular dysfunction in critically ill patients has been attributed to myopathy, polyneuropathy or the combination of both, with myopathy being the major cause for ICUAW (Stevens et al., 2007; Koch et al., 2011). Prolonged immobility leads to cardiorespiratory deconditioning, muscle shortening and myogenic, neurogenic, and arthrogenic contractures (Simpson, & Robinson., 2020).

Intra hospital rehabilitation has shown a positive impact on the patient's level of awareness. It has also improved pulmonary function, reduced ICU length of stay and hospital stay, the mortality rates, the readmission risks and the hospital costs (Morris et al., 2011; Jiang et al., 2020).

Early rehabilitation has been associated with better outcomes for patients requiring prolonged periods on MV. However, in COVID-19 patients, it was observed that even when applied later, and due to the severity of the disease and instability, the rehabilitation protocol have increased the mobility levels from awakening until before discharge from ICU (McWilliams et al., 2021). Thus, the aim of the present study is to describe a functional rehabilitation protocol (PRF) of a patient after 21 days of MV.

2. Methodology

This work is a quantitative study is a case report (Pereira et al., 2018). It was study was approved by the Research Ethics Committee – CAAE: 07351119.2.0000.538.1 The patient’s legal representative signed a free and informed consent form, in accordance with resolution 466/12 of the National Health Council.

The patient is a 56-year-old female patient, with obesity class III, hypertension, and diabetes, living in Pradópolis, São Paulo, Brazil, with initial symptoms of cough, fever and tiredness. Her condition progressed to respiratory distress, she had to use accessory muscles, and her oxygen saturation was 82%, requiring intubation. She was then transferred to the ICU of Santa Casa de Batatais, São Paulo. The diagnosis of COVID-19 was confirmed by real-time reverse transcriptase polymerase chain reaction (RT–PCR) from oro- and nasopharyngeal swab specimens. She remained in the ICU COVID ward area for 21 days, and was later transferred to the general ICU, totaling 130 days of hospitalization. There were numerous complications, such as dialysis renal failure, MV-associated pneumonia, severe sepsis, stage 4 pressure ulcer infection, use of polymyxin, tracheostomy, difficult and prolonged weaning, developing ICUAW, which led to permanent damage to the sensory cells and neurons of the inner ear, causing permanent loss of auditory acuity due to the use of an aminoglycoside (Gentamicin) (Selimoglu, 2007)

The patient was submitted to pulmonary function tests (PFTFs), including slow vital capacity (SVC) measured by a MV pneumotachograph (Graphy net Ts+®); respiratory muscle strength (maximal inspiratory pressure-PImax) and maximal expiratory pressure (PEmax), using a manovacuometer (Comercial Médica®); and skeletal muscle strength, using the modified Medical Research Council (mMRC) scale. The mobility status of the patient was measured using the ICU Mobility Scale and the Perme ICU Mobility Score. The neurological test was carried out using a Semmes-Weinstein® monofilament analog esthesiometer. The proposed treatments included electrostimulation in the upper limbs (Neurodyn®); passive cycleergometry in the upper limbs and active in the lower limbs (Liveup®); assisted active proprioceptive neuromuscular facilitation (PNF) with sensory stimulation (Figure1); and respiratory muscular training (RMT) performed with linear pressure resistor (Threshold IMT®).

Figure 1 - Progress levels of the Functional Rehabilitation Protocol. A: NMES associated with active-assisted exercises, B: LL cycleergometry associated with sensory stimulation, C: Passive orthostatism associated with UL PNF, D: active cycleergometry of the UL. NMES: neuromuscular electrical stimulation; UL: Upper limbs; LL: Lower limbs

Source: Authors (2021).

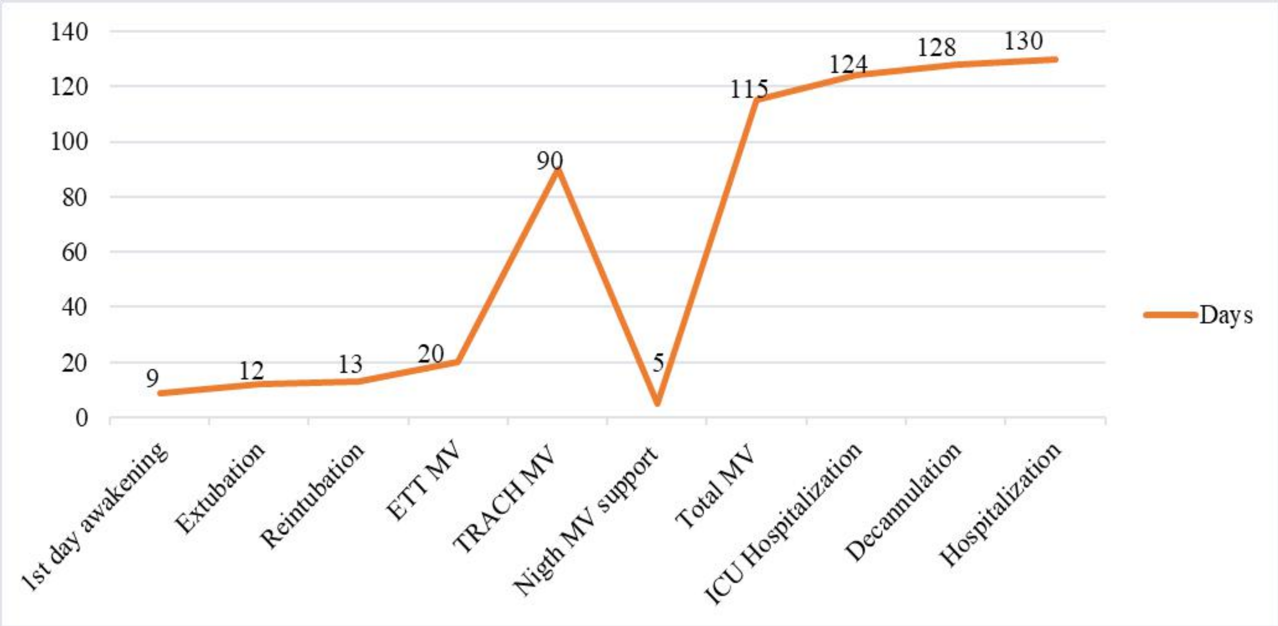
Following these procedures, the patient received regular physiotherapy sessions in the first 21 days of hospitalization. The functional rehabilitation protocol (FRP) initiated after the patient achieved clinical and hemodynamic stability and was tracheostomized. Table 1 and Figure 2 show detailed FRP specificities and the evolution of the patient, respectively.

Table 1 - Types and specificities of the functional rehabilitation protocol NO.: number; WK: week; MIN: minute(s); UL: upper limbs; LL: lower limbs; PNF: propioceptive neuromuscular facilitation; NMES: Neuromuscular Electrical stimulation; HZ: hertz; PW: pulse width

Intervention		Parameters				Time of intervention
Technique	Type	Specificity	Intensity series repetitions	Frequency N /wk/day	Duration (min)	
Respiratory Muscular Training	Threshold	Linear pressure load	3 X 10	2 /day	30	26 sessions
Skeletal muscle training	Kinesiotherapy	LL and UL articular mobilization, PNF techniques, assisted passive and active exercises	3 X 10	6/wk	2/ day	30 sessions
	Orthostatism	Active and passive				
	Cycleergometry	Passive – LL Active – UL	No load ´2/ 1 min interval Fowler´s position in bed No load 3´2/1 min interval Fowler´s position in bed	6/wk	1/day	15 sessions
				6/wk	1/day	15 sessions
Electrical stimulation	NMES (Biceps) NMES (wrist extensor)	50 hz; 300 PW; 15 on; 8 off; 3 rise; 4 decay	1	6/wk	30 min	15 sessions

Source: Authors (2021).

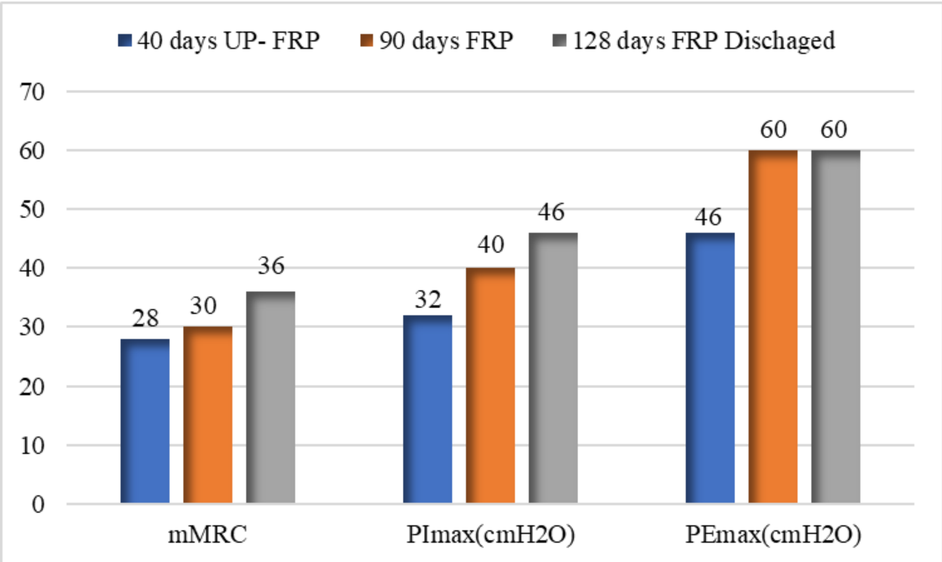
Figure 2 - Days of ventilator support and hospitalization MV: mechanical ventilation; ETT: endotracheal tube; TRACH: Trachestomy; ICU: Intensive Care Unit.



Source: Authors (2021).

Data obtained during the hospitalization stay and the behavior of skeletal muscle strength and respiratory muscles are shown in Figure 3.

Figure 3 - Graphs of the hospitalization periods, ventilator strategies and the behavior of skeletal muscle strength and respiratory muscles. UP: Usual physiotherapy; FRP: Functional rehabilitation program; mMRC: Medical Research Council; PImax: Maximal inspiratory pressure; PEmax: Maximal expiratory pressure.



Source: Authors (2021).

3. Discussion

The FRP has shown positive outcomes, even though it started later. This protocol was able to facilitate ventilator weaning and tracheostomy decannulation as well as to provide gradual functional recovery. The patient was discharged from the hospital, requiring continuity of care intended to reduce the risk of hospital readmission or death. When combined with FRP, physiotherapy should also target respiratory dysfunctions of patients with prolonged MV, aiming at improving global and/or regional ventilation, pulmonary compliance, airway resistance, respiratory work and elimination of secretions, in order to facilitate weaning and to enable decannulation (Thomas et al., 2002; Gosselink et al., 2008).

The patient first awakening occurred 9 days after MV and extubation was possible on the 12th MV day. Extubation failed and reintubation was necessary within 24h. She was tracheotomized within 20 days of MV, remaining under MV for another 90 days, totaling 110 days in continuous NIV and gradual weaning, night support for 5 days, totaling 115 days of MV. Decannulation occurred after the 13th weaning day from the ventilator support.

For the diagnosis of respiratory muscle weakness, the following values are considered: PImax > -80 cm H_2O and PEmax < 90 cm H_2O (Neder et al., 1999). For a successful weaning, the value is PImax < -30 cmH_2O (Nici et al., 2006). After 40 days of hospitalization and 20 days of FRP, the patient measurements were PImax -32cmH_2O and PEmax 46cmH_2O, together with specific respiratory muscle training with linear pressure load, enabling an increase of -40cmH_2O for PImax and 60cmH_2O for PEmax, reaching the value of 45cmH2O for both PImax and PEmax after decannulation and at the time of ICU discharge.

According to Bach Sporito (1996), for a successful decannulation, the values of slow vital capacity (CLV) > 15 mL/Kg and cough peak flow (CPF) >360 L/m are recommended, however, in neuromuscular conditions, such as in ICUAW, CPF value ≥160 L/m is recommended. The patient was weaned within 90 days of the initiation of MV with a CPF =170 L/m and CVL = 10mL/kg, after decannulation. At the time of ICU discharge, the CPF was 250 L/m and the CVL 19.7mL/kg.

Patients with severe COVID-19 need intensive support of organ systems, requiring prolonged length of stay in the ICU, which can lead to a high ICUAW incidence, loss of functional ability and quality of life. The early onset of structured rehabilitation has been associated with improved outcomes for patients requiring extended periods of MV. However, no data are available yet to describe similar interventions or outcomes in COVID-19 populations (McWilliams et al., 2021; Thornton J, 2020).

De Jonghe et al. (2008) have reported that a mMRC score of ≤ 48 indicates muscle weakness (MW) and a mMRC score of ≤ 36 shows severe MW. After 40 days of hospitalization, the patient had a mMRC score of 28, which revealed a severe MW. In the revaluation performed 50 days following the FRP implementation, the mMRC score was 30, evidencing a slow response of the patient. In the final evaluation following decannulation, and achieving standing (active) orthostasis, her mMRC score was 36, i.e. grade 4 for the LL, maintaining grade 3 for the UL.

The FRP applied to the reported patient was based on the recommendations of the European Respiratory Society and European Society of Intensive Care Medicine, in which Gosselink et al. (2008) claimed that mobilization protocols should be recommended for the reduction of ICUAW. These recommendations have particular relevance to future researchers who should focus on new preventive and/or therapeutic strategies for this deleterious complication caused by CCD, and clarify how ICUAW contributes to poor longer-term prognosis (Hermes &Van den Berghe, 2015). We highlight that successful and beneficial mobilization protocols are associated with individualized therapy.

Future studies are also needed to facilitate the identification of characteristics of patients with COVID-19 to allow early mobilization. After discharge, particular attention should be given to patient follow-up aiming at overcoming the consequences of post-ICU syndrome, particularly those patients with CCD.

We have recently contacted the patient after 1 year of hospital discharge. The patient presented hearing loss, and was in the process of obtaining hearing aids. She had discontinue rehabilitation, had deficit of strength and function mainly in the lower limbs. Gait and balance were limited and the pressure injuries in the sacral region were still healing.

The therapeutic strategies for patients with severe COVID-19 remain complex, probably due to the severity of the disease, to complications of prolonged MV and its adjuvant. Systematic progressive protocols should be applied to patients with COVID-19 whenever there is clinical viability and technical and human resources, considering their significant influence on the recovery of these patients.

4. Final Considerations

The results have shown the positive effects of the FRP, even when applied later, revealing the importance of well-designed, individualized protocols based on prior knowledge of the clinical conditions of each patient with CCD and ICUAW. Therefore, it is necessary that more research be carried out, as well as more cases are reported, so that it is increasingly possible to provide care based on scientific evidence. It is also necessary to continue the protocol after hospital discharge to potentiate the skeletal and respiratory muscles, to recover speech, nutrition and cognitive function, psychological and behavioral aspects and return to work and/or to active life.

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