RESPIRATORY REHABILITATION PROTOCOL FOR PATIENTS WITH SPINAL CORD INJURY AND COVID-19.
National Hospital for Paraplegics. Toledo (Spain)

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1. INTRODUCCIÓN

At the beginning of December 2019, an outbreak of cases of pneumonia of unknown origin appeared in Wuhan (Hubei Province, China)[1].The responsible agent was identified as a new beta coronavirus, the severe acute respiratory syndrome 2 coronavirus (SARS-CoV-2)[2,3],causing the newly named coronavirus disease 2019 (Covid 19). The outbreak quickly spread from China to all continents, mainly by transmission from person to person by a mechanism similar to that described for other known coronaviruses, namely through the secretions of infected people mediated by direct contact with respiratory droplets> 5 microns, capable of being transmitted over distances of up to 2 meters or by contamination of the hands with said secretions when touching the mouth, nose or eyes[4,5]. On the 11thMarch 2020, the WHO declared Covid 19 a global pandemic. Currently 716,101 infected patients, 33,854 deceased and 149,071 recovered have been confirmed worldwide. Of these, Spain is responsible for 80,031 cases of confirmed infection, with 6,802 deaths and 14,709 recovered patients[6].

Clinical symptoms appear after an incubation period of around 5 days[3,7], presented in order of frequency as: fever (87.9%), dry cough (67.7%), asthenia (38.1%), dyspnea (18.6%), pharyngeal pain and odynophagia (13.9%), headache (13.6%), arthromyalgia (14.8%), chills (11.4%),nausea or vomiting (5%), nasal congestion (4.8%), anosmia and diarrhea (3.7%). Approximately80% of patients present an asymptomatic or with few symtoms including dry cough and fever or low-grade fever[8], and with the remaining 20% of cases developing around the 7th day after the onset of symptoms, severe hypoxemic respiratory failure that progresses to Acute Respiratory Distress Syndrome (ARDS, 15% of the total) and even to multi-organ failure (5% of the total), requiring mechanical ventilation and admission to an Intensive Care Unit[9,10].

Up to 18% of patients who request consultation for symptoms compatible with Covid 19 do not present radiological alterations. When these appear, the most frequently described is unilateral or bilateral ground glass opacification with an interstitial pneumonia pattern or bilateral patched consolidation, evident on plain radiography and on chest CT examination (56.4%)[11,12].At diagnosis, more than 80% of patients present lymphopenia[1,8], which is more severe and accompanied by neutrophilia in patients requiring intensive care unit (ICU) admission[9]. The main cause for death after Covid 19 infection is respiratory failure and then fulminant myocarditis (FM)[13]. In these patients a highly exaggerated inflammatory response has been described known as hyperinflammatory syndrome, with a massive release of cytokines into the bloodstream[14,15] similar to that observed in hemophagocytic syndromes caused by other virosis[16].

A series of clinical factors have been described that are associated with symptoms of greater morbidity and mortality: male gender, age above 60 years - especially above80 years old, where the fatality rate is close to 16% - and the presence of previous comorbidities such as: hypertension (HT), ischemic heart disease, diabetes mellitus, lung disease and various disease entities that lead to immunosuppression, such as autoimmune diseases orcancer[17]. Analytical markers associated with a higher risk of mortality are sustained lymphopenia and elevation of D-dimer, IL-6, ferritin, LDH and troponin[17].

The prevalence of COVID 19 infection among patients with acute or chronic spinal cord injury (SCI) is unknown, but it is assumed to be a high-risk comorbidity, due to the presence of immunosuppression[18,19] and the autoimmunity[20]which it induces, but above all due to the presence of respiratory muscles weakness in all those patients with a neurological level of injury above T6-T8. Lack of Inspiratory musculature entails a reduction in lung volume and capacity, affecting lungs compliance. Similarly, the limited expansion of the rib cage leads to less compliance, becoming increasingly rigid due to fixation of the costovertebral and sternal joints. The compromise of the expiratory musculature alters peak expiratory flow, negatively affecting the cough mechanism and the ability to eliminate secretions and furthermore, dysautonomia causes pulmonary hypersecretion and bronchospasm. In summary, the patient with spinal cord injury has a decrease in vital capacity, thoracic and pulmonary compliance, an ineffective cough and an increase in secretions and bronchial tone, all of which predisposes them to episodes of hypoventilation, atelectasis due to retention of secretions and respiratory tract infections[21]. In this context, **sustained respiratory physiotherapy treatment** is key to optimizing pulmonary volumes and lung capacity, preventing the loss of lung and chest wall compliance, optimizing and maintaining the strength of the respiratory muscles, achieving correct mucus clearance, maintaining an effective cough, all of which avoid pulmonary complications[21,22].

Advice related to applying respiratory physiotherapy techniques to patients with pneumonia is controversial[23], and it is as much or more in the case of Covid 19pneumonia[24,25]. The main reason for refraining from the application of these techniques is that many, but not all respiratory physiotherapy techniques generate aerosols and favor the transmission of this disease, which is already very contagious. For pneumonia unrelated to Covid19, alveolar using positive expiratory pressure (PEP) devices has been shown to be well tolerated, with no adverse effects and improved tolerance to dyspnea. Antiviral/antibacterial filters should be adapted to PEP devices with a low resistance of 10 cm H_2O, so that they can be used during short periods several times a day so as not to fatigue the patient. This therapeutic option is increasingly considered and defended by experts inpatients with moderate symptoms of Covid19 pneumonia, since it would optimize the alveolar recruitment during functional restriction induced by acute infection and possibly preventing later restrictive sequelae[26].

In the case of patients with spinal cord injury and concomitant infection with Covid 19, and without scientific evidence for the utility of respiratory rehabilitation, the experts recommend the moderate use of PEP devices with low resistance and, if the severity of the SCI does not permit the patient to cough or produce an effective expectoration, bronchial hygiene techniques using appropriate protective measures by the therapist[27].

2. OBJECTIVE

The objective of this protocol is to present our respiratory rehabilitation program that once agreed between the professionals and following a bibliographic review, applies to all patients admitted to the National Hospital for Paraplegics Toledo who present a **SCI** and who also suffer a **concomitant COVID-19**. The general objective of this program is to reduce respiratory difficulties, alleviate symptoms, decrease anxiety and depression, and mitigate the incidence of complications.

3. RESPIRATORY REHABILITATION PROGRAM

3.1 Required Material

To carry out the respiratory physiotherapy intervention, a positive expiratory pressure device should be used *Threshold PEP* (Philips Respironics, ref. HS735EU). An antiviral / antibacterial filter should also be placed in each *Threshold PEP* device. Likewise, a resuscitation balloon (Ambú®) should be available for each patient that will also contain an antiviral / antibacterial filter to carry out bronchial hygiene techniques if necessary and if the patient requires pulmonary hyperinsuflation. Inpatients wearing a tracheostomy cannula an exchange filter should be used for heat and humidity (GibeckTrach-Vent + ®) to be able to carry out preventive measures that involve secretion aspiration. A pulse oximeter will be used to collect the data which will record heart rate and oxygen saturation, a stopwatch to record the respiratory rate and a respiratory volume meter to measure tidal volume (Wright Mark 8 Spire®). A scale will be used to assess patient comfort based on a visual Likert scale, from 1 to 5, with which the patient will reflect how they feel in that moment, where 1 corresponds to feeling very bad and 5 to feeling very good. Dyspnea should be assessed using the Borg scale, which will be shown graphically to the patient.

3.2 Involved Personnel

a) Medical evaluation and monitoring of aspects related to Covid19 infection. This should be carried out by the involved doctors from the Departments of Internal Medicine and / or Pneumology.

b) Assessment and medical follow-up of aspects related to SCI. They will be carried out by practitioners of the Rehabilitation Department.

c) Execution of the respiratory rehabilitation program: this will be performed only and exclusively by Physiotherapists with experience in Respiratory Physiotherapy, as they are most trained in its implementation and therefore are most appropriate to perform the program with minimal risk of possible contagion.

3.3 Development of the Respiratory Rehabilitation Program (RRP)

The RRP will consist of three different parts. The first and second part will be carried out by the patient with the physiotherapist, who will be provided with the appropriate protection measures and using as a support videos and illustrated cards with images of the selected exercises. The third part, will be performed by the patient alone with two objectives: to guarantee necessary breaks to avoid fatigue and to minimize the negative impact of performing the RRP in patients with anxiety and / or depression, two psychological disorders described as a consequence of Covid 19, which may persist in the form of post-traumatic stress disorder once infection has resolved.

3.2.1. Postural control

It is known that certain positions can facilitate the pulmonary ventilation-perfusion relationship[30]. The use of a vertical bed or raising the head of the bed (30 ° -45 ° -60 °)is recommended in patients with cervical SCI and / or in those with a decreased level of consciousness or treated with drugs that cause depression of the central nervous system if the patient's condition allows it. If the general condition and SCI level/ severity allows it, the patient should be placed in a vertical position twice a day, with the adjustable bed, in their wheelchair, standing or even walking for short distances using their usual orthoses.

3.2.2. Lower and Upper limb kinesiotherapy

This will consist of one session a day for 5 days a week of active, active-assisted or even passive mobilizations depending on the patient's possibilities according to their level of injury, general health condition and functionality. A series of a minimum of 5 and a maximum of 10 repetitions of each of the movements, at a slow speed so as not to provoke fatigue. The exercises will preferably be active and will be executed independently with the support of explanatory cards, except in cases of high and complete cervical spinal injury where active movements are impossible.

- ***Lower limbs***: a) Flexion-extension of hip and knee; b) Abduction of hip; c) Internal and external rotation of the hip; d) Plantar and dorsal flexion of ankle.
- ***Upper limbs***: a) Shoulder flexion; b) Shoulder abduction; c)Internal and external shoulder rotation; d) Flexion-extension elbow; e) Pronation-supination elbow; f) Flexion-extension wrist; g) Flexion-extension fingers.

3.2.3. Respiratory physiotherapy

Exercise helps to achieve a better lung expansion and expel the secretions from the pulmonary alveoli and airways, leading to the mayor respiratory airways, thus avoiding the accumulation of sputum and secondary atelectasis. Exercise helps to increase vital capacity and improves lung function. Slow deep breathing and chest expansion during breathing combined with shoulder expansion are two of the main techniques used for respiratory exercises.

a) *Slow and deep breathing*: while inhaling, the patient should try to actively move the diaphragm as much as they can. The breath should be as deep and slow as possible, to avoid loss respiratory efficiency characterised by rapid and shallow breathing. Compared to chest breathing this type of breathing requires less muscle strength and achieves a higher ventilation-perfusion ratio. It can be used to adjust breathing when the patient experiences shortness of breath.

b) *Chest expansion breathing combined with shoulder expansion*: Increases pulmonary ventilation. When taking slow and deep breaths, the chest and the shoulders expand when inhaling, and they are moved backwards when exhaling. Because the specific pathological factors related to viral pneumonia, discontinued assisted breathing should be avoided for long periods, so as not to increase the load on respiratory function and the heart, in addition to oxygen consumption. Excessive rapid movements should also be avoided. The respiratory frequency should be adjusted to 12-15 times / minute.

c) *Secretion drainage*: Patients generally present characteristics of unilateral or bilateral interstitial pneumonia[28,29]. The pneumonia that characterizes Covid-19 does not seem be characterised by exudative consolidation, but rather alveolar tissue inflammation, which develops into a dry non-productive cough. In these circumstances, secretion drainage techniques would not be indicated. However, according to the evidence published so far, up to 34% of patients with COVID-19 present a productive cough[8], where secretion drainage techniques could be beneficial. These techniques should be applied in these patients, even in some of them that cannot remove secretions by themselves. Furthermore, these techniques

can be used if the patient presents comorbidities associated with the respiratory system that are associated with hypersecretion (COPD, cystic fibrosis, bronchiectasis) or who require assistance in coughing.

d) *PEP exercises using a Threshold PEP device with a resistance of 10cm H20*, **with several short sessions a day 5 days a week**. Four morning sessions will be performed, leaving an hour break between each one and two afternoon sessions equally spaced, allowing a rest time of at least two hours after the meal. For patients with SCI, whether or not they have Covid 19, the respiratory physiotherapist will explain the technique to them personally. All the patients will watch an instructional video showing the correct procedure, given that the communication with the patient is very limited due to the personal protection equipment donned by the staff. In each of the sessions they will perform ***5 repetitions using the PEP device***:
   - Slow inspiration through the nose (so as NOT to provoke a cough).
   - Inspiratory apnea of 3 seconds (if the patient is capable of doing this. If not capable, without apnea).
   - Slow expiration through the device.

If the patient needs a tracheostomy tube, the first option will be to perform the technique through the mouth, by occluding the tube. In case this method is not tolerated or if the patient´s tracheostomy tube has a tracheal balloon to prevent broncho-aspirations, this technique will be performed by adapting the device directly onto the tube. In this way, teleinspiratory apnea cannot be performed.

Patients who present difficulties in handling their secretions due to their spinal cord injury will perform bronchial hygiene techniques before performing the exercises with the PEP technique, consisting of assisted cough or hyperinflation with a resuscitation balloon plus aspiration, depending on the needs of each patient.

3.2.4. Rest and exercises for relaxation

Schultz-type relaxation exercises are recommended. The patient will be provided with an audio recording of the relaxation exercise, which must be done autonomously ***after periods of respiratory physiotherapy*** and lasting approximately 10 -15 minutes.

3.4 Preventive measures during application of the techniques

The physiotherapist who performs the treatment will wear personal protective equipment (PPE) composed of high-efficiency masks (FFP3), tight frame eye protection, double glove and impermeable long-sleeved gown. In any of the interventions described above the patient will wear a surgical mask. The mask will only be removed to carry out the PEP technique with a mouthpiece and the device will always have an antibacterial filter attached. Bronchial hygiene techniques applied to a tracheostomised patient will also be performed with appropriate measures to decrease the risks of aerosol contamination: a) for manual hyperinflation, an antiviral / antibacterial filter will be attached to the exhalation valve of the resuscitation balloon, b) If the patient uses a tracheostomy cannula with tracheal balloon, this always used inflated to perform bronchial hygiene techniques, c) the aspiration of secretions will be made using a heat and humidity exchange filter on the cannula.

REFERENCIAS

1. QUN LI et al. Early Transmission Dynamics in Wuhan, China of Novel Coronavirus–Infected Pneumonia. *NEJM, 2020. January 29th*.DOI: 10.1056/NEJMoa2001316.
2. PENG ZHOU et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature, 2020. Vol 579:270-86*. doi.org/10.1038/s41586-020-2012-7.
3. ZHU N, et al. China Novel Coronavirus Investigating and Research Team. A Novel Coronavirus from Patients with Pneumonia in China, 2019.*N Engl J Med. 2020 Feb 20; 382(8):727-733. doi: 10.1056/NEJMoa2001017*.
4. ZOU L,et al. SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients.*NEngl J Med. 2020 Mar 19;382(12):1177-1179. doi: 10.1056/NEJMc2001737*.
5. TO KK-W et al. Consistent detection of 2019 novel coronavirus in saliva. Clin Infect Dis Off Publ Infect Dis Soc Am. 2020, February 12th.
6. https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6;
7. LAUER SA, GRANTZ KH et al. The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application. *Ann Intern Med.2020.* doi:10.7326/M20-0504
8. GUAN WJet al; China Medical Treatment Expert Group for Covid-19. Clinical Characteristics of Coronavirus Disease 2019 inChina.*NEngl J Med. 2020 Feb 28th. doi: 10.1056/NEJMoa2002032*.
9. HUANG C. et al.Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; 395: 497–506.
10. MATTHAY MA, ALDRICH JM, GOTTS JE. Treatment for severe acute respiratory distress syndrome from COVID-19. *Lancet Respir Med 2020, doi.org/10.1016/S2213-2600(20)30127-2.*
11. ZU ZY, JIANG MD, XU PP, CHEN W, NI QQ, LU GM, ZHANG LJ. Coronavirus Disease 2019 (COVID-19): A Perspective from China.*Radiology. 2020 Feb 21:200490. doi: 10.1148/radiol.2020200490*.
12. HOSSEINY M, KOORAKI S, GHOLAMREZANEZHAD A, REDDY S, MYERS L Radiology Perspective of Coronavirus Disease 2019 (COVID-19): Lessons from Severe Acute Respiratory Syndrome and Middle East Respiratory Syndrome.*AJR Am J Roentgenol. 2020 Feb 28:1-5. doi: 10.2214/AJR.20.22969*.
13. RUAN Q, YANG K, WANG W, JIANG L, SONG J. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. *Intensive Care Med* 2020; published online March 3. DOI:10.1007/s00134-020-05991-x.
14. MEHTA P, McAULEY DF, BROWN M, SANCHEZ E, TATTERSALL RS, MANSON JJ. COVID-19: consider cytokine storm syndromes and immunosuppression. *Lancet 2020. doi.org/10.1016/S0140-6736(20)30628-0*
15. RITCHIE AI, SINGANAYAGAM A. Immunosuppression for hyperinflammation in COVID-19: a double-edged sword? *Lancet* March 23, 2020. doi.org/10.1016/S0140-6736(20)30691-7
16. RAMOS-CASALS M, BRITO-ZERON P, LOPEZ-GUILLERMO A, KHAMASHTA MA, BOSCH X. Adult haemophagocytic syndrome. *Lancet 2014; 383: 1503–16*.
17. ZHOU Fet al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 inWuhan, China: a retrospective cohort study. Lancet. 2020 Mar 11. pii: S0140-6736(20)30566-3. doi: 10.1016/S0140-6736(20)30566-3.
18. KASINATHAN N, VANATHI MB, SUBRAHMANYAM VM, RAO JV. A Review on Response of Immune System in Spinal Cord Injury and Therapeutic Agents useful in Treatment. *CurrentPharmaceuticalBiotechnology, 2015 (16):26-34.*
19. XIN SUN et al. Multiple organ dysfunction and systemic inflammation after spinal cord injury: a complex relationship.*Journal of Neuroinflammation (2016) 13:260. DOI 10.1186/s12974-016-0736-y*
20. AREVALO-MARTIN A, et al. Elevated Autoantibodies in Subacute Human Spinal Cord Injury Are Naturally Occurring Antibodies. *Front. Immunol. (2018) 9:2365. doi: 10.3389/fimmu.2018.02365*
21. SHAH A, SHEM K, McKENNA S, BERLLY M. Respiratory management of the spinal cord injured patients. In: KIRSHBLUM S, CAMPAGNOLO DI. Spinal Cord Medicine. 2011. Lippincott Williams & Wilkins, Philadelphia.
22. McCAUGHEY EJ, BUTLER JE, MCBAIN RA, BOSWELL-RUYS CL, HUDSON AL, GANDEVIA SC, LEE BB. Abdominal Functional Electrical Stimulation to Augment Respiratory Function in Spinal Cord Injury.*Top Spinal Cord InjRehabil. 2019 Spring;25(2):105-111. doi: 10.1310/sci2502-105*.
23. YANG M, YAN Y, YIN X, WANG BY, WU T, LIU GJ, DONG BR. Chest physiotherapy for pneumonia in adults. *Cochrane Database of Systematic Reviews* 2013, Issue 2. Art. No.: CD006338. DOI:10.1002/14651858.CD006338.pub3.

24. ZHONGHUA J et al. Expert consensus on preventing nosocomial transmission during respiratory care for critically ill patients infected by 2019 novel coronavirus pneumonia. 2020 Feb 20;17(0):E020. doi: 10.3760/cma.j.issn.1001-0939.2020.0020.
25. SIMONDS AK, HANAK A, CHATWIN M, et al. Evaluation of droplet dispersion during noninvasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: Implications for management of pandemic influenza and other airborne infections. *J Health Technol Assess, 2010, 14(46):131-172. DOI: 10.3310/hta14460-02*.
26. ARBILLAGA A, PARDÀS M, ESCUDERO R, RODRÍGUEZ R, ALCARAZ V, LLANES S, HERRERO B, GIMENO E, RÍOS A. Fisioterapia respiratoria en el manejo del paciente con covid-19: recomendaciones generales. SEPAR, versión 1.0, 26 de marzo 2020.
27. THOMAS P, BALDWIN C, BISSETT B, BODEN I, GOSSELINK R, GRANGER CL, HODGSON C, JONES AYM, KHO ME, MOSES R, NTOUMENOPOULOS G, PARRY SM, PATMAN S, van der LEE L. Physiotherapy management for COVID-19. Version 1.0, 23/3/2020.
28. PAN F, YE T, SUN P, GUI S, LIANG B, LI L, et al. Time Course of Lung Changes On Chest CT DuringRecovery From 2019 Novel Coronavirus (COVID-19) Pneumonia. (2020) Radiology.
29. SHI H, HAN X, JIANG N, CAO Y, OSAMAH A, GU J, et al. (2020) Radiologicalfindings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptivestudy. Lancet InfectDis. 2020 Feb 24. pii: S1473-3099(20)30086-4. doi: 10.1016/S1473-3099(20)30086-4.