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Pulmonary rehabilitation post COVID-19

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***Abstract*---**Coronavirus disease 2019 (COVID-19) a pandemic is caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). The virus belongs to the Coronaviridae family and the key reservoir of the virus are bats. Since the outbreak of this disease across the globe, millions of people have been affected, resulting in mild to severe illness and significant mortality. COVID-19 is primarily transmitted from person to person through droplet infection, contact, or feco-oral routes. The host, environmental, and viral risk factors all play a role in COVID-19. The infection can manifest as a mild illness including upper respiratory infections and non-severe pneumonia, or as a severe pneumonia involving ARDS, multiple organ failure, and death. Symptoms of COVID-19 include fever, cough, fatigue, dyspnea, anorexia, productive sputum, myalgia, sore throat, nausea, dizziness, diarrhea, headache, vomiting, abdominal pain, loss of taste and smell. Management includes primary care, community care and acute care. In this article, we present a brief overview of the epidemiology,

etiopathogenesis and general symptoms of SARS-CoV-2, as well as current understanding of pulmonary rehabilitation procedures routinely recommended to treat patients post COVID-19.

***Keywords*---**physiotherapy, COVID-19, breathing techniques, chest physiotherapy, pulmonary rehabilitation.

Introduction

Novel coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 [severe acute respiratory syndrome coronavirus type-2] (Banerjee I *et al.* 2020; Rathi H *et al.* 2021; Li X *et al.* 2020). The coronavirus is the third in a series of human pathogenic beta coronaviruses and the seventh coronavirus to be pathogenic to humans. The first of the beta coronavirus triad was responsible for Severe Acute Respiratory Syndrome (SARS), while the second was responsible for Middle East Respiratory Syndrome (MERS) (Banerjee I *et al.* 2020; Li X *et al.* 2020). The virus belongs to the Coronaviridae family, Nidovirales order having subgroups of coronavirus family namely alpha (α), beta (β), gamma (γ), and delta (δ) (Mahalmani VM et al, 2020; Rathi H *et al.* 2021). The key reservoir of the virus are bats (Mahalmani VM *et al.* 2020; Rathi H *et al.* 2021), hence making COVID-19 a zoonotic disease.

Epidemiology

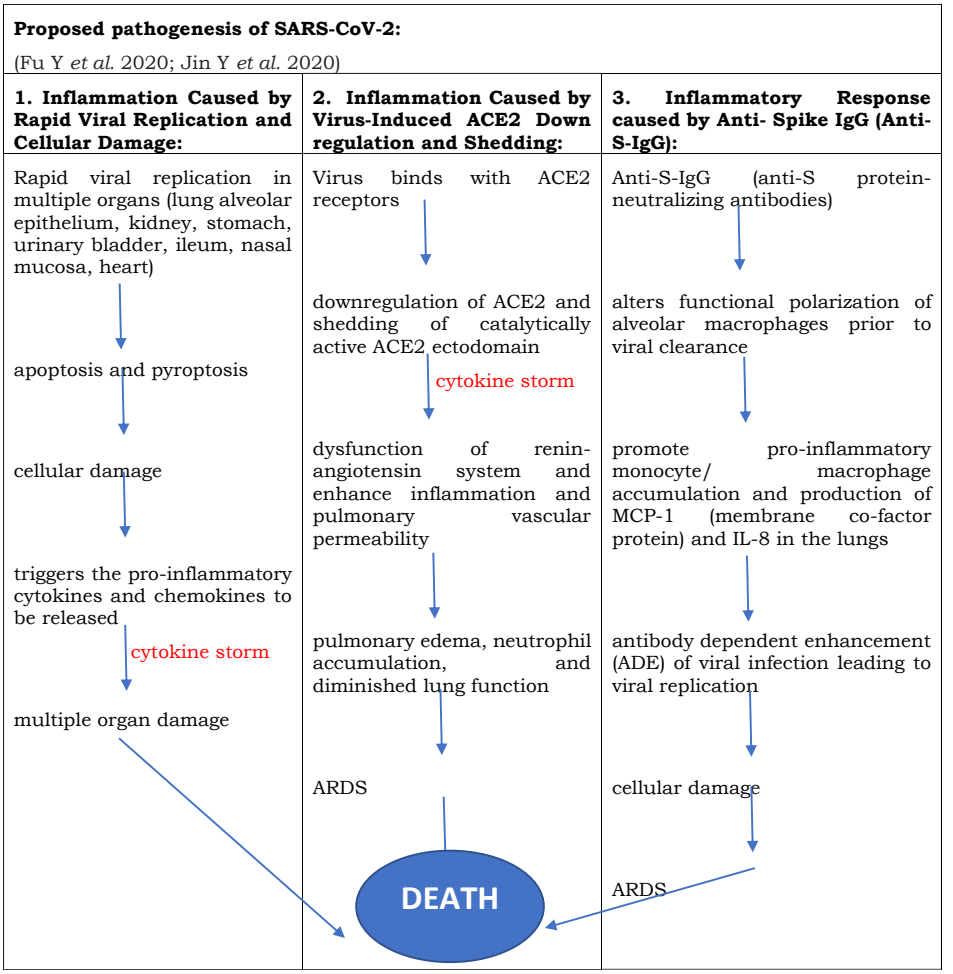
The outbreak of coronavirus in December 2019 was thought to have originated from the Hunan seafood market at Wuhan, in China. Since then there has been an outburst of this disease across the globe affecting millions of human inhabitants resulting in mild to severe illness and substantial deaths. COVID-19 was declared the 6th "public health emergency of international concern (PHEIC)" by the WHO on January 30, 2020, and a pandemic on March 11, 2020. In India, the first instance of COVID-19 was reported on January 30, 2020 (Mahalmani VM *et al.* 2020; Banerjee I *et al.* 2020; Rathi H *et al.* 2021).

Etiopathogenesis

The causative micro-organism of COVID-19 is SARS-CoV-2 having exponential transmission rate (Banerjee I *et al.* 2020; Rathi H *et al.* 2021). Mode of transmission of COVID-19 is primarily a human-to-human transmission via droplet infection or by contact or feco-oral route. Infection is spread through respiratory droplets while coughing or sneezing produced by symptomatic as well as by asymptomatic patients. The virus can persevere in the aerosols for nearly 3 hours and can be ascertained up to 72 hours after application on different surfaces. As a result, if one comes into contact with such contaminated surfaces and subsequently touches their mouth, nose, or eyes, transmission can occur (Rashedi J *et al.* 2020; Mahalmani VM *et al.* 2020; Banerjee I *et al.* 2020; Rathi H *et al.*2021). The average incubation period of COVID-19 is 5.2 days and the total 95th percentile of the distribution of the virus is seen in 12.5 days (Banerjee I *et al.* 2020).

The risk factors for COVID-19 are the following: (Rashedi J *et al.* 2020; Rathi H *et al.* 2021)		
Host risk factors	Environmental risk factors	Viral risk factors
• Underlying chronic medical comorbidities such as cardiovascular diseases, respiratory disorders, diabetes, hypertension, malignancy, chronic renal disease, malnutrition, and immunodeficiency. • Older age	• Crowding • Low education • Occupational risk to healthcare workers • Poor ventilation • Animal contact • Poor hygiene	• Transmissibility (primary reservoir of the virus, number of the infected people, and the transmission route) • Viral evolution • Viral load

The pathophysiology for SARS-CoV-2 likely resembles that of SARS-CoV. The virus attacks the lungs, resulting in fatal acute respiratory distress (Fu Y *et al.* 2020). Acute respiratory distress syndrome (ARDS) is a life-threatening lung disorder that prevents enough oxygen from reaching the lungs and circulatory system, resulting in and acute lung injury and mortality of most respiratory disorders (Thompson, B.T *et al.* 2017). It is proposed that virus passes through nasal and larynx mucous membranes and the initial viral replication occurs in the mucosa's epithelium in the upper respiratory tract, which later moves into the lower respiratory tract and, finally, the mucosa of the gastrointestinal system, giving rise to a mild viremia. At this point, few infections that are controlled, remain asymptomatic while others may manifest non-respiratory symptoms such as acute liver and heart injury, kidney failure, diarrhea etc implying multiple organ damage (Jin Y *et al.* 2020; Rathi H *et al.* 2021). The virus binds to ACE2 (angiotensin-converting enzyme2) receptors in humans, causing severe pathological symptoms. ACE2 is widely expressed in the lung alveolar epithelium, kidney, stomach, urinary bladder, ileum, nasal mucosa, heart. After binding with receptor on the host cell (mediated by S protein of the virus), this virus further replicates, eventually making all these organs susceptible/vulnerable to SARS-CoV-2 (Jin Y *et al.* 2020; Rashedi J *et al.* 2020; Rathi H *et al.* 2021)



Clinical Presentation

The course of infection manifests as mild disease limiting itself to upper respiratory, non-severe pneumonia, or as severe pneumonia involving ARDS, multiple organ failure and ultimately death (Rathi H *et al.* 2021). Most common symptoms include fever (82.2%), cough (61.7%), fatigue (44.0%), dyspnea (41.0%), anorexia (40.0%), productive sputum (27.7%), myalgia (22.7%), sore throat (15.1%), nausea (9.4%), dizziness (9.4%), diarrhea (8.4%), headache (6.7%), vomiting (3.6%), and abdominal pain (2.2%) (Siordia Jr JA. 2020), loss of taste and smell; those who fall under critical category requires ventilation support (Rathi H *et al.* 2021).

Investigations

The gold standard for diagnosing COVID-19 remains RT-PCR. Other laboratory values that indicates COVID-19 infection include lymphopenia, prolonged prothrombin time (PT), elevated lactate dehydrogenase (LDH), elevated alanine

aminotransferase (ALT), elevated aspartate aminotransferase (AST), elevated D-dimer, elevated neutrophils, eosinopenia, elevated C-reactive protein (CRP), and elevated troponin (Siordia Jr JA. 2020). In COVID- 19 instances, chest CT scans reveal bilateral ground glass opacification, which is more prominent in the early stages, or consolidation, which appears later (Wang S et al. 2021). Despite the majority of patients having CT scan findings, 33%–60% of patients have abnormal chest x-rays (Siordia Jr JA. 2020).

Pulmonary rehabilitation post COVID-19

Physiotherapist (PT), who works as a primary health care professional in dealing COVID-19 patients are more susceptible to the transmission of infectious diseases. Physiotherapists must utilize their professional judgment in addition to their position as primary practitioners to choose when and how to offer the best care to their patients. Physiotherapists, in conjunction with a multidisciplinary team that includes occupational therapists, speech and language therapists, dieticians, and psychologists, are responsible for rehabilitation during the recovery period. The role of PT in managing COVID-19 patients can be broadly classified into:

- Primary Care
- Community Care
- Acute Care (Hospital Care)

Primary Care

PT must consider two aspects while justifying their role as a primary health care worker.

- **Avoid transmission**: In order to prevent transmission of COVID 19, PT must adhere to basic protective measures at all times such as maintaining hand hygiene, wearing PPE kit and medical mask, avoid touching nose, eyes and mouth and maintaining social distancing (Thomas P *et al.* 2020).
- **Patient education:** PT deals as a patient educator by providing manuals/ video materials to emphasize the importance of respiratory rehabilitation; promoting healthy lifestyle education; by encouraging patients to indulge in family and social activities (Demeco A *et al.* 2020). Physiotherapists are competent to give health-maintenance recommendations relating to activities, diet, sleep, and mental health, and they should be proactive in doing so.

Community Care

If a person has minimal symptoms and is suspected of being infected with COVID-19, care can be offered at home. In this case, PT determines whether the residential setting is suitable for providing basic and essential health care to the elderly, patients with comorbidities, or patients with disabilities.

Acute Care (Hospital Care)

Physiotherapist have an active role in the respiratory care of the patients who need to be hospitalized, most often with the symptoms of pneumonia ARDS, or septic shock. PT must follow the measure to avoid transmission while treating patients infected with COVID-19. As far as the acute condition of COVID-19 is concern, chest physiotherapy maneuvers including percussion, vibration and shaking should be implemented on to the hemodynamically stable and afebrile patient (Shakerian N *et al.* 2021). While dealing with COVID positive patients in hospital or home set ups, PT must teach the patient about controlled breathing techniques. Shallow, rapid breathing is commonly seen in anxious and often dyspneic patients which increases dead-space ventilation and airflow through narrowed airways, thus increasing the flow work of breathing. Patients with COVID 19 must perform following techniques in order to reduce the work of breathing, to maintain the optimal level of SpO2, to move the aggregate airway secretions (Kalirathinam D *et al.* 2020; Shakerian N *et al.* 2021). These techniques must be used once the patient is wean off from the ventilator support.

Techniques to improve SPO2 (Pryor JA *et al.* 2008; Kisner *et al.* 2018)

Prone lying position (recommended for ≈20 min.) is a preferred choice of position in COVID patients, but as it may not be a comfortable position, patient will not be able to opt this position for prolonged time. Apart from positioning following are the techniques which proves to be beneficial in order to maintain optimal SpO2 level among the COVID patients:

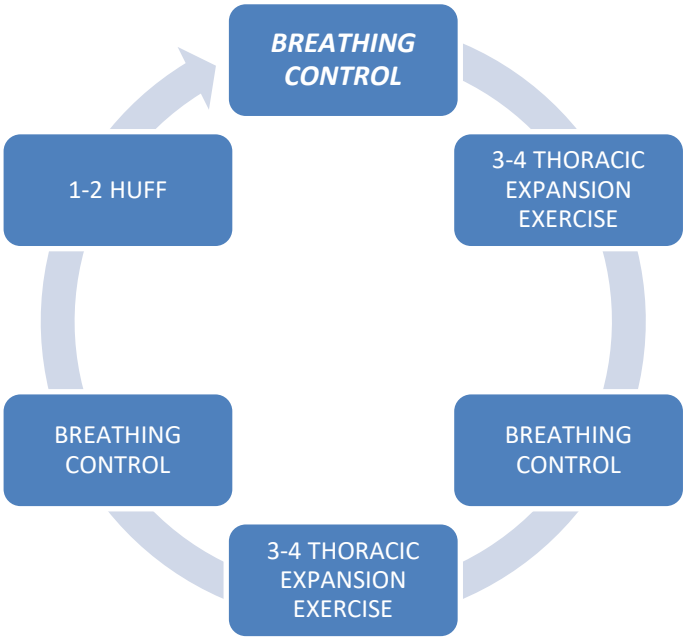
- ***Diaphragmatic breathing:***
  It is used to reduce the abnormal/ overwork of accessory respiratory muscles recruitment in COVID 19 patients. Patient uses the diaphragm, relaxes abdominal muscles during inspiration. Ask the patient to lie down at 15% to 25% head-down position, the patient places one hand over the thorax below the clavicle to stabilize the chest wall, and the other over the abdomen. The patient takes a deep breath, and expands the abdomen using the diaphragm. This increases tidal volume, decreases functional residual capacity, and helps in increasing maximum oxygen uptake.
- ***Segmental breathing:***
  This pattern of breathing technique is used to facilitate the expansion of adjacent regions of the thoracic cavity that may have decreased ventilation. Prior to teach this technique; obstructions such as mucous plugs, should be cleared. The patient is asked to inspire while the clinician applies pressure to the thoracic cage to resist respiratory excursion in a segment of the lung. As the clinician feels the local expansion, the hand resistance is decreased to allow inhalation. This technique is used to reduce dyspnea and the work of breathing.
- ***Pursed-lip breathing:***
  Patient inhales through the nose for a few seconds with the mouth closed, then exhales slowly for 4–6 seconds through pursed lips. By forming a wide, thin slit with the lips, the patient creates an obstruction to exhalation, slowing the velocity of exhalation and increasing mouth pressure. Expiration lasts 2–3 times as long as inspiration. Classically, this technique equalizes pleural and

bronchial pressures, thus preventing collapse of smaller bronchi and decreasing air trapping. The combination of diaphragmatic and pursed-lip breathing decreases the respiratory rate, coordinates the breathing pattern, and can improve SpO2. It should be used often, particularly during routine ADLs or exercise. When used correctly, it can help maintain the cadence of breathing. It can also improve exercise performance by relaxing accessory muscles and improving breathing efficiency. Air-shifting techniques may be useful to decrease micro atelectasis. Air shifting involves taking a deep inspiration that is held with the glottis closed for 5 seconds, during which time the air shifts to lesser-ventilated areas of the lung. The subsequent expiration is via pursed lips. This technique may be most beneficial when performed several times per hour. It promotes greater gas exchange in the alveoli, increases tidal volume, reduces dyspnea and work of breathing in COVID 19 patients. When added to diaphragmatic breathing, reduces the respiratory rate and can improve blood ABGs.

Airway clearance techniques (controlled cough, huffing) (Pryor JA *et al.* 2008; Kisner *et al.* 2018)

- ***Controlled cough:***
  The patient assumes an upright sitting position, inhales deeply, holds the breath for several seconds, contracts the abdominal muscles ("bears down" increasing intrathoracic pressure), then opens the glottis and rapidly and forcefully exhales while contracting the abdominal muscles and leaning slightly forward. This is repeated 2-3 times followed by normal breaths for several minutes before attempting controlled cough. Coughing generates high expulsive forces promoting secretion retention and may exacerbate air trapping; also leads to fatigue if the cough is weak.
- ***Huffing:***
  Huffing involves deep inhalation, followed by attempting a short, frequent exhalations by contracting the abdominal muscles and saying "ha, ha, ha". The glottis remains open during huffing, and does not increase intrathoracic pressure, therefore, in COVID 19 patients, this is a more efficient means of secretion removal.
- ***Active Cycle of Breathing technique (ACBT):***
  ACBT is a cycle of the techniques of breathing control, thoracic expansion exercises, the forced expiration technique (huffing and breathing control) and coughing to assist with mucus clearance. ACBT is an airway clearance & active breathing technique performed by the patient and can be used to mobilize and clear excess pulmonary secretions and to generally improve lung function. It's used to loosen and clear secretions from the lungs. This helps in reducing the risk of chest infections, improve ventilation in the lungs, and improve the effectiveness of a cough. It is a flexible method of treatment that can be used in conjunction with positioning. Each component can be used as per the patient's problem (Shakerian N *et al.* 2021). ACBT consists of repeated cycle of three ventilatory phase:
  - Breathing Control
  - Thoracic expansion exercise
  - Forced expiratory technique (FET)

- ***Breathing control:*** Upper chest and shoulders should remain relaxed while the lower chest and abdomen should be active. Ask the patient breathe in a relaxed manner with tidal volume breathing. This phase may last as long as patient requires to relax and prepare himself for the next phase. Breathing control may require in between the cycle in order to prevent bronchospasm.
- ***Thoracic expansion exercise:*** After breathing control, patient is instructed to take in a deep breathe to the inspiratory reserve volume, expiration is passive and relaxed. Chest percussion, vibration, shaking may be performed as the patient exhales. For surgical patients or those with lung collapse, a breath hold or a sniff at the end of inspiration encourages collateral ventilation to redistribute air into collapsed segment and assist in re-expansion of lung.
- ***Forced expiratory technique:*** It consists of huffing with breathing control. To mobilize secretion from peripheral airways, a huff after a medium sized inspiration will be effective. This huff will be longer and quieter. To clear secretion that have reach the larger, proximal airways, a huff after a deep inspiration will be effective. This huff will be shorter and louder.



Promoting active life style

It has been observed that there is a subsequent reduction in muscle strength of a COVID positive patient. In order to improve physical strength and function, PT recommend the patient to not to stay in bed all day, try to sit in a chair for meals and activities and go on short walks in and around the room. Intensity and frequency of exercise can be varied as per the condition of the patient. Some of the exercises which can be advised to the COVID positive patient are as follows (Gloeckl R *et al.*2021):

- Activities of daily living training (4-5 times per week for 30 min)
- Strength training: leg press, knee extension, pull-down and push-down, butterfly forward/backward, rowing, back extension and abdominal trainer (3 sets per exercise at an individual intensity to reach momentary muscular failure after 15–20 repetitions)
- Resistance training (~30 min per session for 5 days per week)
- Cycle endurance training (10–20 min per session at 60–70% of peak work rate 5 days per week)
- Progressive muscle relaxation (Jacobson technique) (twice per week for 30 min)

It may take some time before patient is well enough to return to work. Physiotherapist shall continue to take care of their patient at home, and advise when patient may be ready to return to work. The above specified physiotherapy treatment is beneficial for the COVID-19 patient to return to his normal routine of life and minimize the side effects of COVID-19.

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