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Post COVID Comprehensive Pulmonary Rehabilitation - The Limelight Case Report

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Abstract: ***Background: In the pandemic of COVID 19, though the natural history and phases of infectivity and severity indices are known through various available scientific evidences, yet there are some patients with atypical post-acute COVID sequelae of prolonged subacute phase/delayed recovery phase requiring meticulous attention and comprehensive assessment to look into the pulmonary and functional impairments. Materials and methods: The standard respiratory and endurance parameters, level of physical function by FIM and Barthel index score, Quality of life questionnaire are assessed prior to and post rehabilitation intervention and compared. Discussion: The prototype of pulmonary rehabilitation may suit as a framework, particularly in a subset of patients with long term respiratory consequences where the program of customized rehabilitation intervention, formulated on a graded target-oriented basis focusing on the level of tolerance and the physical capacity of the patient, thereby improving the functional ability with a short follow up. Conclusion: Better outcome in terms of Quality of Life and independent ambulation with concomitant improvement in respiratory and endurance parameters in this case, has given way to frame the customized comprehensive, rehabilitation program as a prima facie evidence in a situation where pragmatic approaches are scarce and some ethical trials need to be implemented for the betterment of the patients and their functional wellbeing to be restored at the earliest.***

Keywords: COVID 19, post COVID sequelae, pulmonary rehabilitation, hypoxemia, quality of life

1. Introduction

The need for the emergence of comprehensive rehabilitation services and their importance in restoring back the impaired functional activities and pulmonary functions in COVID 19 survivors made us the physiatrists, to look into our keen role in post-acute COVID rehabilitation.

Since there was gradual increase in the patients getting admitted in COVID ICU and isolation wards with various presentations like acute respiratory distress requiring mechanical ventilation/CPAP/High flow nasal oxygen with radiological and clinical features of COVID pneumonia ,resting desaturation (happy hypoxia)[2] exertional hypoxemia, prolonged recovery phase, long COVID and various variants of post distress recovery, the integration of pulmonary rehabilitation in the sub-acute and recovery phases were considered to be definitely effective and the pathway of comprehensive and holistic approach opened up.

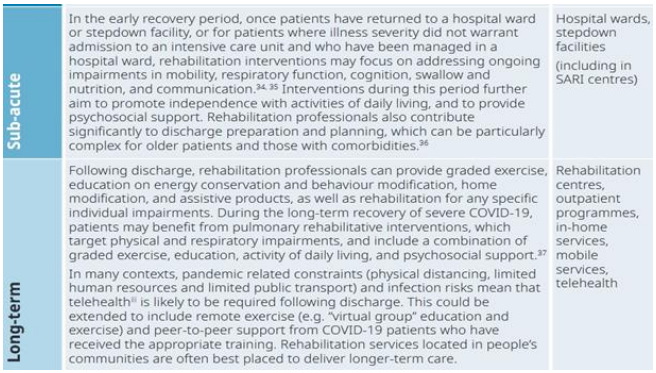


Figure 1: Rehabilitation intervention recommendation Guidelines by WHO Americas (Pan America Health Organization

This study is regarding the challenges encountered while rehabilitating the first post-acute atypical COVID sequelae that was referred to the Department of PMR in a tertiary care COVID treating medical college hospital in Chennai, Tamil Nadu.

The post COVID patient categorization technically for planning appropriate customized rehabilitation intervention is being done primarily based on oxygen saturation levels and categories-0,1,2,3,4 is subdivided accordingly to evolve a standard treatment protocol, also by considering the pulmonary and endurance parameters.

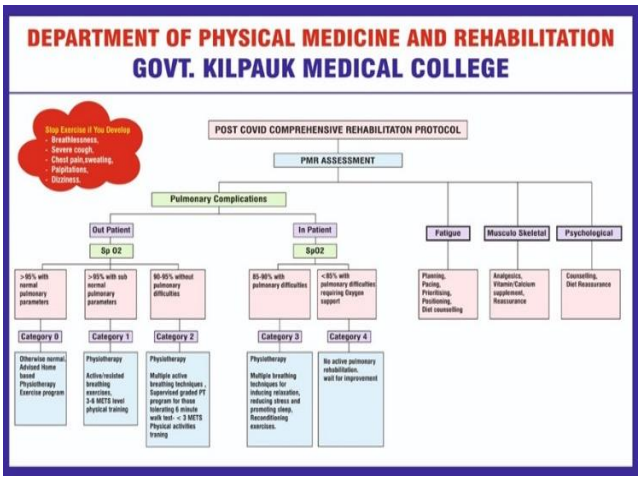
Table 1: Post COVID Rehabilitation- categorisation chart

Category	*Oxygen Saturation (in room air)*	*Pulmonary parameters*		*Respiratory rate/min*	*Borg dyspnea scale*	*Endurance performance (6 mins walk)*
		SBC (count)	*BHT (secs)*	*At Rest*		
0	>=95%	>20	>30	16-20	0	Able to do
1	>=95%	15 -20	21 -30	20-24	0.5	Able to do
2	90- 94%	11-14	16-20	25-30	1	May/may not [1 min walk may b possible]
3	>85-<90%	8-10	10 -15	31-35	2	Bed side standing/1-minute walk with oxygen support
4	<=85%	<8	<10	>35	3	Not able to exert

2. Objectives

To determine the pulmonary and functional impairments and to assess the impact of a comprehensive interdisciplinary pulmonary rehabilitation program on pulmonary and functional impairments prior to and post rehabilitation intervention by means of clinical, quality of life and functional outcome.

To formulate a standard operating protocol for rehabilitation guidelines for the post-acuteCOVID-19 19 survivors



Flowchart-1: Rehabilitation protocol-category wise based on oxygen saturation

3. Case Report

We hereby report a 63 years old male, a case of Severe Acute Respiratory Syndrome cov-2/Post ARDS recovery/known case of type 2 diabetes mellitus who was hospitalized as inpatient in COVID ICU for Acute respiratory distress with spo2 77% in room air, with no preexisting respiratory disorders who had Positive RT-PCR (SWAB 1) POSITIVE and subsequent second swab negative after10 days of admission.Positive CT CHEST

Figure 2: CT chest report on admission

radiological signs initially minimal <25% lung involvement at the time of admission with bilateral lower lobe, left upper lobe and lingula ground glass opacities and left lower lobe central consolidation later repeat CT chest after 14 days showed moderate 50-75% lung involvement with peripheral ground glass opacities involving all lobes of both sides and septal thickening involving lobes

Figure 3: CT chest report-Post acute COVID-19

bilaterally [8] The inflammatory markers were on the higher side with highly elevated CRP and Interleukin -6 and other COVID profile markers like serum LDH, Serum ferritin, D-dimer were mildly elevated during acute phase. The idea of framing a standard operational procedure for assessing and categorizing the patients based on the oxygen saturation levels of the patient is first initiated and formulated while attempting to rehabilitate the post-acute COVID sequelae who didn't have subjective dyspnea at rest but objective exertional desaturation , who was hospitalized for a prolonged period and there was struggle in making decision of how and when to wean off from oxygen support /how and when to exert the patient for returning to near normal activities of daily living and when and how to plan for discharge from hospital, when there is paucity of standard guidelines.

4. LAMP Therapy

Patient has been admitted and treated in COVID ICU with

- Low molecular weight heparin 0.6 ml SC BD
- Azithromycin 500mg OD
- Methyl Prednisolone 125 mg IV OD
- Prone ventilation
- Meropenem 1g IV BD
- High flow nasal oxygen (15-40 lit/min)
- *LAMP regimen was framed first and implemented by Department of General Medicine, Government Kilpauk Medical college, Chennai

Hypoxemia-clue to rehabilitation

Since the patient had no subjective symptoms of dyspnea at rest, yet the saturation drops down to >5-10% from baseline without O2 supplementation [3]. It is at this point Rehabilitation help was sought to decide about weaning from oxygen support and to handle the oxygen desaturations. As the patient has crossed acute state the term of happy hypoxia was reluctant to be considered [4]yet the worsening radiological changes and the spontaneous desaturations to 77-82%at rest without O2 ;with respiratory rate of 24/min and with 6 lit O2 it was 93% the prolonged inflammatory states with persistent increased CRP levels made to restart intravenous steroids and we started to look for evidences in literature to assess and rehabilitate post-acute COVID19 patient and the new term 'long COVID / long haul COVID 'started to gain attention.

5. Pulmonary and Endurance Assessment

Table 2: Assessment Chart-Pulmonary, Endurance and functional Parameters

Pulmonary and endurance/primary outcome measures
Oxygen saturation
Measured with pulse oximeter, in all 4 limbs and in various positions and the values are tabulated
Respiratory/primary outcome measures-
Oxygen saturation prior to, during and post exercises
Single breath count
Breath holding Time
Respiratory rate
Modified Borg scale of dyspnoea at rest [appendix 1] and after exertion, [appendix 2]
Dyspnoeic index [appendix 3]
Aerobic endurance/secondary parameter
6 minutes' walk test / one-minute walk test
Functional/secondary outcome measures
Sit to stand.
Barthel Index
FIM score
Quality of life assessment
St. George Respiratory Questionnaire pre- and post-rehabilitation intervention

The standard respiratory parameters were assessed for primary clinical outcome and the endurance, functional performance was assessed for secondary outcome. [appendix 1, 2, 3] The Quality-of-life outcome is measured by St. George Respiratory Questionnaire.

6. Materials and Methods

All assessments and therapy instructions were given at 2 meters distance and by following all safety precautions. Therapeutic breathing exercises with scientific evidence for their probable mechanics are included gradually in each category for addressing each category specific needs. [1]

Table 3: Possible goals in each category and the breathing and endurance exercises prescribed accordingly

Category	*Goal*	*Breathing*	*Endurance*	*Remarks*
0	To maintain their prior levels of functionality and independence	Progressive resistive intercostal exercises and diaphragmatic exercises with weights to strengthen diaphragm and intercostal muscles and rib cage mobilization	Brisk walking, gradual increase in intensity and duration of aerobic activities	Home exercise program and overall reconditioning
1	Optimize health and functioning outcomes and to reverse atelectasis	Active cycle of breathing techniques, Incentive spirometry /ballooning exercises helps in regaining the inspiratory lung functions and also expiratory volumes along with visual feedback	3 to 6 METS activities	To look for red flags
2	To improve recovery and reduce disability	Therapeutic breathing exercises like segmental breathing and alternate nostril breathing to enhance or maintain deep and slow inspiration thereby helps in increasing inspiratory reserve volume and to have a better control over breathing and reduces anxiety	<3 METS activities	Education on energy conservation
3	To enhance lung compliance and to reduce the work of breathing and distal airway expansion	Breathing exercises to make the patient to do slow and sustained breathing exercises facilitating airway clearance, suppressing cough and provide relaxation and increases trans pulmonary pressure	• No active endurance training • If tolerated, only bed side standing allowed/one-minute bed side walking with	make the patient to actively participate in rehab program and to look for exertional hypoxemia

			oxygen support	
4	Vitals monitoring	Relaxation breathing exercises to alleviate anxiety with oxygen support, customized to the SPO2 level of the patient under expert supervision	Nil	Look for hypoxemia

At first when patient was categorized under category 4, patient was kept under strict observation. On subsequent visit, after the initial baseline assessments and after identifying the exercise capacity of the individual, patient was fitted to category 3 and started with the rehabilitation program as planned based on the oxygen saturation levels along with awake proning.

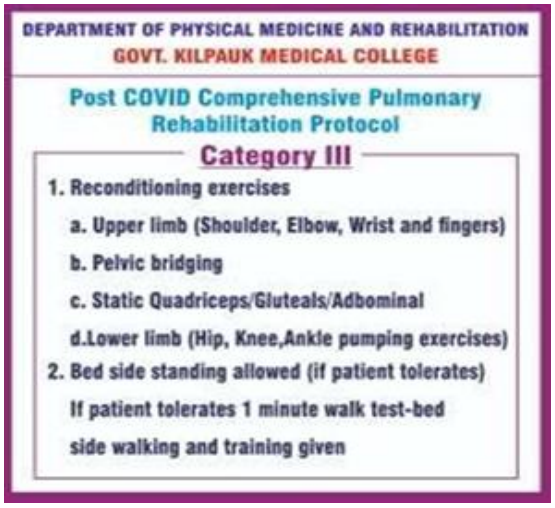


Figure 4: Category 3 exercise program

All the respiratory and functional parameters were recorded prior to and post therapy in each session. Re categorization to category 2 happened after 10 days of intense respiratory retraining techniques and patient was able to do one-minute walk test without oxygen and oxygen saturation and prone ventilation time also showed improvement.

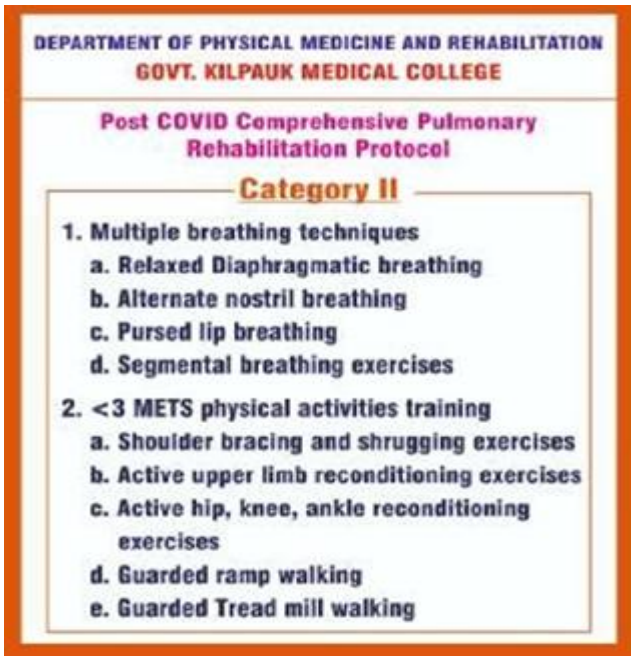


Figure 5: Category 2 exercise program

The intensity and duration of breathing retraining therapy by means of graded therapeutic breathing exercises subjected to the level of tolerance and low intensity aerobic exercises started and patient was assessed for 6 minutes' walk test without oxygen which he was able to tolerate without gross desaturation and patient is able to do and maintain self proning for better lung ventilation.

Recategorization from category 2 to 1

Figure 6: Category 1 exercise program;

occurred after 2 weeks and the intensity of aerobics exercises gradually intensified with increase in duration and segmental breathing and incentive spirometry also showed improvement which is reflected in increase in FIM score and oxygen saturation levels and the measures of exercise capacity. Periodically there is significant category shift to zero

Figure 7: Category zero exercise program;

occurred, on telephonic assessment and follow up.

Table 4: Respiratory and Endurance Parametersoutcome Assessment prior to and post rehabilitation intervention

Date of Assessment	Dept where patient assessed	Whether patient was in COVID ICU? (Yes/No)	Current Symptoms	SpO2 in RA	Heart rate/min	Single breathe count	Breathe holding time in seconds	Respiratory rate/min	Borg Scale of Dyspnoea at rest	Borg scale of dyspnoea after exertion	Dyspnoea Index	Sit to stand test (30 seconds)	Support oxygen	6 mins walk test		1 min walk test		Category	Re categorisation time
														SpO2/ HR		SpO2/ HR			
17.7.20	isolation ward	Yes	Nil	82	100	13		26	1		1		yes					4	
27.7.20	isolation ward	Yes	Nil	90	102	22	26	22	0	9	0	7	Yes			90	112	3	10 days
5.8.20	isolation ward	Yes	Nil	92	98	26	32	22	0	8	0	10	Yes	89	112			2	9 days
31.8.20	post COVID op	Yes	Nil	94	102	28	32	18	0	8	0	10	No	92	104			1	25 days
24.9.20	Telephonic assessment		Nil	95	98	40	55	22	0	7	0	12	No	93	102			0	24days

Patient has been followed up subsequently for every 10 days during hospitalizationand follow up at 25 days interval post discharge as post COVID outpatient and one another follow up through telephone. All parameters in the assessment form are taken into account and serial evaluation is done at each follow up and the results revealed considerable improvement in single breath count, breath holding time and 6 minutes' walk endurance. Hence significant category shift has been noted in each follow up visit with promising clinical outcome which improved our hope and reliability on the treatment program which we followed.

Patient is still under follow up to address any other post COVID consequences hindering to interfere with the progression of maintaining the functional potential gained back and to enhance the endurance and lung functions further.

It took 3 months in this case to return to near normal pre morbid status from the time of post-acute respiratory distress /category shift from 4 to 0 as per the formulated protocol.

7. Summary

The probability of rehabilitating a post-acute COVID patient is being performed on a structured rehab program basis, which showed stepladder objective and subjective sense of improvement reflected by the respiratory, endurance parameters measured prior to and post rehabilitation, subjective quality of life questionnaire and strengthened the thoughts of our physiatrist's role in rehabilitation of post-acute COVID patients.

8. Discussion

This first index case of atypical recovery in the post-acute COVID phase definitely created way for the lateral thinking and application of pulmonary rehabilitation program in a comprehensive and customized manner with dosage and duration of exercises gradually increased, consistent with the impairment and the functional capacity level of the patient, which gave us an insight to the integrated rehabilitation idea and prompted us to frame the protocol for categorization.

Since there are no prima facie scientific evidence for the therapeutic breathing exercises available, we decided to bring out our own rehabilitation program with possible relatable pathophysiological modifications happening that shall act as a potential adjuvant for early recovery.

Table 5: Probable pathophysiology of COVID 19 and the justification for the proposed mechanics of breathing and endurance rehabilitation plan prescribed category wise

Category	*Probable pathophysiology*	*Proposed mechanics of breathing and endurance rehab plan*
0	Established adaptive host immune response and raise in specific neutralizing antibody titers->healing[9]	Intercostal and alveolar expansion, regain functional independence with endurance training
1	Systemic inflammatory response begins to decrease->cellular adaptation [7]	Reverse atelectasis and good breathing control achieved.
		Peripheral muscles can effectively made to utilize oxygen by aerobic training
		To reduce pulmonary and functional impairment
2	Virus infected apoptotic epithelial cells can be phagocytosed by dendritic cells and macrophages or actions of the immune system (i.e., cytotoxic T cells), damage to the lung tissue there can lead to rapid turn-over of the epithelium [6] and hence gradual decrease in viral load, organizing phase with loose organizing fibrosis within alveolar septa and type 2 pneumocyte hyperplasia	Increase vital capacity and inspiratory lung capacity and deep inspiration enhances oxygen inflow across alveolar membrane and enhances alveolar permeability To reduce pulmonary and functional impairment
3	Resolving inflammatory exudative phase with oedema of alveoli, hyaline membrane and interstitium and decreased alveolar permeability	Distal airway expansion and clearance of large and small airways, suppresses cough

	Concurrent with signs of inflammation in the lungs, there is evidence of systemic modulation of the immune response [6]	
4	Ongoing lung parenchyma and alveolar injury and inflammatory response (diffuse alveolar damage) [5]	Exercise shall worsen hypoxemia

This created a pavement for planning of discharge from isolation ward and progressive weaning from oxygen supplementation and returning back to pre-morbid functional level.

9. Limitations

Due to the machine constraint and the difficulties involved due to safety precautions followed for COVID19, [since we have to use the same machine for non COVID patients also, being in government set up] the pulmonary function tests could not be done in this case at present, which will be dealt in future while we do rehabilitate the forthcoming patients of same scenario.

10. Conclusion

This journey to pulmonary rehabilitation logically and practically acquainted with the help of published scientific evidences and literatures reduced the fear of the patient being dependent to supplemental oxygen and reassuring in a far better way to perform their pre morbid level of functions, without compromising their ADL and IADL activities in an energy conserving way by incorporating the METS activities according to the level of possible physical functioning and oxygen saturation.
The clinical and quality of life outcome

Table 6: Quality of life assessment tool-St George Quality of life Respiratory Questionnaire

Sections assessed	*Pre- Rehabilitation score*	*Post rehabilitation score*
1. Over the past 3 months, I have had shortness of breath	Most days a week	Few days in a month
2. During the past 3 months how many severe or very unpleasant attacks of chest trouble have you had?	One attack	No attack
3. How long did the worst attack of chest trouble last?	A week or more	No
4. Over the past 3 months, in an average week, how many good days (with little chest trouble) have you had?	No good day	Nearly every day is good
5.How would you describe your chest condition?	The most important problem I have	Causes me a few problems
6.If you have ever had paid employment.	My chest trouble made me stop work altogether	My chest trouble made me change my work
Questions about what activities usually make you feel breathless these days.		
Sitting or lying still	True	False
Getting washed or dressed	True	False
Walking around the home	True	False
Walking outside on the level	True	False
Walking up a flight of stairs	True	False
Some more questions about your cough and breathlessness these days.		
I get exhausted easily	True	False
These are questions about how your activities might be affected by your breathing.		
I take a long time to get washed or dressed	True	False
I cannot take a bath or shower, or I take a long time	True	False
Jobs such as housework take a long time, or I have to stop for rests	True	False
We would like to know how your chest usually affects your daily life.		
I cannot go out for entertainment or recreation	True	False
I cannot go out of the house to do the shopping	True	False
I cannot do housework	True	False
I cannot move far from my bed or chair	True	False
Maintaining a conversation while walking	Not possible	Possible

measures clearly reflects the gradual serial improvements in return of respiratory and physical functioning ability.

Table 7: Clinical outcome variables studied prior to and post rehabilitation intervention;

Outcome variable	*Pre-Rehabilitation*	*Post Rehabilitation*
Incentive spirometry	Insp-2 balls	Insp-2 balls
	Exp-2 balls	Exp-3 balls
FIM score	93/126	126/126
Barthel index	55	100
Chest expansion	1 cm	4 cm
Respiratory rate	26	22
Modified Borg scale of dyspnea at rest	1	0
Borg scale of rate of perceived exertion	9	7
Sit to stand	6	14
Single breath count	13	40
Dyspneic index	1	0
Breath holding time	26 seconds	55 seconds
Oxygen saturation at rest without oxygen	88%	95%
6 minutes' walk distance	185 meters	405 meters

The process of framing a customized rehabilitation protocol and categorizing the post-acute COVID patients based on their oxygen saturation and the respiratory and endurance parameters enabled us ,probably the first of its kind in Pulmonary Rehabilitation protocols to expand our PMR services in post COVID outpatient and inpatient set up came into limelight from the positive hope gained from the success of rehabilitation of this case and our Rehabilitation protocol hopes to be the pioneer effort in the PMR view of pulmonary rehabilitation in categorizing the patients based on their oxygen saturation levels for effective customized rehabilitation plan.

What we already know

The pathophysiology in restrictive lung diseases like other viral pneumonias and the pattern of healing that has occurred in MERS, H1N1 outbreaks which lead to complicated pulmonary fibrosis, ananticipated restrictive lung disease sequela shall may be more disabling consequence the individual has to face to move on with daily routine of life along with the disease per se.

What we learnt

For rehabilitating the patient, the knowledge of natural history, disease progression and the pathophysiological mechanisms that are damaging the lung alveoli and the recovery pattern of healing in COVID pneumonia definitely helps a lot in corroborating with the clinical, radiological findings according to the phases of infectivity. The concept of customized Pulmonary rehabilitation has emerged out to play a significant role especially for the COVID 19 survivors to ease the road to faster recovery in a scientific evidence-basedmanner, with proper follow up and addressing the post COVID illness/complications expected. This will cause a productive effect in building up the respiratory and peripheral endurance and effective utilization of the available oxygen, with appropriate energy conservation techniques.

11. Future Scope

This index case of post COVID rehabilitation paved way for us to implement the strategy of customized pulmonary rehabilitation in a coherent manner in the subset of post COVID 19 survivors for whom the chances of progression of tailored rehabilitation needs progressing to disability as a result of the acquired pulmonary and functional impairments, is considered and will be planned and executed soon

Though the long-term consequences of COVID-19 are not fully understood, we know that the impact of an ICU stay for acute respiratory distress syndrome (ARDS) has a significant impact on physical function. There is a need for further research aroundsequelae of COVID-19 and the long-term impact it may have on individuals.

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Appendix-1

Modified Borg Dyspnea Scale (at rest)

- 0 Nothing at all;
- 0.5 Very, very slight (just noticeable);
- 1 Very slight; 2 Slight;
- 3 Moderate;
- 4 Somewhat severe;
- 5 Severe;
- 6 7 Very severe;
- 8 9 Very, very severe;
- 10-almost maximal

Appendix-2

Borg Rating of Perceived Exertion (RPE)

- 6-7 Very, very light
- 8-9 Very light
- 10-11 Fairly light
- 12-13 Somewhat hard
- 14-15 Hard
- 16-17 Very hard
- 18-19 Very, very hard
- 20-Almost maximal

Appendix-3
Dyspnea index

- Levels of shortness of breath (SOB)
- 0—No SOB; can count to 15 (takes about 8 seconds) without taking a breath in the sequence.
- 1—Mild SOB; can count to 15 but must take one short breath in the sequence.
- 2—Moderate SOB; need to take 2 breaths to count to 15 in the sequence.
- 3—Definite SOB; must take 3 breaths in the sequence of counting to 15.
- 4—Severe SOB; unable to count or speak.

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