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Case Report

Incorporating Respiratory Muscle Strengthening into a Physical Therapy Program for an Adult with Pneumonia and Respiratory Failure: A Case Report

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Abstract

Background and Purpose

Short Term Physical Therapy (PT) at the inpatient sub-acute level often focuses on returning patients home at their highest functional level. Patients who have had an ICU admission and use of non-invasive mechanical ventilation (NIMV) for pneumonia and respiratory failure may benefit from incorporating respiratory muscle strengthening exercises into functional training to maximize their PT outcome. The purpose of this case study is to demonstrate the integration of respiratory strengthening exercises into the PT plan of care of an individual previously hospitalized with pneumonia and respiratory failure.

Case Description

A 56-year-old male presented to the Emergency Room with shortness of breath and generalized weakness. He was diagnosed with pneumonia and acute hypoxic respiratory failure. After 10 days in the hospital, he was transferred to a Skilled Nursing Facility (SNF) for rehabilitation on 13L of supplemental oxygen and in a severely weakened state.

Intervention

Mr. X received 3 weeks of PT working on improving overall strength and endurance, functional mobility, and eventually respiratory muscle strength.

Outcomes

Initially, Mr. X was unable to complete a 6-Minute Walk Test, walking only 1.5m (5 feet) with a rolling walker and physical assistance from the PT. He required 13L of oxygen to maintain SpO_2 at 90%. After 3 weeks of PT, he completed a 6-Minute Walk Test scoring 656 meters without supplemental O_2 maintaining SpO_2 in 94-98% range.

Discussion

With little published literature on this subject, this case highlights potential benefits of incorporating respiratory muscle strengthening exercises as part of a comprehensive PT program. Further research to determine whether PT's should look beyond traditional red flags and PT interventions for similar patients would be beneficial.

Keywords: Pneumonia; Respiratory Failure; Respiratory Muscle Strengthening Exercises

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Introduction

Community-acquired pneumonia (CAP) is responsible for 1.1 million hospitalizations in the United States with an average length of stay for acute hospitalization for being 5.2 days [1]. CAP causes approximately 50,000 deaths per year in the adult population alone [2]. Acute respiratory failure (ARF) is a complication which can arise if CAP is not treated effectively or in a timely fashion. ARF is estimated to affect 430 per 100,000 patients each year [3]. Complications such as ARF are most commonly observed in patients who have other serious medical conditions such as diabetes or compromised immune systems [4]. Guidelines for the management of CAP for patients with ARF include admission to the ICU, supplemental oxygen therapy, and often ventilator support [3,5]. Patients admitted to the ICU who are treated with non- invasive mechanical ventilation (NIMV) show fewer complications and have better outcomes with shorter stays in the ICU than those who receive invasive mechanical ventilation [3, 6,7]. Mortality for patients admitted to the ICU who receive mechanical ventilation is higher than for patients diagnosed with CAP in earlier stages who may be treated at home or on a regular hospital floor [5]. In addition, patients with a prolonged ICU stay often develop ICU acquired weakness (ICUAW) which has been shown to contribute to functional disability, including profound neuromuscular weakness, and decreased quality of life for survivors [8-10]. PT aimed at early mobilization in the ICU has been shown to decrease the risk of ICUAW, improve outcomes, and decrease costs associated with care in the ICU [8-10]. However, there are limited studies looking at the effects of continued Physical Therapy post-ICU stay and even fewer that look at continued respiratory muscle weakness or training in those patients and the effect it has on their outcome [11-13]. Those studies do not, however, address the scenario described here. The following case chronicles sub-acute PT management of an individual after ICU admission for CAP with ARF. Ongoing reassessment of effectiveness of a PT program aimed primarily at functional training led to the addition of respiratory muscle specific exercises to enhance endurance and functional outcome.

Case Description

History

Mr. X is a 56 year-old male who presented to the Emergency Room at a community hospital in June of 2014 with the chief complaint of shortness of breath and generalized weakness. He was found to be hypotensive, hypoxic, and had a large right-sided pulmonary infiltrate by imaging. After an extensive workup in the ICU, it was determined that the infiltrate was due to CAP and because of his oxygen requirements (SpO_2 on 2L supplemental oxygen via nasal mask was 70%), he was diagnosed with acute hypoxic respiratory failure. He was admitted to the ICU and placed on Vapotherm - a non-invasive high-flow mechanical respiratory support system delivered by nasal cannula used to treat ARF that has been shown to improve oxygenation in hypoxic patients [14]. Mr. X had history of lung cancer and underwent right upper lobectomy in 2009. There was concern initially that the infiltrate noted on imaging could be the return of lung cancer but this was ruled out by the medical team. After 8 days in the ICU, Mr. X was transferred to a medical floor on high-flow oxygen at 15L and was subsequently transferred to a skilled nursing facility (SNF) for short-term rehabilitation 11 days after admission to the hospital. He received no physical therapy in the acute care hospital and was only assisted from the bed to the chair for short periods of time once out of the ICU. Upon admission to the SNF Mr. X was evaluated by Physical Therapy. Per both the participant and his wife, he had "a lot of medical problems." In speaking with them about their concerns, they reported he is in remission from lung cancer after having surgery, chemotherapy, and radiation in 2009. They also report that he had poor balance prior to this hospitalization and, due to a history of falls, primarily used a manual wheelchair pushed by his wife when out of his house. He would use a rolling walker (RW) when ambulating short distances in his home - a small single level house with no steps inside or out. The participant states he was often tired and weak and his wife reports he "napped frequently." His wife was his primary caretaker and helped him with transfers, ambulation, and ADL's. He had a daughter in high school but did not feel comfortable asking her for help. There were no other supports. He tells the PT that he quit smoking just prior to this illness and that he had used alcohol and heroin in the past but has not used either for "some time." He is a war veteran and was diagnosed with PTSD, which he feels is responsible for his many medical problems. They report he had no history of using supplemental oxygen at home, not even after his lobectomy in 2009. A medical chart review and review of systems was also completed by PT and findings are as noted in Table 1. Medications Mr. X was receiving upon admission are noted in Table 2.

Presenting Concerns

Mr. X has a complicated medical history. His prior level of function indicates that there may be other processes going on that are yet undiagnosed such as COPD or a neurological disorder that is affecting his overall muscle strength and respiratory muscle strength. As well, his PTSD seems to have been limiting his function prior to this illness as his wife reports he needed encouragement to perform ADL tasks. He had a prolonged ICU stay without early mobilization and is in a severely weakened state. He will need extensive strengthening and endurance training. Although he has some anxiety about Physical Therapy, he is motivated to participate and to ultimately return home.

Table 1. Medical Chart Review and Review of Systems.

Past Medical History:	Review of Systems
Lung Cancer with lobectomy	Cognition: Alert and oriented to person, place, time, and situation
Diabetes	BP: 140/86
Hepatitis C	Heart Rate: 76, normal rhythm
PTSD	Respiratory Rate: 20
Prior Alcohol/heroin/nicotine additions	SpO_2: 90% on 13L O_2
Alcohol-related cerebellar ataxia	Lung Sounds: Diminished on right with slight crackles noted bilateral bases
Restless leg syndrome	Dyspnea: Mild while carrying on a conversation
Hypertension	Edema: None noted
Hypokalemia	Sensation: Intact to light touch
Gout Concussion due to motor vehicle accident 2013 Chronic Back Pain	Other: Patient reports his hands always feel cold and that he feels "weak all over." He is noted to have tremors of both distal upper extremities both at rest and during motion and general muscle wasting.

Table 2. Medications.

Name	Indication for use (per medical chart)
Albuterol	Respiratory
Wellbutrin SR	PTSD
Clonazepam	PTSD and Restless leg syndrome
Gabapentin	Chronic Back Pain
Prednisone	Respiratory
Zoloft	PTSD
Prilosec	No indication noted in chart
Trazodone	PTSD
Spiriva	Respiratory
Advair	Respiratory
Acetominophen	Pain and fever
O_2 continuous high flow at 13-15L/min	Maintain SpO_2 about 89%
Intravenous levofloxacin and vancomycin were completed in hospital	Pneumonia

Examination

Mr. X was first examined in bed with the head of the bed elevated approximately 75 degrees and was on 13L of oxygen via nasal cannula. He spoke slowly and had a soft, weak voice. He became dyspneic during conversation, occasionally requiring a break to catch his breath. It was noted that he had poor use of his diaphragm with decreased expansion of his lower thorax during inspiration and that he was using mostly accessory muscles when trying to catch his breath. His color was normal and skin appeared dry. Active range of motion of all extremities was within normal limits in the supine position. When asked to sit up over the edge of the bed, he required maximal assistance (see Table 3). Initially he was unable to sit unsupported, requiring maximal assistance from the PT to maintain upright sitting balance over the edge of the bed. He was able to maintain his balance for 2 minutes with only supervision and UE support. He was unable to maintain sitting without support from his upper extremities for any amount of time. He was noted to have increased dyspnea while in an upright sitting position. When asked to stand, Mr. X required maximal assistance from the PT to push off the bed [raised to a higher position as Mr. X was 1.93 meters (6 feet, 4 inches) tall] and come to a fully upright position.

Table 3. Definitions of Levels of Assistance.

Level of Assistance	Definition
Complete Independence	All of the task described as making up the activity are typically performed safely, without modification, assistive devices, or aids, and within a reasonable time; no assistance required. Performs activity safely alone and feels secure.
Modified Independence	One or more of the following may be true: the activity requires an assistive device; the activity takes more than reasonable time, or there are safety considerations; not manual assistance/helper required.
Supervision	Patient requires no more than standby, cueing or coaxing, without physical contact, or someone is needed to set up needed items or apply orthoses; requires supervision and/or verbal cues to complete activity (may not always be done safely or correctly.)
Contact Guard	A variation on minimal assist where patient requires occasional contact to maintain balance or dynamic stability; requires hand contact because of occasional loss of balance (protective safeguard).
Minimal Assistance	Patient requires small amount of help to accomplish activity; patient requires no more help than touching, and expends 75% or more of the effort. Patient is able to assume all of his body weight, but requires guidance for initiation, balance, and/or stability during the activity.
Moderate Assistance	Patient requires more help than touching; expends half (50%) or more (up to 75%) of the effort. Patient is able to assume part of his body weight in initiating and performing the activity.
Maximal Assistance	Patient contributes little or nothing toward execution of activity; patient expends less than 50% of the effort, but at least 25%.
Total Assistance	Patient lacks the necessary strength or mental capability to perform any part of the activity or performance is impractical; patient expends less than 25% of the effort. Patient is unable to safely initiate and/or perform any part of the activity on his own.

He was unable to remain standing without maximal assistance from the PT and support of the RW and was only able to maintain this position for 45 seconds before becoming dyspneic and needing to sit, requiring maximal assistance and verbal cueing to use his UE's. Stand pivot transfers from the bed to his wheelchair and standing from the wheelchair required maximal assistance. Once standing, he was only able to walk 1.5 meters (5 feet) with the RW and maximal assistance from the PT. Gait was noted to be ataxic and he ambulated with a wide base of support, taking small steps due to decreased stance phase bilaterally. He had moderate dyspnea after walking the 1.5 meters. He required frequent rest periods during the examination and instruction and demonstration by the PT for diaphragmatic and pursed lip breathing throughout the examination. His SpO_2 remained at 90% on 13L oxygen. Mr. X was unable to tolerate a 6MWT or any other formal functional assessment testing.

Evaluation

Mr. X required maximal assistance to perform all transfers and was unable to ambulate without maximal assistance or greater than 1.5 meters. He demonstrated severe dyspnea on exertion (DOE) and use of accessory muscles during breathing - in particular sternocleidomastoid, pectoralis muscles, and trapezius - with poor use of his diaphragm and intercostals. He had difficulty performing diaphragmatic and pursed lip breathing even with verbal and visual instruction.

Taking into consideration Mr. X's medical diagnoses, prolonged ICU stay without mobilization, and data collected from PT evaluation, Mr. X may be classified into the following PT practice patterns: 1) impaired aerobic capacity/endurance associated with deconditioning and, 2) impaired ventilation and respiration/gas exchange associated with respiratory failure [15]. In order for him to return home, he would require PT to improve strength, endurance, and functional mobility. He would benefit from a PT program of general strengthening, transfer training, gait training, balance training, and require monitoring of SpO_2 during all interventions. His poor endurance and poor respiratory muscle control with inability to perform diaphragmatic and pursed lip breathing correctly may make weaning from oxygen difficult and require PT to factor in rest periods to his treatment sessions. The Six Minute Walk Test (6MWT) - a submaximal test of aerobic capacity/endurance and is often used as a valid and reliable measure for patients with respiratory diagnoses - will be used as an indication of progress and as an outcome measure. The Minimal Detectible Change (MDC) score at 90% confidence interval for the 6MWT is 66.3 m [16-18]. In order to assess dyspnea, the Modified Borg Scale (MBS) will be used during PT sessions and during the 6MWT. The MBS has been proven to be a valid tool for the assessment of dyspnea in patients with respiratory diagnoses and the recommended minimally clinically important difference (MCID) is 1-unit [16,19-21]. Mr. X received PT twice a day, 5 days per week for an hour to an hour and a half total. Re-evaluation was every 7 days.

Table 4. Summary of Progress.

	Initial	End of Week 1	*End of Week 2	Week 3 - D/C
Transfers	Maximal assist	Mimimal to Moderate assist	Contact Guard	Modified Independence
Ambulation/6MWT time	1.5m/-	7.6m/2 min	365.7m/6 min	656m/6 min
Rests Required	-	4 (standing)	3 (standing)	0
Reason for Stopping Test Early	Dyspnea/weakness	Dyspnea	Completed	Completed
Assistance (RW also used)	Maximal assist	Minimal to Moderate assist	Contact Guard	Modified Independence
MBS Rating	Not Assessed	5	3-4	2
Supplemental Oxygen	13L	10L	5L	None
Resting SpO_2	90%	93%	94%	98%
SpO_2 after 6MWT	83%	87%	90%	94%
SpO_2 5 minutes post 6MWT	89%	93%	94%	98%

*Respiratory Muscle Strengthening Incorporated at the beginning of Week 2

Interventions (See Table 4 for additional data)

Week One: PT initially focused on general muscle strengthening starting with supine and seated therapeutic exercises for both upper and lower extremities and trunk in straight planes (sagittal and coronal), initially without weights then progressing slowly to use of weights, starting with a 1/2 pound and gradually increasing weight to tolerance. Transfer training also progressed smoothly working on sit to stand activities from both a raised exercise mat and chair focusing on eccentric and concentric contraction of the quadriceps and hamstring muscles. Trunk strengthening exercises were combined with balance activities and initially performed seated progressing to standing. Activities included reaching out of base of support in both sagittal and coronal planes as well as trunk rotation. Mr. X often had difficulty with diaphragmatic and pursed lip recovery breathing requiring verbal, visual, and tactile cues during exercise and when resting. SpO_2 was monitored during exercise and remained in the low 90's on 13 L. At the end of week one, he was able to maintain static standing balance with the use of his RW with contact guard from the PT for two minutes and partially complete a 6MWT (see Table 4). He was unable to carry on a conversation at the end of the test. It took over five minutes his SpO_2 to return to 93% and for the dyspnea to subside to an MBS rating of 1 (very slight). He was severely fatigued and discouraged.

Week Two: Of concern to PT was that although Mr. X was progressing with general strength and static balance, he was not progressing with endurance to ambulation and other functional activities such as ADL's with OT. He continued to become severely dyspneic during these activities with SpO_2 frequently dropping to low 80's on 13 L of supplemental oxygen requiring long rest periods. Although not the primary focus of Mr. X's treatment plan, diaphragmatic and pursed lip breathing exercises were being performed more as a way to recover from dyspnea than to strengthen respiratory musculature. It was decided to look at adding respiratory strengthening exercises to his PT plan of care. A review of the literature was done to see if there was some way to assist Mr. X with his continued breathing difficulties and low endurance. A case study by Chang A et al showed that inspiratory muscle training in addition to a standard physical therapy protocol can be beneficial for patients who have had an ICU stay with prolonged mechanical ventilation [22]. A study by Tout R et al in which patients with COPD who had diaphragmatic muscle training in conjunction with a standard PT protocol showed that respiratory muscle training is beneficial [23]. Another study looking at the use of inspiratory muscle training (IMT) combined with expiratory muscle training (EMT) showed that the use of IMT and IMT plus EMT were both beneficial to increase respiratory muscle strength [24]. Mr. X did not technically have COPD but had a history of lobectomy. No literature was found specifically describing the scenario of CAP with ARF after lobectomy and whether or not respiratory muscle training would help. It was decided that respiratory muscle training may be beneficial and was added to his treatment plan since there was literature proving that it was beneficial in patients who had had a prolonged ICU stay and in patients with other similar respiratory diagnoses who experienced persistent DOE.

Mr. X was started with simple diaphragmatic breathing exercises in supine with the goals of reducing dyspnea, normalizing his breathing pattern, and decreasing the work of breathing [25]. Diaphragmatic breathing exercises were started in supine with the head of the bed elevated approximately 45 degrees. Using both verbal instruction and demonstration by the PT, he was instructed to place one hand over his diaphragm approximately 1 inch above the umbilicus and the other hand on the center of his chest. He was then instructed to breathe normally and try to feel the pattern of his breathing – when each hand would rise and lower. Once he was able to feel the pattern he was asked to "elevate" the hand over his diaphragm when he inhaled and to "lower" when he exhaled while at the same time trying to keep the hand over his chest from moving excessively. Mr. X had a great deal of difficulty with this and it took 3 separate sessions of PT for him to begin to do it correctly. Once he was able to perform this exercise in supine it was started in sitting and progressed to unsupported sitting and then standing and finally being able to use the diaphragmatic breathing pattern during ambulation and ADL's over the course of two weeks.

Segmental breathing exercises were also initiated, focusing on the lower lobes with the goal to augment lung expansion and ultimately improve strength, endurance and efficiency of the respiratory system [25]. To perform these exercises, the participant was first given a demonstration by the PT using another PT as a "patient." The therapist placed her hands over the lower lateral costal areas bilaterally. The participant was instructed to take a deep breath, breathing into the therapist's hands. Once maximal inspiration was reached, the participant was instructed to hold his breath for two seconds then forcefully exhale. The exhalation was assisted by gentle force from the PT's hands. The individual was then told to inspire and resistance was applied to the lower lateral costal area by the PT. The resistance was gradually lessened toward the end of full inspiration. This was repeated 3-5 times as tolerated then he was allowed to rest before repeating for a total of 3 cycles every PT session. Over a week, this exercise became progressively easier for Mr. X and he was able to complete 5 repetitions for each cycle. Mr. X was also given an inspiratory muscle resistive training device to use on his own after initial training by the PT. He used this two times a day for 15 minutes for the last two weeks of PT with the goal of increasing strength and endurance of respiratory muscles [25].

Outcome

At the end of the third week, marked improvement was noted in the participant's endurance evidenced by less dyspnea during functional tasks and increased distance with ambulation. At the end of his PT (a total of three weeks with the last 2 having incorporated breathing exercises) Mr. X was able to complete a 6MWT using a RW without oxygen. He was discharged home three weeks after his admission to SNF walking independently with a RW. He was also able to walk up and down 6 steps using railings for support – something he had not been able to do prior to this spell of illness.

Discussion

The addition of respiratory muscle strengthening exercises seemed to enhance Mr. X's PT program. This was observed as improved respiratory function not only during functional mobility, but the individual developed a stronger voice and his overall outlook became more positive as he was able to perform tasks without becoming dyspneic. In addition, the 6MWT showed that there was a clinically significant change in Mr. X's function from initial (7.6m) to final performance of test (656 meters) (MDC = 66.3m) and his MBS rating went from 5 (severe dyspnea) to 2 (slight dyspnea) (MCID = 1 unit) [17,18, 21]. Prior to adding these exercises, progress was noted in *musculoskeletal strength* but not in *endurance* - mostly contributed to the dyspnea that he was experiencing. This was discouraging to Mr. X – he did not feel he was making progress.

We know that classical mechanical ventilation can result in diaphragm weakness. NIMV is shown to have fewer complications but there is no research indicating whether or not weakened respiratory muscles may result from its use. Mr. X had not had invasive mechanical ventilation, which may have been a more obvious flag to the PT indicating the need for the addition of respiratory muscle exercises. It was assumed that since Mr. X had not had *invasive* mechanical ventilation, there would not be significant respiratory muscle weakness that would interfere with his rehabilitation. However, there were signs initially that may have been red flags indicating respiratory muscle weakness may be present – either due to NIVN, ICUAW, or the absence of early mobilization in the ICU. The individual was on high flow O2 at 13 L, had severe dyspnea on exertion, and difficulty performing diaphragmatic breathing. He also had a low functional level prior to his admission to the hospital.

Should these have alerted the PT that Mr. X may have respiratory muscle weakness and that the initial focus of his rehabilitation should have been respiratory muscle training? In reviewing literature to answer this question, one study that was found was by Berry M and Morris P and entitled *Early exercise rehabilitation of muscle weakness in acute respiratory failure patients.* The PT focus in this study was solely on skeletal muscle weakness and strengthening - there is no mention of respiratory muscle strengthening exercises [26].No literature was found discussing respiratory muscle weakness or the use of respiratory muscle strengthening exercises after NIMV. It would be beneficial to have future clinical studies that look at patients post ICU stay who have had NIMV to determine if expanding the red flag list for the possibility of respiratory muscle weakness related to NIMV would be warranted and to see if there is a true correlation between the addition of respiratory strengthening exercises to a PT plan of care versus a more traditional course of sub-acute PT in these patients.

Conflict of Interest

Author declares no conflict of interest or sources of funding.

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