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Effect of 4-Week Pulmonary Rehabilitation on Dyspnea, Fatigue, Quality of Life and Radiological Findings in a Patient with Pulmonary Renal Syndrome Suffering from Pneumonia - A Case Study

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ABSTRACT

Background: Pulmonary renal syndrome (PRS) is a rare, autoimmune disease, defined as combination of pulmonary symptoms (cough, chest pain and dyspnea- at acute stage) and rapidly progressive glomerulonephritis. Pneumonia is an inflammatory condition caused by infectious agents leading to fever, cough and shortness of breath. We report a case of a 42 years old female suffering from PRS and recently diagnosed with bacterial pneumonia. Medically she was managed through antibacterial and oral corticosteroids. At initial encounter of pneumonia, she was in intensive care unit and had cough, dyspnea, pyrexia and fatigue with oxygen saturation (SpO_2) of 94% on 15 liters of oxygen via non rebreathable mask. Her chest x-ray demonstrated lobar pneumonia involving right upper lobe. Even after the resolution of pneumonia, she had fatigue, dyspnea and baseline SpO_2 of 90-92% on room air. Thus, all the above traits were treated by pulmonary rehabilitation.

Purpose: To study the effect of tailor-made pulmonary rehabilitation in pneumonia along with PRS.
Method: Physiotherapy was divided into 2 phases: (1) Acute phase: chest physiotherapy (breathing exercises, nebulization, bronchial hygiene, percussion and vibration) (2) Subacute and Late phase: dyspnea management, energy conservation techniques, early mobilization, exercise training (aerobic and strength)
Result: 4 weeks of pulmonary rehabilitation resulted in significant improvement in radiological finding, St. George's respiratory questionnaire (85.39 to 15.53), SpO_2 at room air (90% to 99%), Modified Medical Research council score (4 to 1), fatigue severity scale (43 to 21) with an improved inspiratory capacity measured by incentive spirometer.
Conclusion: Pulmonary rehabilitation is a structured and multifaceted approach which improves respiratory function, enhance physical fitness, reduces fatigue and the length of hospital stay, prevent recurrence and optimize overall quality of life. Our findings underscore the pivotal role of pulmonary rehabilitation in the treatment of

pneumonia alongside Pulmonary Renal Syndrome.

Keywords: pulmonary rehabilitation, pneumonia, pulmonary renal syndrome

INTRODUCTION

Pulmonary- renal syndrome (PRS) is a rare, autoimmune disease, defined as combination of pulmonary symptoms such as cough, chest pain and dyspnea- at acute stage, Diffuse alveolar hemorrhage (DAH)- at chronic stage along with rapidly progressive glomerulonephritis.[1] Coughing up blood, known as hemoptysis, is the predominant symptom of Diffuse Alveolar Hemorrhage (DAH), although it may not be present in as many as 30% of cases.[1] Acute kidney injury can often be detected through initial serum biochemistry upon admission, and its diagnostic value is enhanced when accompanied by an active urinary sediment. While proteinuria is more frequently observed than hematuria, the presence of both in urinalysis suggests glomerular membrane injury due to glomerulonephritis.[2] PRS is Commonly caused by Antineutrophil cytoplasmic antibodies (ANCA) positive small vessel vasculitis, ANCA-negative vasculitis, anti-glomerular basement membrane disease, and Systemic Lupus Erythematosus. Pulmonary involvement occurs in 30-50% of cases whereas renal involvement extends to over 95% of cases.[1,2]

Pneumonia, an inflammatory lung condition, is primarily instigated by bacteria but can also stem from viruses, fungi, parasites, and various infectious agents. It stands as the foremost cause of mortality among infectious diseases. Symptoms of pneumonia may include fever, coughing, breathlessness, and chest discomfort. In certain instances, pneumonia can lead to the buildup of mucus and fluids within the lungs, complicating the breathing process. [3] Physiotherapy interventions for pneumonia focus on enhancing lung function, facilitating effective breathing, and preventing or addressing complications that may arise from extended periods of immobility when the patient is at critical care unit. [3]

CASE REPORT

We present the case of a 42-year-old female diagnosed with pulmonary-renal syndrome (PRS) and pauci-immune crescentic glomerulonephritis (P-ANCA associated), for which she had been receiving immunosuppressants for the past year. She was recently diagnosed with bacterial pneumonia caused by *Klebsiella pneumoniae*. Medically, she received treatment involving antibacterial agents and oral corticosteroids for pneumonia. During that period, her renal urine output was reduced, indicating overload, which was addressed by undergoing three sessions of dialysis per week via a triple-lumen catheter.

During the initial encounter with pneumonia, she was admitted to the intensive care unit and presented with symptoms including cough with expectoration (whitish secretion), dyspnea, fever, and fatigue. Her oxygen saturation (SpO2) level was recorded 72% on room air, prompting a transfer to a non-rebreather mask where her SpO2 improved to 94% with 15 Liters of oxygen flow. A chest X-ray revealed lobar pneumonia affecting the right upper lobe. The St. George's Respiratory Questionnaire (SGRQ) yielded a score of 85.39, indicating the patient's respiratory health status. The Modified Medical Research Council score (MMRC) was recorded as 4, reflecting the severity of breathlessness experienced by the patient. Additionally, the Fatigue Severity Scale (FSS) returned a score of 43, indicating the level of fatigue experienced by the patient. Medications and chest physiotherapy were given accordingly for pneumonia. Even after the resolution of pneumonia, she had fatigue, dyspnea and baseline SpO2 of 90-92% on room air. Thus, all the above traits were treated by pulmonary rehabilitation.

INTERVENTIONS

Physiotherapy was divided into 2 phases: (1) In acute phase (To treat pneumonia) - chest physiotherapy (breathing exercises, nebulization, bronchial hygiene, percussion and vibration) (2) In Subacute and Late phase (After resolution of pneumonia): dyspnea management, energy conservation techniques, early mobilization, exercise training (aerobic and strength). Summary of protocol is mentioned in ***table 1***

Table 1. Summary of Interventions

TIME	GOAL	INTERVENTION
Week 1 ***Admission in ICU***	To reduce dyspnea	• Diaphragmatic breathing exercise, pursed lip breathing • Dyspnoea relieving positions • Functional activates including 1-2 METS
	Airway clearance	• Nebulization • Active cycle of breathing technique • Positioning left lateral • Percussion and vibrations were added after the resolution of fever
	Improve chest expansion	• Segmental breathing exercises • Thoracic mobility exercises • Incentive spirometry • Postural correction exercise
	Maintain range of motion	• Active range of motion exercises for all joints (free exercises)
	Bed mobility and ambulation	• Upright positioning and ambulation • Up till 3-4 METS
Week 2 ***Shifted to Wards***	*IN ADDITION TO PREVIOUS TREATMENT*	
	Dyspnea Management	• Energy conservation techniques • Dyspnea relieving positions • Breathing retraining • Stretching of accessory muscles of respiration
	Exercise Training	1. WARM UP • General slow paced free range of motion exercises 2. PHYSICAL CONDITIONING PHASE • **Resistance exercise** of bilateral upper and lower limb with 500 grams of mechanical weight. • **Frequency**- 5 days a week • **Intensity**- up to 5 METS/Modified Borg's Scale of 3 • **Time**- 30-40 mins (with 1-2 breaks in between) • **Type** - Muscle Performance → Strength → 10 repetitions and 2 sets - Endurance Performance → Walking of 10 minutes - Initiation of stair climbing (10-15 stairs) 3. COOL DOWN PHASE • Static stretching of major muscles and low repetitions free exercises
Week 3 ***Dyspnea and Hypoxia after the resolution of pneumonia***	*IN ADDITION TO PREVIOUS TREATMENT*	
	Exercise Training	1. PHYSICAL CONDITIONING PHASE • **Resistance exercise** of bilateral upper and lower limb with 500 grams of mechanical weight. • **Frequency**- 5 days a week • **Intensity**- up to 6 METS/Modified Borg's Scale of 4 • **Time**- 40-50 mins (with 1-2 breaks in between) • **Type** -Muscle Performance →Strength →20 repetitions & 3 sets -Endurance Performance → Walking of 20 minutes - Stair climbing 20-25 stairs *All Exercises Were Performed in With Pursed Lip Breathing Coordinated Movements.*

Week 4 ***Fatigue***	*IN ADDITION TO PREVIOUS TREATMENT*	
	Exercise Training	1. PHYSICAL CONDITIONING PHASE • **Resistance exercise** of bilateral upper and lower limb with 1 kilogram of mechanical weight. • **Frequency**- 5 days a week • **Intensity**- up to 7 METS/Modified Borg's Scale of 5 • **Time**- 50-60 mins (with 1-2 breaks in between) • **Type** - Muscle Performance → Strength → 20 repetitions & 3 sets - Endurance Performance →Walking of 30 minutes - Stair climbing 20-25 stairs *All Exercises Were Performed in With Pursed Lip Breathing Coordinated Movements*

FIGURE 1: Nebulization with ACBT

FIGURE 2: Incentive spirometry

FIGURE 3: Aerobic training

FIGURE 4: Strength training

RESULT

By the end of the fourth week, the patient demonstrated notable improvements across various measures. Specifically, the St. George's Respiratory Questionnaire score showed a significant improvement, dropping from 85.39 initially to 15.53. Oxygen saturation, which started at 72% on room air, increased substantially to 99% following rehabilitation efforts. Additionally, the Modified Medical Research Council (MMRC) score improved from 4 to 1, indicating reduction in dyspnoea. The Fatigue Severity Scale score also exhibited improvement, decreasing from 43 to 21. Furthermore, there was a remarkable increase in inspiratory capacity, measured by incentive spirometer, rising from 600cc/s to 1200cc/s. Notably, radiological findings also demonstrated improvement, reflecting the overall positive response to pulmonary rehabilitation intervention.

Table 2: St. George's Respiratory Questionnaire (SGRQ)		
Score	Week 1	Week 4
Total	85.39	15.53
Impact	78.78	6.64
Activity	92.03	92.03
Symptoms	96.56	26.85

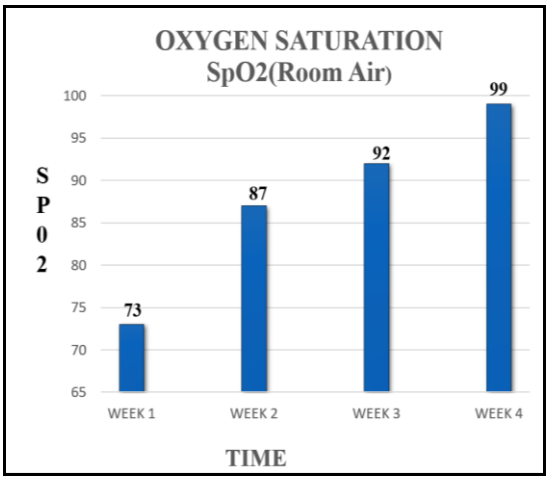

FIGURE 5: graph illustrating progression of Spo2 at room air

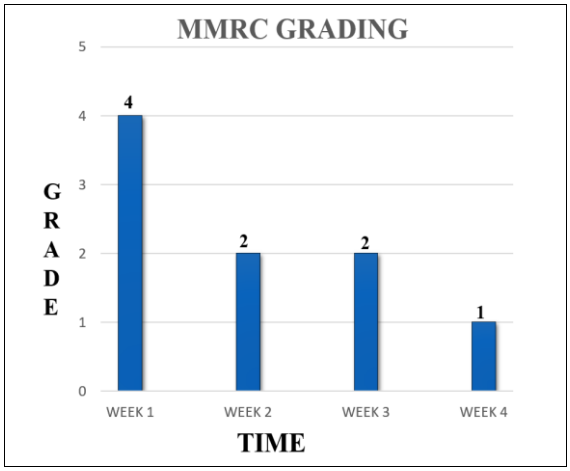

FIGURE 6: graph illustrating progression of MMRC grading

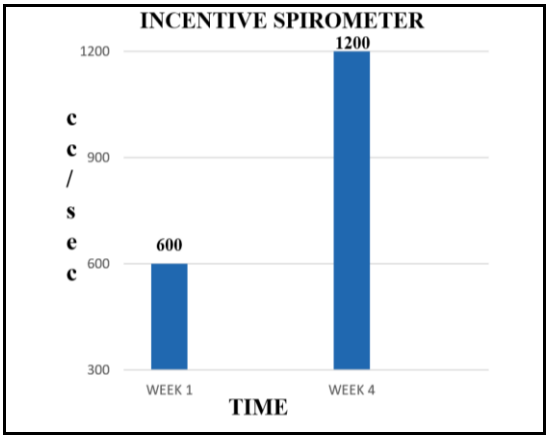

FIGURE 7: graph illustrating progression of incentive spirometer

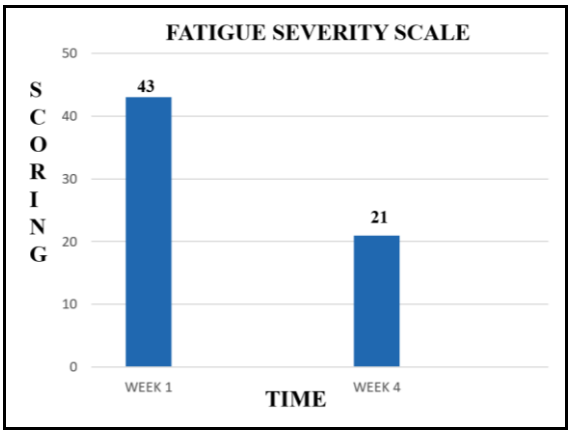

FIGURE 8: graph illustrating progression of fatigue severity scale

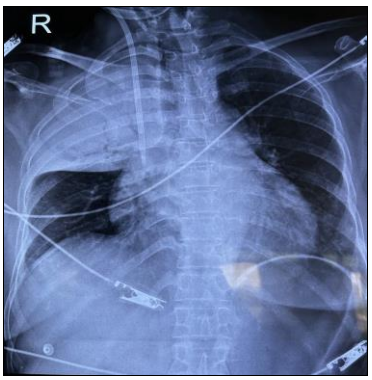

FIGURE 9: Chest X-ray suggestive of right upper lobar pneumonia (Day-1)

FIGURE 10: Chest X-ray suggestive of regression of pneumonia (Day-4)

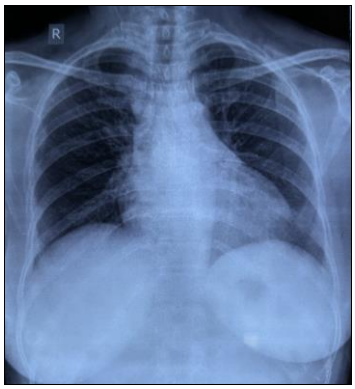

FIGURE 11: Chest X-ray suggestive of resolution of pneumonia (After 2) weeks)

DISCUSSION

Deconditioning, respiratory impairment, and particularly muscle weakness plays crucial role in the diminished functional status observed following critical infectious diseases like pneumonia during stays in the intensive care unit (Hermans G, et.al).[3]

Optimal physiological functioning depends on the upright body position, so bed rest and limited mobility during critical illness result in profound physical deconditioning which can be exacerbated by inflammation and pharmacological agents, such as immunosuppressants, corticosteroids, neuromuscular blockers and antibiotics (Dittmer DK, et.al).[4]

In patients diagnosed with fibrotic nonspecific interstitial pneumonia (f-NSIP), there was a frequent observation of reduced maximal expiratory pressure (PEmax) and quadriceps force (QF). Significantly, QF emerged as the leading factor impacting exercise capacity, highlighting the prevalence of quadriceps muscle weakness and its connection to exercise limitations in f-NSIP patients. Additionally, around half of the patients experienced desaturation during exertion, potentially due to hypoxia-induced oxidative stress that could impair muscle performance and consequently affect exercise capacity. The inflammatory nature of NSIP, marked by the infiltration of inflammatory cells in lung interstitium, is thought to contribute to quadriceps weakness. Lower peripheral muscle strength is also associated with lower quality of life and higher levels of fatigue. Furthermore, deconditioning stemming from limitations in daily activities may also contribute to impaired quadriceps muscle function (Fumiko Watanabe et.al, 2013).[5]

Currently, there is limited literature available on pulmonary renal syndrome and its early-stage management with physiotherapy. Pulmonary renal syndrome itself can manifest with symptoms such as dyspnea, coughing, and fatigue. [1,2] Despite the resolution of pneumonia, the patient may continue to experience intense symptoms of dyspnea and fatigue. There could be several reasons for this persistence. Firstly, the underlying pulmonary renal syndrome may contribute to ongoing respiratory symptoms. Secondly, residual lung damage or scarring from the pneumonia could lead to persistent respiratory difficulties.[3] Additionally, renal impairment associated with pulmonary renal syndrome can also contribute to fatigue and overall reduced functional capacity. Lastly, psychological factors such as anxiety or depression resulting from the illness experience may also exacerbate symptoms of dyspnea and fatigue.

The study conducted by Anderson José et.al (2016),[6] demonstrates the beneficial effects of inpatient rehabilitation on patients with community-acquired pneumonia. highlighting that participation in rehabilitation programs leads to improvements in various aspects including functional capacity, peripheral muscle strength, and overall quality of life among pneumonia patients. These findings underscore the importance of incorporating rehabilitation interventions as part of the comprehensive management of community-acquired pneumonia to enhance patient outcomes and recovery.

LIMITATION

The study presents limitations that suggest avenues for further research. Firstly, being a single case study, its generalizability may be limited. To address this, future investigations could employ a randomized controlled trial methodology with a larger and more diverse sample size. This would provide more robust evidence regarding the effectiveness of pulmonary rehabilitation in patients with pneumonia and Pulmonary Renal Syndrome.

Moreover, the nutritional status of the patient was not accounted for during pulmonary rehabilitation, despite its known significance in overall health and recovery. Integrating nutritional assessments and interventions into future rehabilitation protocols could offer a more comprehensive approach to patient care. By addressing both

pulmonary function and nutritional needs, these efforts may potentially enhance treatment outcomes and promote sustained wellness in affected individuals.

CONCLUSION

Our findings emphasize pulmonary rehabilitation as a crucial part in treating pneumonia alongside Pulmonary Renal Syndrome, notably improving various aspects such as exercise tolerance, radiological findings, dyspnea, ability to perform routine activities of daily living (ADLs), fatigue, and muscle strength, endurance, and mass. Furthermore, it reduces the length of hospital stay and prevents recurrence. These results underscore the importance of integrating pulmonary rehabilitation into treatment plans, offering sustained and comprehensive benefits for patients with this condition, thereby enhancing both their short-term and long-term outcomes.

FOLLOW-UP

The patient was re-evaluated and re-educated for home-based exercises with self-monitoring methods. Additionally, she was advised to follow up regularly in the physiotherapy department with each follow-up consultation in the nephrology department of the institute.

Declaration by Authors

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