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The role of early respiratory rehabilitation in the management of acute exacerbations of chronic obstructive pulmonary disease (COPD)

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Abstract: Background: Chronic Obstructive Pulmonary Disease (COPD) is characterized by persistent respiratory symptoms and airflow limitation. Acute exacerbations significantly impair lung function and increase the risk of hospitalization and mortality.
Methods: This case report describes a 66-year-old female patient with GOLD 2023 Group E COPD, admitted to the University Hospital in Cracow due to an acute exacerbation triggered by human metapneumovirus infection. Standard pharmacological therapy was initiated, followed by a 10-day program of individualized respiratory rehabilitation. The rehabilitation interventions included bronchodilator and hypertonic saline nebulization, oscillating positive expiratory pressure (OPEP), gravity-assisted drainage, vibratory massage, and the Active Cycle of Breathing Techniques (ACBT). In addition, limb muscle training using a bedside ergometer was implemented. The rehabilitation began on the second day of hospitalization and was conducted twice daily.
Results: Significant clinical improvements were observed: the patient reported reduced dyspnea (Borg scale decreased from 5 to 2), increased FEV_1 (from 30% to improved post-rehabilitation values), and an extended distance in the six-minute walk test (+80 meters), with no exertional desaturation. Inflammatory markers returned to normal. The patient was discharged with recommendations for continued home-based rehabilitation.
Conclusions: This case illustrates that early implementation of comprehensive respiratory physiotherapy during COPD exacerbation can result in functional improvement and symptom relief. These findings align with current evidence supporting the benefits of early pulmonary rehabilitation in reducing the impact of exacerbations and improving quality of life in patients with COPD.

Keywords: COPD, exacerbation, respiratory rehabilitation, physiotherapy, OPEP, ACBT.

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Introduction

Chronic obstructive pulmonary disease (COPD), as defined by the Global Initiative for Chronic Obstructive Disease (GOLD), is a heterogeneous condition characterized by persistent respiratory symptoms — such as dyspnea, cough, increased sputum production and recurrent exacerbations, resulting from chronic airway and/or alveolar abnormalities. The underlying pathological processes including chronic bronchitis, bronchiolitis and emphysema contribute to a progressive and usually irreversible limitation of airflow [1].

COPD develops as a result of lifelong interaction between genetic predisposition and environmental exposures. While smoking remains the predominant risk factor, although air pollution, occupational exposure, and abnormal lung development in early life are significant as well [1].

The diagnosis of COPD is based on the interpretation of spirometry results and the patient's clinical presentation. The basic diagnostic criterion is the presence of persistent airflow limitation in the airways, expressed as a FEV_1/FVC ratio <0.7 (>5th percentile or SR > –1.645) after administration of a bronchodilator [1]. The assessment of disease severity is not limited to FEV_1 values alone. GOLD recommends a system based on the analysis of clinical symptoms of dyspnea (e.g., mMRC, CAT) and the assessment of the risk of exacerbations [1], which is important in individual therapeutic management, i.e., the personalization of treatment.

In 2023 (GOLD guidelines), patients were divided into three categories: A, B, and E (Exacerbation), based on symptom severity and risk of exacerbations, which was maintained in the 2025 report. Each group was recommended appropriate treatment and possible further modifications depending on the clinical response, number of exacerbations, and level of eosinophilia in peripheral blood [1].

A COPD exacerbation, defined as a sudden worsening of symptoms (e.g., shortness of breath, cough, increase and/or change in sputum character), lasting less than 14 days and requiring a change in treatment [1], leads to a deterioration in lung function, an increased risk of hospitalization, and even death.

Treatment of exacerbations includes pharmacological and non-pharmacological methods. Respiratory physiotherapy is very important in the treatment of exacerbations of chronic obstructive pulmonary disease (COPD) because it improves patients' functional and mental state and increases their quality of life.

Case description

A 66-year-old female patient, a long-term ex smoker (25 pack-years), diagnosed with chronic obstructive pulmonary disease, category E, was admitted to the Pulmonology Department of the University Hospital in Cracow on an urgent basis from the Hospital Emergency Department due to exacerbation of COPD symptoms.

The patient's medical history included two exacerbations of COPD in the last year. The first was treated on an outpatient basis and required an increase in the doses of bronchodilators in nebulization and systemic steroids (methylprednisolone at an initial dose of 32 mg). The second exacerbation required hospitalization and was accompanied by respiratory failure (January 2025). The patient remains under the care of the local pulmonology clinic. In addition, the patient was diagnosed with hypertension, an incidentally detected focal lesion of the left adrenal gland (during diagnosis), gallbladder stones, and depressive disorders.

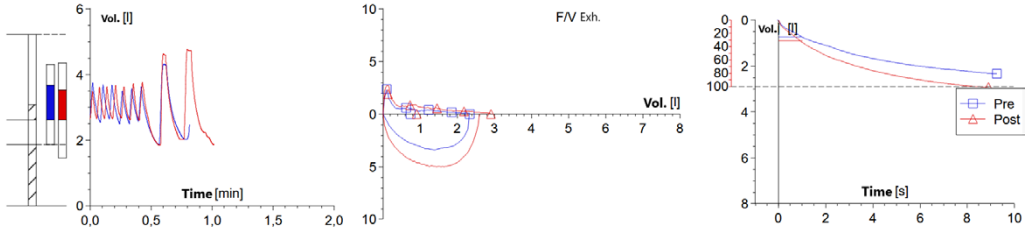
Upon admission to the clinic, the patient reported worsening shortness of breath for 3 days, which initially took the form of exertional dyspnea and then also at rest. The severity of dyspnea was assessed as grade 5 on the Borg scale. The symptoms were accompanied by worsening cough with large amounts of sputum and fever up to 39°C in the last 2 days.

Upon admission to the ward, the patient was in fair general condition and respiratory efficient. Physical examination revealed signs of severe obturation over the lung fields. Laboratory tests showed elevated inflammation parameters (CRP 31.40 mg/l) and high D-dimer levels (2.3 mg/l). No significant deviations from normal parameters were found in the other tests.

Genetic material of human metapneumovirus was detected in a respiratory panel performed on a nasopharyngeal swab. Due to the positive D-dimer result and symptoms of shortness of breath, a contrast-enhanced chest CT angiogram was performed. The CT scan did not reveal the presence of embolic material in the pulmonary arteries or fresh infiltrative changes in the lungs.

During her stay in the ward, she received typical treatment for COPD exacerbation, including systemic steroid therapy, bronchodilators, and thromboprophylaxis.

After initial clinical improvement, the patient underwent spirometry, which revealed a persistent severe obturation in the airways (GOLD 2023) with an FEV_1 of 30% predicted (Z-score: –4.27) and a positive response to bronchodilator inhalation (Fig. 1).



Parameter	Unit	Pred.	1	%(1/Pred.)	P_1	SR	2	%(2/Pred.)	P_2	SR_2	% Change
VC MAX	L	3,13	2,46	79%	8,66	-1,38	2,91	93%	31,02	-0,46	14%
IC	L	2,12	1,7	80%	0		2	94%	0		14%
ERV	L	0,75	0,77	102%	100		0,9	121%	100		18%
VT	L	0,48	1,08	222%	100		0,92	192%	100		-30%
BF	1/min	20	12,9	65%	0		15,56	78%	0		13%
IRV	L		0,64				1,08				
FEV 1	L	2,45	0,74	30%	0,05	-4,27	0,91	37%	0,1	-3,88	7%
FEF 25	L/s	5,31	0,56	11%	0,25	-3,52	0,83	16%	0,35	-3,32	5%
FEF 50	L/s	2,13	0,35	16%	1	-3,32	0,57	27%	1,74	-2,68	10%
FEF 75	L/s	0,57	0,19	32%	4,51	-1,91	0,26	46%	7,85	-1,35	13%
MFEF 75/25	L/s	2,13	0,32	15%	0,93	-3,41	0,45	21%	1,3	-2,99	6%
PEF	L/s	6,05	2,38	39%	0,1	-4,07	1,92	32%	0,04	-4,58	-8%
FVC	L	3,13	2,33	74%	5,61	-1,66	2,91	93%	31,02	-0,46	18%
FEV1 % FVC	%	78,7	31,59	40%	0	-4,66	31,26	40%	0	-4,68	0%
FEV1 % VC MAX	%	78,7	29,89	38%	0	-4,75	31,26	40%	0	-4,68	2%
FVC IN	L	2,87	2,3	80%	9,02	-1,36	2,59	90%	24,43	-0,66	10%
VC MAX	L	3,13	2,46	79%	8,66	-1,38	2,91	93%	31,02	-0,46	14%
FIV1 % VC MAX	%		92.81								
FEF 50 % FVC	%		14.81				19,48				
FIF 50	L/s		3,29				4,99				
FET	s		9,23				8,65				
FET PEF	s		0,04				0,05				
FEV1	L		2,29								
FIV1 % FVC	%		99,3								
MIF	L/s		0,84				0,74				

Fig. 1. Spirometry result with bronchodilator reversibility test — comparison of flow-volume curves before and after bronchodilator inhalation.

A six-minute walk test was also performed, during which the patient covered a distance of 280 meters. A drop in oxygen saturation to 86% was observed during exertion.

A significant therapeutic intervention in the patient's treatment was the use of an individual rehabilitation program based on the most effective, recommended physiotherapy methods [2].

The following techniques and methods were used in the patient:

1. Nebulization — two sessions of pneumatic nebulization for bronchial tree drainage procedures. A nozzle was used to break the drug down into 5 μm particles and an inspiratory valve was used to control the peak inspiratory flow so that it was optimal for proper drug deposition:
   a) 30 minutes before drainage, nebulization was performed with a bronchodilator that was best tolerated by the patient, in this case Ventolin at a dose of 2 ml for 10 minutes of nebulisation.
   b) The next nebulization had a mucolytic effect and was performed just before drainage with hypertonic NaCl 3%, the highest dose tolerated by the patient (recommended concentration from 3% to 10%). Nebulization time was 15 minutes to clear the bronchial tree.

The patient was instructed on the correct position during nebulization, the benefits of using a mouthpiece, and proper breathing during the procedure [3].

2. Oscillating vibration massage and prone position. During exercises with the PipeP® (Positive Inspiratory Positive Expiratory Pressure) device, the patient was placed in a gravitational drainage position. In this case, the patient was placed on her right side with a pillow under her hips and her head on a pillow. This position was maintained for 10 minutes on each side. While lying down, gravity was used to move secretions from the lower to the upper respiratory tract. At the same time, exercises were performed on the PipeP® device (described above) and superficial massage was performed in the areas above the shoulder blade, between the shoulder blades, and under the shoulder blade, using a "VIBRAX-MEDEX®" device. High-frequency mechanical oscillations and vibrations were used to help thin and loosen secretions and relax tired respiratory muscles. Clinical experience shows that this technique is very well tolerated by patients as it allows them to relax, loosen their muscles, regulate their breathing, mobilize secretions, and prepare for more intensive treatments. After 10 minutes in the left lateral position, the patient was repositioned to a sitting position with her legs down on a chair with a backrest, and the Active Cycle of Breathing Technique (ACBT) described below was performed. After effective expectoration of secretions, postural and vibration drainage was performed while lying on the left side, and the ACBT technique was performed again [4].
3. The method of applying positive expiratory pressure (OPEP) and positive expiratory pressure (PEP) during ACBT. The results of most scientific studies indicate the positive effects of using the ACBT technique during COPD exacerbations to mobilize and evacuate mucus [5]. This method consists of four stages and is performed in a sitting position on a chair with a backrest so that the neck and shoulder girdle are relaxed and the diaphragm can work freely:
   a) Controlled breathing — consists of free diaphragmatic breathing to stabilize vital signs and prepare the patient for more intense work in the next stage.
   b) Deep breathing (expansive thoracic exercises) — slow, deep breathing that expands the chest walls, helping to mobilize secretions and detach them from the bronchial walls. It can also be performed with a PEP/OPEP device with high resistance.
   c) Huffing (FET, forced expiratory technique) — rapid expulsion of as much air as possible through the open mouth, a tube, or OPEP/PEP equipment if a diagnosed of airway collapse during coughing has been made.

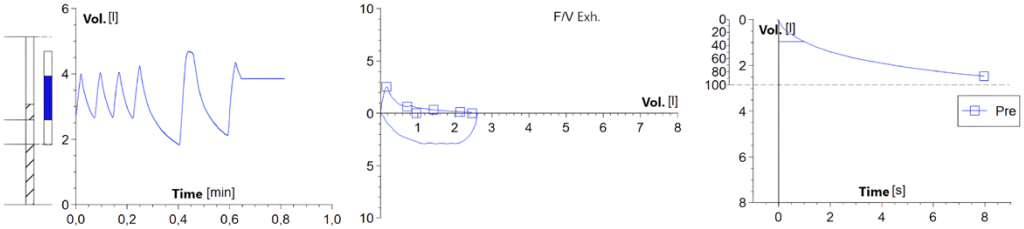
d) Effective coughing — if secretions are audible at the beginning of exhalation, it is recommended to use the coughing technique with an OPEP/PEP device or through an open mouth, depending on the patient's diagnosis. The technique should not be repeated more than 2–3 times, as it is very invasive and may lead to a deterioration of respiratory parameters. Regular use of this technique can contribute to better lung ventilation and less mucus retention, which will translate into a reduction in the number of exacerbations in the future [6]. During drainage, a device generating positive pressure in the airways was used to prevent the closure of the bronchi and trachea during rapid exhalations and to maintain the widest possible lumen of the upper airways, which facilitates the movement of secretions. In addition, intra-bronchial vibrations generated by air oscillations in the device help to detach and move secretions towards the throat. A PipeP® device, belonging to the "respiratory muscles exerciser" group, was used to generate positive pressure in the airways without vibrations. At the beginning, a yellow valve was selected for exhalation resistance (selection based on the patient's feelings). Approximately 18 exhalations were performed through the valve in the following sequence: 3 repetitions with deep inhalation and long exhalation, followed by 3 with shallow inhalation and prolonged exhalation in 3 series. The resistance should be felt by the patient, but it must not be too great so that the patient does not generate pressures greater than 35 cm H2O, which can be controlled with a manometer [6]. The patient performed this breathing exercise lying on her side to facilitate the movement of secretions to the main bronchi through the positioning.

Aerobika® (OPEP) was used during the final phase of drainage, when secretions were audible at the beginning of exhalation. The patient was instructed to blow into the device at the beginning with high resistance (5 on the device scale) for about 5 exhalations, and then the resistance was changed to a lower level (2 on the device scale) in order to increase the exhalation volume, which facilitates the movement of secretions from the trachea to the throat and their evacuation. The patient was allowed to cough into the OPEP device.

The above exercises were performed in a sitting position [5].

4. Lower and upper limb muscle training: In order to increase the muscle strength of the lower and upper limbs, resistance exercises were performed using the Thera-Trainer BEMO® bedside rotor. The patient was instructed to ride a cycle ergometer in a supine position for 20 minutes, with well-tolerated resistance. Oxygen saturation SpO2 (above 92%) and heart rate (below or equal to 50% HRmax) were monitored throughout the exercises. Diaphragmatic breathing was recommended during the exercises. The patient was instructed in advance on how to check if she was breathing correctly [7].

All of the above techniques and drainage methods were used twice a day — in the morning in the presence of a physical therapist, and in the afternoon independently by the patient. Lower and upper limb training on a cycle ergometer was used once a day until noon, and in the afternoon, a 20-minute walk in the corridor was recommended. The above techniques were used from the second day of hospitalization and lasted for 10 days. After the physiotherapy treatments, the patient had significantly less sputum, did not report shortness of breath according to the Borg Scale (at admission it was rated as 5-severe, at discharge as 2-mild) and chest heaviness. The FEV_1 bronchial obturation index improved significantly (Fig. 2), and the 6MWT distance was 80 meters longer with saturation (SpO2) during the test not falling below 92%. Inflammatory parameters decreased, and the patient was discharged home with physiotherapy recommendations.



Parameter	Unit	Pred.	Best	%(Best/Pred.)	Perc.	SR
VC MAX	L	3,09	2,86	93 %	30,94	-0,46
IC	L	2,08	2,08	100 %	100	
ERV	L	0,75	0,78	104 %	100	
VT	L	0,49	1,35	278 %	100	
BF	1/min	20	12,14	61 %	0	
IRV	L		0,74			
FEV 1	L	2,41	0,97	40 %	0,14	-3,71
FEF 25	l/s	5,28	0,74	14 %	0,33	-3,36
FEF 50	l/s	2,11	0,41	20 %	1,2	-3,09
FEF 75	l/s	0,56	0,21	36 %	5,34	-1,72
MEF 75/25	l/s	2,11	0,38	18 %	1,1	-3,19
PEF	l/s	5,99	2,52	42 %	0,14	-3,86
FVC	L	3,09	2,46	80 %	9,73	-1,3
FEV 1 % FVC	%	78,73	39,22	50 %	0,01	-4,18
FEV 1 % VC MAX	%	78,73	33,73	43 %	0	-4,53
FVC IN	L	2,83	2,56	91 %	25,46	-0,63
VC MAX	L	3,09	2,86	93 %	30,94	-0,46
FIV 1 % VC MAX	%		85,29			
FEF 50 % FVC	%		16,72			
FIF 50	l/s		2,86			
FET	s		8			
FET PEF	s		0,06			
FIV 1	L		2,44			
FIV 1 % FVC	%		95,29			
MIF	l/s		1,19			
PIF	l/s		2,93			
Measurement date			08.12.2023			
Measurement time			10:54			

Fig. 2. Result of baseline spirometry after treatment and rehabilitation.

Discussion

In the presented case study, the patient was admitted to the hospital due to exacerbation of chronic obstructive pulmonary disease (COPD) caused by a viral infection, accompanied by profuse, retained bronchial secretions. The implementation of early respiratory physiotherapy brought

measurable clinical benefits, including improved exercise tolerance and reduced subjective dyspnea severity. The program used, which included breathing training, general fitness exercises, and education, is consistent with current (GOLD) recommendations for the management of COPD exacerbations.

Available meta-analyses indicate that early rehabilitation contributes to improved functional parameters and a reduced risk of rehospitalization. A systematic review of 18 randomized clinical trials (Meneses-Echavez *et al.*, 2023) provided evidence of a reduction in the frequency of readmissions to hospital and an improvement in exercise tolerance in patients undergoing rehabilitation during COPD exacerbations. The impact on quality of life and dyspnea severity was assessed as highly likely, although interpretation was hampered by the heterogeneity of protocols and the limited quality of some of the analyses [8].

Similar conclusions are presented in earlier studies, including Cochrane reviews and the work of Zeng *et al.* (2024), which confirm the validity of implementing comprehensive rehabilitation already during hospitalization. Among other things, a significant increase in distance in the 6MWT, a reduction in dyspnea, and an increase in muscle strength were demonstrated [9, 10]. The case described confirms these observations — beneficial effects were noted after a few days of intervention.

The correct qualification of patients and the individualization of the physiotherapy program, taking into account the clinical condition and the patient's ability to exert effort, are of key importance. The aim of the treatment is to achieve a level of fitness that allows the patient to move independently, maintain muscle mass, and be independent in hygiene activities. Therefore, during hospitalization, the emphasis is placed on activities of daily living, such as walking in the corridor, using the toilet, or climbing stairs. Some meta-analyses reported a higher risk of adverse events, but this was related to programs that were not adapted to the current cardiorespiratory fitness of patients.

In the case described, rehabilitation began on the second day of hospitalization. Even simple, appropriately selected physiotherapy interventions brought measurable clinical benefits, including an increase in the distance in the 6MWT and a reduction in shortness of breath. A meta-analysis by Lu *et al.* (2023), including 12 studies involving 876 hospitalized patients with COPD exacerbation, confirmed that starting rehabilitation within ≤7 days of admission significantly improves 6MWT results, reduces the severity of dyspnea on the mMRC scale, and is not associated with complications [11]. These results, consistent with our clinical experience, indicate that early physiotherapy should be the standard of care even in the acute exacerbation phase and improves patients' quality of life.

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Conflict of interest

None declared.

Author's contributions

B.Ż. and K.P. conceived the study and wrote the manuscript. J.R. prepared the figures and verified the technical accuracy. K.S. revised the manuscript. All authors approved the final version.

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