Scholastic Medical Sciences (ISSN: 3139-7352) Case Report

Volume 3 Issue 11 November 2026

Postoperative pulmonary rehabilitation following lobectomy for intralobar pulmonary sequestration in an adult: A Case Report with 12-month follow-up

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Received: October 14, 2026**; Published:** October 20, 2026

Abstract

Pulmonary sequestration is a rare congenital lung malformation that may remain undiagnosed until adulthood. We describe functional recovery during structured postoperative rehabilitation following right lower lobectomy for intralobar pulmonary sequestration. A 33-year-old woman with recurrent respiratory infections underwent lobectomy in February 2024 and subsequently completed 20 outpatient physiotherapy sessions combining thoracic and shoulder mobility exercises, breathing exercises, progressive strengthening, and cycle-ergometer training. Clinical assessments were performed before rehabilitation, after 10 and 20 sessions, and at 1, 6, and 12 months after completion. Six-minute walk distance increased from 415 m at baseline to 490 m after 20 sessions and 565 m at 12-month follow-up. Right shoulder abduction increased from 150° to 180°, while pain, fatigue, and physical and mental component scores of the SF-12 improved. Activities-of-daily-living indices remained unchanged. No adverse events occurred during treatment, and no new pulmonary infections were documented during follow-up. This case describes the feasibility of individualized rehabilitation and longitudinal functional improvement after surgery for a rare pulmonary condition. The specific contribution of physiotherapy cannot be distinguished from postoperative recovery in a single uncontrolled case.

Keywords: Pulmonary sequestration; Pulmonary rehabilitation; Lobectomy; Exercise therapy; Case report.

Background

Pulmonary sequestration is a rare anomaly in the spectrum of congenital bronchopulmonary malformations, characterized by a mass of non-functioning lung tissue that receives its blood supply from a systemic artery and is separated from the normal tracheobronchial tree [1, 2]. This sequestered tissue can be extra lobar (14%-25%), usually diagnosed within the first six months of life, or intralobar (75%-86%), which generally comes to medical attention at an older age [3].

Although pulmonary sequestration can be asymptomatic, it may present with recurrent respiratory infections, chronic cough, and respiratory symptoms. Surgical resection is commonly considered in symptomatic cases to treat the affected lung tissue and limit recurrent complications [1, 3].

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Pulmonary rehabilitation has been studied extensively in chronic respiratory disease, including chronic obstructive pulmonary disease, and exercise-based rehabilitation has also been investigated in patients with lung cancer and following lung resection [4–6].

Pulmonary rehabilitation encompasses individualized interventions intended to improve physical function, symptoms, and participation in daily activities. Multidisciplinary care and respiratory muscle training may be relevant components depending on individual patient needs [7, 8].

Components of rehabilitation following thoracic surgery can include breathing exercises, upper-limb and thoracic mobility, muscle strengthening, and progressive aerobic exercise. Selection and progression of these interventions should be guided by postoperative impairments and exercise tolerance [9, 10].

This report describes clinical decision-making and functional outcomes through 12 months of follow-up during and after structured outpatient physiotherapy following right lower lobectomy for intralobar pulmonary sequestration in an adult. It aims to document the clinical course in an area with limited condition-specific rehabilitation evidence, rather than to establish treatment efficacy.

Case Presentation

Written in accordance with the CARE guidelines [11], this case report describes the diagnostic, surgical, and postoperative rehabilitation course of a 33-year-old woman with intralobar pulmonary sequestration who was followed by physiotherapists at Poliambulatorio San Felice (ASL Roma 2).

Written informed consent for publication of this case report was obtained from the patient on March 12, 2024, before the outpatient physiotherapy program began.

The patient was a 33-year-old woman (168 cm; 48 kg) who worked as a teacher. She reported smoking approximately five cigarettes per day for 15 years, occasional alcohol use, and regular physical activity twice weekly. She reported no family history of respiratory disease, lung cancer, or rheumatological disorders. Her medical history included bilateral breast augmentation in 2013 and corrective surgery for strabismus in childhood. She had experienced recurrent right-sided lower respiratory tract infections since early childhood and was referred after diagnosis of intralobar pulmonary sequestration and right lower lobectomy.

At 1 year old, the patient was hospitalized for 15 days for right basal pneumonia with parenchymal consolidation and a subsequent hospitalization about a year later. She reported recurrent respiratory infections in childhood, with stability until age 26. Since then, she had about 2 bronchial exacerbations per year and complained of morning cough with mucous expectoration.

In 2022, she was hospitalized in day hospital, presenting a 2021 chest X-ray that showed pseudo-round radiolucent areas suggestive of possible bronchial cystic ectasia.

In September and November 2023, she was hospitalized twice for lower right pneumonia and intercostal pain at the level of the right fifth rib, which began at night. On these occasions, the following diagnostic tests were performed:Chest HRCT: showed multiple coarse cystic air spaces involving the entire middle and lower right lobes;

- Pulmonary scintigraphy: revealed hypoperfusion of the right lung compared to the contralateral side (left lung 63%, right lung 37%);
- ECG with cardiology consult: within normal limits;
- Transthoracic echocardiogram: ejection fraction (EF) of 60% and systolic pulmonary arterial pressure (PAPs) 25 mmHg;
- Arterial blood gas analysis: pH 7.40; partial pressure of oxygen (pO2) 97 mmHg; partial pressure of carbon dioxide (pCO2) 39 mmHg; SpO2 99.4% in room air;
- Global spirometry with diffusion: (FVC 2.81 l $^{(69\%\ pr)}$, FEV1 2.24 l $^{(66\%\ pr)}$, IT $^{(79.6\%pr)}$, TLC 4.24 l $^{(80\%\ pr)}$, RV 1.43 l $^{(92\%\ pr)}$, DL'co 5.72 mmol/min*kPa $^{(74\%pr)}$);
- Six Minutes Walking Test (6MWT): walked 400 meters in room air without needing breaks (Initial BORG-M: 0, Final BORG-M: 3; Initial SpO2 98%, Final SpO2 97%).

Specialist physicians confirmed the diagnosis of cystic malformations with bronchiectasis features localized in the lower lobe of the right lung. These changes favoured airway infections and altered lung function, resulting in air trapping and reduced forced vital capacity.

(FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in the first second; IT: Tiffeneau index; TLC: Total Lung Capacity; RV: Residual Volume; DL'co: Diffusion Lung CO; BORG-M: Dyspnea assessment scale; SpO2: peripheral capillary oxygen saturation).

Surgical evaluation for resection of the affected lung area was recommended; the patient initially postponed surgery but later underwent right lower lobectomy and hilar-mediastinal lymphadenectomy on 01/02/2024.

The postoperative course was characterized by slow re-expansion of the lung parenchyma, requiring pleural drainage repositioning on 15/02/2024. She also underwent a further Talc Slurry procedure on 18/02/2024, which improved lung expansion.

The patient was discharged after 25 days of hospitalization with medical therapy to be performed at home and was referred for outpatient respiratory physiotherapy to improve chest expansion and physical performance, aiming to return to an age-appropriate lifestyle.

The timeline of the clinical and rehabilitation course is shown in Figure 1.

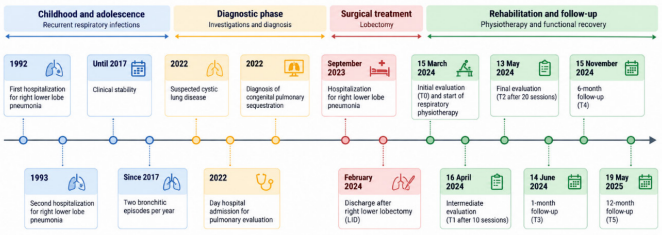


Figure 1: Timeline for the clinical and rehabilitation course.

Interventions and results

The patient began physiotherapy on March 15, 2024; the rehabilitation protocol is shown in Table 1. The progression of aerobic and therapeutic exercise loads was determined by the Rehabilitation Team based on heart rate, the degree of muscle fatigue, and dyspnoea reported by the patient. The patient performed aerobic activity at moderate intensity using a target of 70% of heart-rate reserve estimated with the Karvonen formula [12, 13].

Table 1: Rehabilitation Protocol.

Timing	**Short-term (10 sessions)**	**Medium-term (20 sessions)**	**Long-term (follow-up)**
Goal	Recovery of right upper limb ROM and strength Recovery of thoracic mobility Reconditioning to effort.	Recovery of right upper limb strength Training to effort	Return to activities of daily living
Sessions/week	3	3	2
Treatment	-Release of target intercostal and abdominal respiratory muscles. -Cervical, trapezius, SCM, and scalene "pompages". -Surgical wound mobilization. -Therapeutic exercise for right upper limb ROM; -Rib mobilization; -Deep breathing exercises and pursed-lip exhalation; -Reconditioning with progressive load on stationary bike (20'; Watts: 30-40); -Muscle strengthening with 1kgx2 weights and PVC stick; -5' cooldown and stretching.	-Training with progressive load on stationary bike (25'; Watts: 50-60). -Muscle strengthening with 2kgx2 weights and elastic band. -Surgical wound mobilization; -5' cooldown and stretching.	-Aerobic training. -Strength training

The theoretical maximum heart rate (HRmax) was calculated with the formula: HRmax = 220 − age (33 years), resulting in 187 bpm. The average resting heart rate (HRrest) recorded at initial assessments was about 73 bpm. Applying the Karvonen formula [(HRmax − HRrest) × %intensity + HRrest], and considering intensity as 0.7, a calculated target heart rate of approximately 153 bpm was determined, guiding aerobic activity intensity throughout the rehabilitation program.

On March 12, 2024, the patient underwent physiotherapy assessment (T0) using the following outcome measures:

- Range of Motion (ROM) using a goniometer;
- Medical Research Council (MRC) [14];
- Visual analog scale (VAS) [15];
- Health assessment questionnaire (HAQ) [16];
- Short form health survey (SF-12) [17, 18];
- Dyspnea assessment scale (BORG-M) [19] and Rate of Perceived Exertion (RPE) [20];
- Sit to Stand Test (STST) [21];
- Six Minutes Walking Test (6MWT) [22];
- Fatigue Severity Scale (FSS) [23];
- Activities of Daily Living (ADL) [24];
- Instrumental Activities of Daily Living (IADL) [25].

Objective examination revealed right-convex scoliosis with a COBB angle of 30°, flat back, limitation of abduction ROM of the right upper limb in the last degrees of movement (ROM: 150°) with pain during anterior and lateral elevation of the right upper limb (VAS: 3) Table 2. The patient was eupnoeic with respiratory rate (RR) 18. No bronchial secretions, normal transmission of tactile vocal fremitus, vesicular murmur present but significantly reduced in the right posterior-lateral basal area, hypoexpansion and asymmetry of the hemithoraces with less joint excursion in the right hemithorax. The patient reported moderate dyspnoea at rest and during exertion with high perception of fatigue (FSS 6).

At 6MWT at T0, she walked 415 meters with baseline SpO2 97% and NADIR 92%.

Control assessment was performed after 10 sessions (1 month of treatment: T1) and after 20 sessions, at the end of the rehabilitation program (2 months of treatment: T2). Follow-up was scheduled after 1 month (T3), 6 months after the end of the rehabilitation program (T4), and after 12 months (T5).

Across serial assessments, improvements were observed in walking distance, right shoulder abduction, selected symptom scores, and both components of the SF-12. ADL and IADL scores remained unchanged. All outcome measurements are presented descriptively in Table 2.

Regarding upper limb ROM, a total increase of 30° was observed from T0 to T5; in particular, the greatest increase occurred between T1 (160°) and T2 (180°), amounting to 20°; from T2 onwards, ROM remained stable at the maximum physiological level.

Table 2: *Outcome measures at different time points*

OUTCOME	T0	T1	T2	T3	T4	T5
ROM Abduction	150°	160°	180°	180°	180°	180°
MRC Deltoid (Anterior and lateral bundles)	3	3	4	4	4	5
MRC Trapezius (Upper bundle)	4	4	5	5	5	5
VAS	3	3	1	1	1	0
HAQ	32	23	8	5	4	4
PCS-12	29	36.6	50.5	54.3	55.5	56.2
MCS-12	36.7	44.2	50.8	52.8	54.8	55.4

30''-STST (reps)	10	10	12	15	16	17
6MWD (m)	415	460	490	519	525	565
BORG-M	4	2	1	0.5	0.5	0
RPE	8	7	7	7	6	6
FSS	6	4.2	3	2.1	1.4	1.1
ADL	6	6	6	6	6	6
IADL	8	8	8	8	8	8

Note: T0, baseline; T1, after 10 sessions; T2, after 20 sessions; T3, 3-month follow-up; T4, 6-month follow-up; T5, 12-month follow-up.

ROM, active range of motion of shoulder abduction, expressed in degrees (range 0–180°; higher values indicate greater mobility). MRC, Medical Research Council scale for muscle strength (range 0–5; higher scores indicate greater strength). VAS, Visual Analogue Scale for pain (range 0–10; higher scores indicate more severe pain). HAQ, Health Assessment Questionnaire, an 11-item questionnaire assessing the impact of the disease on activities of daily living; each item is scored from 0 (no problem) to 10 (severe problem) (total range 0–110; higher scores indicate greater impairment). Total scores of 0–30 indicate no need for rehabilitation, 31–80 indicate the need for rehabilitation monitoring, and >80 indicate the need for rehabilitation management. PCS-12 and MCS-12, Physical and Mental Component Summary scores of the 12-Item Short Form Health Survey (range 0–100; norm-based scores with a mean of 50 and a standard deviation of 10 in the general population; higher scores indicate better physical and mental health status). Borg, Borg Category-Ratio 10 scale for perceived dyspnea (range 0–10; higher scores indicate greater perceived dyspnea). FSS, Fatigue Severity Scale (range 9–63; higher scores indicate greater fatigue severity; scores ≥36 indicate clinically relevant fatigue). ADL, Katz Index of Independence in Activities of Daily Living (range 0–6; higher scores indicate greater independence). IADL, Lawton Instrumental Activities of Daily Living Scale (range 0–8; higher scores indicate greater independence).

ADL and IADL scores remained at the maximum value at all time points, indicating a ceiling effect.

At the end of the 20-session rehabilitation program (T2), six-minute walk distance had increased by 75 m compared with T0 (490 vs 415 m). This change exceeds minimal important differences of approximately 25–35 m reported in some chronic respiratory disease populations [24, 25], although those thresholds have not been validated specifically after surgery for pulmonary sequestration. Post-test SpO2 was 92% at T0 and 98% at T2, while post-test modified Borg dyspnoea scores decreased from 4 to 1 and post-test perceived exertion scores from 8 to 7. Fatigue Severity Scale scores decreased from 6 at T0 to 3 at T2 and 1.1 at T5. These findings describe the clinical course of one patient and should not be interpreted as evidence of a treatment effect.

The results are shown in Table 3.

Table 3: *6MWT results at different time points*

		PRE-TEST					POST-TEST				
6MWT	**Mt**	**BP**	**HR**	**SpO2**	**BORG**	**RPE**	**BP**	**HR**	**SpO2**	**BORG**	**RPE**
T0	415	100/60	73	97%	0	6	100/65	80	92%	4	8
T1	460	100/65	76	96%	0	6	100/65	74	97%	2	7
T2	490	100/65	80	96%	0	6	100/60	90	98%	1	7
T3	519	95/60	84	98%	0	7	100/60	95	98%	0.5	7
T4	525	100/60	73	98%	0	6	100/70	83	99%	0.5	6
T5	565	100/65	74	98%	0	6	110/70	80	98%	0	6

Note: BP, blood pressure (mmHg); HR, heart rate (beats/min); SpO_2, peripheral oxygen saturation (%); Borg-M, modified Borg scale for dyspnea (range 0–10; higher scores indicate greater dyspnea); RPE, rating of perceived exertion (Borg scale, range 6–20; higher scores indicate greater perceived exertion). All parameters were measured at rest before the test (pre-test) and immediately after its completion (post-test)

The results measured at 6MWT were compared with models in the literature by Enright [28], Chetta [29], and Gibbons [30], which, through their equations, allow the prediction of the distance covered in six minutes by healthy adults based on sex, age, height, and weight.

At successive assessments, the observed 6MWD approached the estimates derived from normative reference equations, although the predicted values differed appreciably among models. Table 4 presents these comparisons descriptively; the reference equations do not establish treatment effects or a validated postoperative normality threshold for this patient.

Table 4: *Actual and predicted 6MWT result*

6MWT	Meters walked	Predicted 1*	%*	Predicted 2**	%**	Predicted 3***	%***
T0	415	720.8	57.8	596.9	69.5	695.4	59.7
T1	460	720.8	63.8	596.9	77	695.4	66.1
T2	490	720.8	68	596.9	82.1	695.4	70.4
T3	519	720.8	72	596.9	87	695.4	74.6
T4	525	720.8	72.8	596.9	87.9	695.4	75.5
T5	565	720.8	78.4	596.9	94.6	695.4	81.2

** Enright Model: 6MWD(m) [female] = (2.11 × height$^{(cm)}$) – (2.29 × weight$^{(kg)}$) - (5.78 × age) + 667 [28];*

*** Chetta Model: 6MWD(m) [female]= (1.25 × height$^{(cm)}$) – (2.816 × age) + 479.783 [29];*
**** Gibbons Model: 6MWD(m) [female] = 794.1 – (age × 2.99) [30].*

For descriptive comparison, the percentage of predicted 6MWD was calculated using three reference equations. At T5, the observed value of 565 m represented 78.4%, 94.6%, and 81.2% of the Enright, Chetta, and Gibbons predictions, respectively. These models produce different reference values, and a universal 80% normality threshold should not be inferred for this postoperative case. No adverse events occurred during the treatment. At each session, physiotherapists measured vital parameters before and after therapy. The patient reported progressively perceiving improvements over the course of rehabilitation. Although she described the physiotherapy program as physically demanding, she remained highly motivated and actively engaged in treatment. Rehabilitation enabled her to resume activities comparable to those performed by her age-matched peers.

Discussion and Conclusion

This report describes a structured outpatient rehabilitation program and repeated functional assessments after right lower lobectomy for congenital intralobar pulmonary sequestration in an adult. Published reports of this condition primarily emphasize diagnosis and procedural management [1, 3], while detailed longitudinal descriptions of postoperative rehabilitation remain limited. In the absence of a condition-specific rehabilitation protocol, treatment planning was informed by approaches used following lung resection for other indications. Decisions were individualized by a team including a pulmonologist, physiotherapist, and nurse, in consultation with the patient.

The 20-session intervention combined shoulder and thoracic mobility, breathing exercises, progressive resistance training, and aerobic reconditioning on a cycle ergometer. Similar components have been described following surgery for lung cancer [31–33], and postoperative pulmonary rehabilitation has been examined in other lobectomy populations [34]. However, evidence from patients undergoing cancer surgery cannot be assumed to apply directly to younger adults with congenital pulmonary sequestration. In this case, six-minute walk distance increased by 75 m during supervised treatment and by 150 m from baseline to 12-month follow-up, accompanied by improvements in pain, fatigue, and SF-12 scores. Although the walking-distance improvement exceeded published thresholds in selected chronic respiratory populations [26, 27], the clinical significance of these thresholds has not been established for this condition.

Continued functional improvement after the supervised program is consistent with a prolonged postoperative recovery trajectory, as also reported in other lobectomy populations [35]. A causal contribution of physiotherapy cannot be distinguished from recovery after lung resection, resolution of prior infections, or changes in activity levels in this uncontrolled case. Moreover, the Enright, Chetta, and Gibbons equations provided appreciably different predicted 6MWD values [28–30], supporting their use as descriptive benchmarks rather than definitive normality thresholds. The ADL and IADL scores were unchanged, possibly because functional independence was already high at baseline.

During the reported follow-up, no new pulmonary infections were documented, and the patient was reported to have resumed work and physical activity. Interpretation is limited by the single-case design, absence of a control condition, concurrent recovery from surgery, and limited information about adherence to ongoing exercise after supervised sessions. Consequently, the observed improvements cannot be attributed specifically to rehabilitation or generalized to other patients. The principal clinical lesson is the value of longitudinal functional assessment and individualized exercise progression after surgery for a rare respiratory malformation; further studies are needed to clarify the contribution of postoperative rehabilitation.

Acknowledgements

The authors would like to thank the clinical staff involved in the patient's care for their collaboration and support during the rehabilitation process.

CRediT authorship contribution statement

Matteo Tamburlani: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

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Giovanni Sellitto: Formal analysis, Writing – original draft, Writing – review & editing.

Annamaria Servadio: Conceptualization, Supervision, Writing – review & editing.

Declarations

Funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent and patient details: Written informed consent to take part in the study and to publish the article has been obtained from all participants or their legal representatives. The privacy rights of participants have been observed.

Studies in Human: This study was performed in compliance with relevant laws, regulatory frameworks and guidelines where the research took place. This study was conducted in accordance with CARE. Ethics committee approval was not required under relevant laws and institutional guidelines. The study was conducted in accordance with the ethical standards of the institutional and national research committee and with the Helsinki Declaration.

Case Reports: This research follows the CARE guidelines and the CARE checklist.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of generative AI and AI-assisted technologies in the writing process: During manuscript revision, the authors used ChatGPT (OpenAI) to assist with language editing and organization of

the text. The authors must review and validate all revisions and remain responsible for the final manuscript.

CRediT authorship contribution statement

Matteo Tamburlani: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Federica Bressi: Supervision, Writing – review & editing.

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Conflict of Interest Statement

The authors have no conflicts of interest to declare

Funding Statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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