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What are the barriers to the completion of a home-based rehabilitation programme for patients awaiting surgery for lung cancer: a prospective observational study

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ABSTRACT

Objectives Home-based rehabilitation programmes (H-RPs) could facilitate the implementation of pulmonary rehabilitation prior to resection for non-small cell lung cancer (NSCLC), but their feasibility has not been evaluated. The aim of this study was to identify determinants of non-completion of an H-RP and the factors associated with medical events occurring 30 days after hospital discharge.

Design A prospective observational study.

Intervention All patients with confirmed or suspected NSCLC were enrolled in a four-component H-RP prior to surgery: (i) smoking cessation, (ii) nutritional support, (iii) physiotherapy (at least one session/week) and (iv) home cycle-ergometry (at least three times/week).

Outcomes The H-RP was defined as 'completed' if the four components were performed before surgery.

Results Out of 50 patients included, 42 underwent surgery (80% men; median age: 69 (IQR 25%–75%; 60–74) years; 64% Chronic Obstructive Pulmonary Disease (COPD); 29% type 2 diabetes). Twenty patients (48%) completed 100% of the programme. The median (IQR) duration of the H-RP was 32 (19; 46) days. Multivariate analysis showed polypharmacy (n=24) OR=12.2 (95% CI 2.0 to 74.2), living alone (n=8) (single vs couple) OR=21.5 (95% CI 1.4 to >100) and a long delay before starting the H-RP (n=18) OR=6.24 (95% CI 1.1 to 36.6) were independently associated with a risk of non-completion. In univariate analyses, factors associated with medical events at 30 days were H-RP non-completion, diabetes, polypharmacy, social precariousness and female sex.

Conclusion Facing multiple comorbidities, living alone and a long delay before starting the rehabilitation increase the risk of not completing preoperative H-RP.

Trial registration number NCT03530059.

INTRODUCTION

Lung cancer is the leading cause of cancer related deaths worldwide.[1] Surgical resection for early stage non-small cell lung cancer

Strengths and limitations of this study

► This is the first study to explore barriers to the completion of a home-based rehabilitation programme for patients awaiting lung resection surgery for lung cancer.

► This study provides important information to identify patients who are at risk of failure of a home-based programme.

► The sample size was small, thus the power of this exploratory study may be limited.

► The lack of collection of information relating to participation refusals means the risk of selection bias cannot be determined.

► Since no recommendations exist, the criterion on which completion of a rehabilitation programme was defined was arbitrary.

(NSCLC) offers the best chance of cure, but is associated with a risk of postoperative complications and rehospitalisation.[2–4] Fragile patients are particularly at risk of such complications.[5 6] The overall rate of hospital readmissions within 3 months after lobectomy for lung cancer can reach 18%; in patients with comorbidities, each additional comorbidity was associated with a 2.0% increased probability of readmission.[7] Thomas *et al*[5] have shown that underweight patients had a higher surgical complication rate than normal-weight patients (23.2% vs 13.8%; p<0.001, respectively). Guidelines from the European Respiratory Society and the European Society of Thoracic Surgery recommend early preoperative rehabilitation for patients with resectable lung cancer who have borderline lung function or poor exercise capacity.[8] It is well recognised that pulmonary rehabilitation

programmes effectively improve exercise capacity and help to maintain pulmonary function and quality of life following surgery; they also reduce the risk of developing postoperative pulmonary complications and shorten hospital stay.[9 10] Despite those recommendations, preoperative rehabilitation programmes remain difficult to set up. The two main barriers are (i) the time available before surgery is often only a few weeks,[11 12] and (ii) the lack of standardised protocols.[9]

Pulmonary rehabilitation is a comprehensive intervention that includes, but is not limited to, smoking cessation, nutritional support, cardiopulmonary training and physiotherapy.[13] This is standard care for patients with respiratory disability and rehabilitation programmes can be conducted in both healthcare establishments and at home.[14–16] However, very few studies have assessed the feasibility and efficacy of presurgery, home-based rehabilitation programmes (H-RPs).[17]

The aim of this study was to identify the barriers to the completion of a home-based presurgical, multimodal rehabilitation programme.

METHODS

Study design

This prospective, observational study was conducted in four different medical facilities (one tertiary university hospital and three private hospitals).

Participants

Patients were included if they (i) were at least 18 years old, (ii) had proven or suspected operable NSCLC and scheduled lung surgery, (iii) were referred for an H-RP and (iv) required at least two out of the four components of the programme (see details later). All patients were asked to participate by their lung cancer specialist during the appointment when surgery was scheduled. Written informed consent was obtained from all participants.

Patients involvement

Patients were not involved in the design, conduct, reporting or dissemination plans of our research.

Components of the rehabilitation programme

The H-RP was prescribed by a thoracic surgeon or a pulmonologist at the time the surgery date was scheduled. The minimum time before surgery should be 4 weeks.

The multimodal rehabilitation programme targeted four aspects of care that are important for good postsurgical outcomes in patients with NSCLC: (i) support for smoking cessation for active smokers, (ii) nutritional support, (iii) physiotherapy and (iv) a home-based training programme.
1. A tobacco consultation with a physician was proposed to active smokers, along with a prescription for nicotine patches.
2. Nutritional support: a dietician carried out a nutritional assessment at home; in case of nutritional deficiency, defined as body mass index (BMI) <21, or unintentional body weight loss >10% in 6 months or >5% in 1 month, food fortification advice was provided and oral nutritional supplements were prescribed. The participant's nutritional requirements were assessed by calculating the number of calories received from the 24 hours dietary recalls and compared with the required amount calculated through the Harris-Benedict equations.[18 19]
3. Physiotherapy consisted of weekly sessions supervised by a physiotherapist located near the participant's home (outpatient clinic). These consisted of strengthening exercises, stretching, respiratory muscle training (POWERbreathe International, Southam, UK), advice and teaching regarding the importance of breathing and coughing techniques during the postoperative period. Participants were asked to attend at least one physiotherapy session per week.
4. The training programme consisted of exercise on a cycle-ergometer. Each patient was provided with a cycle-ergometer at inclusion until their date of surgery. The cycle-ergometer was delivered to the patient's home by a homecare provider technician during a scheduled appointment. All patients had sufficient space within their homes for the device. Participants were asked to perform at least three 20–40 min exercise sessions per week. The initial cycling intensity was fixed at 50% of peak work rate. The participants were instructed to reach at least 30 min at this intensity without excessive dyspnoea (<6 on a modified Borg Scale)[20] and then to progressively increase the intensity by 10%Wmax increments while still being able to achieve 30 min of exercise. All patients were asked to complete a logbook to record the exercise sessions carried out.

Data collection
1. Demographic data (age, sex, BMI, medical history and living situation) were collected by the physician in charge in each centre.
2. Preoperative respiratory function tests were performed according to the American Thoracic Society (ATS)/European Respiratory Society (ERS) standards.[21] A symptom-limited Cardio-Pulmonary Exercise Test was performed on an electronically braked cycle ergometer with breath-by-breath expired gas analysis, determined as the highest average values over 30 s, and peak work rate was identified.[22]
3. Patient-reported outcomes were assessed just before the beginning of the rehabilitation programme by using three different standard questionnaires: the Hospital Anxiety and Depression Scale (HADS),[23] the Pichot fatigue scale and the French Evaluation of Deprivation and Inequalities in Health Score (EPICES) questionnaire to assess social precariousness and health inequity.[24]

Postoperative medical events after hospital discharge were collected by telephone interviews with participants as well as by review of their medical charts at

the end of the study (30 days after hospital discharge). Surgical complications such as pneumothorax, pleural effusion and nerve injuries, and medical complications such as infection, prolonged pain or any other problem requiring medical attention were recorded.

Outcomes
Primary outcome
The completion rate of the rehabilitation programme was defined as the proportion of participants who completed 100% of the four components of the programme defined as follows: (i) for current smokers—initiation and maintenance of smoking cessation; (ii) for those with dietary requirements—initiation and maintenance of dietary changes; (iii) participation in at least one supervised physiotherapy session per week (this component of physiotherapy was initially determined at two supervised sessions/week but was subsequently reconsidered because it was considered too difficult to achieve); (iv) performance at least three home cycle-ergometry sessions per week.

Each component achieved was attributed a rating of 25%. The smoking cessation and diet components were automatically rated as 25% if they were unnecessary (ie, former smoker at inclusion and no nutritional requirements).

Example 1: if at inclusion a participant was (i) a non-smoker, (ii) did not need nutritional intervention, and during the H-RP participated in at least one supervised physiotherapy session/week and performed at least three home cycle-ergometry sessions/week, completion was rated as 100%.

Example 2: if at inclusion a participant was (i) non-smoker, (ii) did not need nutritional intervention, and during the H-RP participated in at least one supervised physiotherapy session/week but performed only one cycle-ergometry session/week, completion was rated as 75%.

Secondary outcome
The secondary outcome was the rate of postoperative medical events assessed 30 days after hospital discharge.

We also reported early post-surgical complications before hospital discharge.

Statistical analysis
Data were analysed using SAS software V.9.4 (SAS Institute). Continuous variables were expressed as medians (25th–75th percentiles) and categorical variables were reported as absolute numbers and percentages.

To assess the determinants of completion of an H-RP, univariate logistic regression models were used (all variables were categorised (>median versus ≤median). Variables that were associated with the risk of non-completion of the programme in the univariate analysis (p<0.05) were used to determine the optimal multivariable regression model (procedure involving all subsets with optimisation on lowest Akaike information criterion) to find

the independent variables associated with the risk of non-completion of the programme. Colinearity between variables (defined as r>0.4) was verified by Pearson's or Spearman's coefficient, or Cramer's V.2. Variables associated with the risk of 30-day postdischarge events were also assessed by univariate and multivariate logistic regression models.

For all the tests, two-sided p values <0.05 were considered significant.

RESULTS
Study population
Between February 2018 and July 2019, 50 patients scheduled for surgery were included and started the programme. Eight participants were later excluded, 7 because the surgery was subsequently cancelled (small cell lung cancer (n=2), metastatic disease (n=2), frailty (n=2), misdiagnosis (n=1)) and one because he withdrew his consent (n=1)). The characteristics of the 42 participants who completed the study are reported in table 1. Most participants were men; there was a high rate of cardio-respiratory comorbidities and exercise capacity was generally relatively low. Most participants (62%) were non-smokers at inclusion. Twenty-four participants (57%) required three components of the programme and 15 (36%) required four components. The median delay between inclusion and the first day of rehabilitation was (median (25th–75th percentiles) 8 (6–13) days and the median delay between inclusion and surgery was 43.5 (31.0–57.0) days. The median (25th–75th) duration of the H-RP was 32 (19–46) days.

Primary outcome
The completion rate of each component of the programme and the completion rate of the overall programme is reported table 2. Twenty participants (48%) completed the whole programme.

Figure 1 shows the forest plots of factors related to non-completion of the rehabilitation programme: BMI at inclusion over $26.5 \, \text{kg/m}^2$ (OR=6.43; 95% CI 1.66 to 24.86, p=0.007), diabetes mellitus (OR=7.45; 95% CI 1.39 to 40.43, p=0.019), polypharmacy (≥5 drugs) (OR=6.31; 95% CI 1.63 to 24.5, p=0.008) and a short delay between programme initiation and surgery (OR=4.67; 95% CI 1.19 to 1835, p=0.028) were significantly associated with the risk of non-completion in the univariate analysis.[25] Living alone also tended to increase the risk of non-completion (OR=8.87; 95% CI 0.98 to 80.18, p=0.052). The risk of non-completion was also associated with a long delay between inclusion and starting the programme (OR=4.67; 95% CI 1.19 to 18.35, p=0.028). In contrast, high scores on the fatigue scale, depression and anxiety scale and social status (EPICES) were not associated with the risk of non-completion. Finally, living alone, polypharmacy and a long delay before starting the programme were the three independent variables that best explained the risk of non-completion (table 3).

Table 1 Subject characteristics (n=42)

	n (%) or median (25th–75th)
Age (years)	69 (60–74)
Sex (% male)	34 (81)
BMI (kg/m^2)	26.5 (23.4–30)
Living with a partner (yes)	34 (81)
Delay to start the programme (days)	8 (6–13)
Medical history	
Hypertension	20 (47.6)
Cardiac arrhythmias	3 (7.1)
Coronary artery disease	4 (9.5)
Chronic obstructive pulmonary disease	27 (64.2)
Type 2 diabetes	12 (28.6)
Current Smoker	16 (38.1)
Pulmonary function	
FEV$_1$ (% predicted value)	72.5 (57–86)
FEV$_1$/FVC	64 (58–73)
Peak work rate (W)	90 (70–110)
VO$_2$ peak (mL/kg/min)	18 (15.5–20)
VO$_2$ peak (% predicted value)	67 (58–85)
Patient reported outcomes	
HAD anxiety scale	7 (5–11)
HAD depression scale	5 (2–7)
EPICES>30, n (%)	19 (45.2)
Pichot fatigue scale	7 (4–15)
Postoperative cancer stage	
Stages I–II, n (%)	26 (61.9)
Stages III, n (%)	11 (26.2)
Stages IV, n (%)	3 (7.1)
Stages other, n (%)	2 (4.8)

BMI, body mass index; EPICES, Evaluation of Deprivation and Inequalities in Health Score; FEV$_1$, forced expiratory volume in 1 s; FVC, forced vital capacity; HAD, Hospital Anxiety and Depression; VO$_2$, oxygen consumption.

Secondary outcomes

Thirteen patients participants (31%) had at least one postoperative medical event within 30 days of hospital discharge (one recurrent nerve injury, one pneumothorax, two late postoperative episodes of severe pain and/or pain that was not alleviated by treatment, five infections, one pleural effusion, one transfusion for haemorrhage of a stomach ulcer, one hypertensive crisis and one postsurgical anaemia).

Figure 2 shows the forest-plots of factors related to the occurrence of at least one medical event after hospital discharge. Diabetes mellitus (p=0.020), polypharmacy (≥5 drugs) (p=0011), social precariousness (p=0.043) and female sex (p=0.043) were significantly associated with the occurrence of late complications in the univariate analysis. Non-completion of the programme was also associated with the risk of late complications. It was not possible to build a multivariate model to determine independent variables due to the high colinearity between the variables.

Table 4 reports early postsurgical complications (before hospital discharge) and length of hospitalisation:

Table 2 Completion rate for each component of the programme

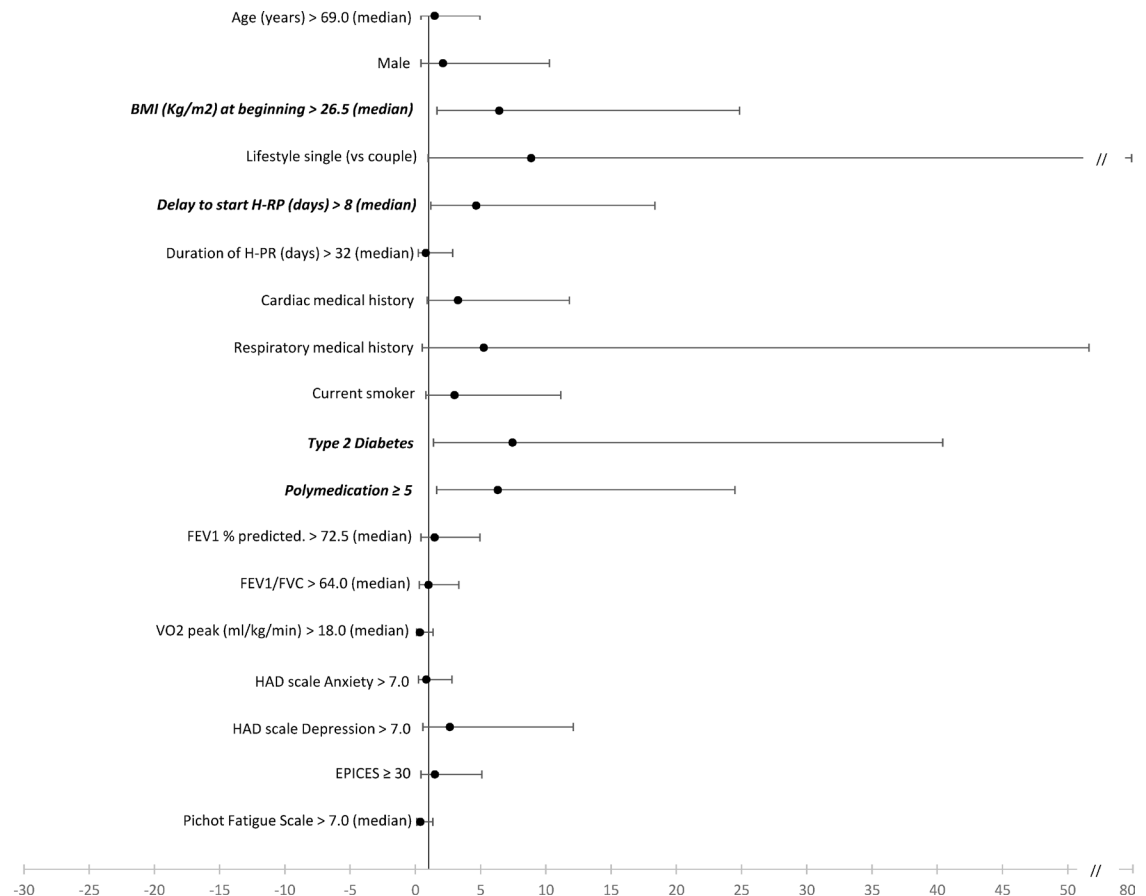|	Number of patients concerned	Completion rate, n (%)
Smoking cessation	16	12 (75)
Nutritional support	38	30 (79)
Physiotherapy	42	31 (74)
Exercise training	42	33 (79)
Full programme	42	20 (48)

Figure 1.

Figure 1 Forests plots: ORs related to non-completion of the rehabilitation programme (univariate analyses). BMI, body mass index; EPICES, Evaluation of Deprivation and Inequalities in Health Score; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; H-RP, home-based rehabilitation programme; HAD, Hospital Anxiety and Depression; VO_2, oxygen consumption.

neither early postsurgical complications nor the duration of hospitalisation differed between participants who had completed the H-RP and those who had not.

DISCUSSION

The aim of this prospective study was to identify barriers to the completion of a H-RP for patients awaiting lung resection surgery for lung cancer. Living alone, polypharmacy and a long delay before starting the rehabilitation programme were the main factors associated with the risk of not completing the programme. Furthermore, the results showed that polypharmacy, social precariousness and non-completion of the rehabilitation programme were associated with a risk of late medical events.

Although the impact of the delay between the diagnosis of NSCLC and surgery on patient prognosis is still debated,[26] current guidelines recommend that this time should be minimised (~6 weeks).[27–29] Thus, any delay in the implementation of the rehabilitation programme reduces the possibility of completing the programme, especially if the date of surgery is already scheduled. In the present study, all patients were prescribed presurgical pulmonary rehabilitation by a lung cancer specialist as soon as surgery was scheduled. The initiation of the rehabilitation programme could be delayed either by the time required to pass a cardio-respiratory test (cardiac clearance) or because of patient related constraints (difficulty in scheduling an appointment). Our results show that a period of at least 6 weeks is likely to be required

Table 3 Factors associated with the risk of not completing the rehabilitation programme in the multivariate analysis

Variables	OR (95% CI)	P Value
Living alone	21.5 (1.4 to >100)	0.0269
Polypharmacy ≥5	12.19 (2.01 to 74.15)	0.0066
Delay in starting the programme (from inclusion to the first day of the rehabilitation)	6.24 (1.07 to 36.57)	0.0423

Result of Akaike information criterion=47.4 (lower values indicate a better model), p value global test=0.0225.
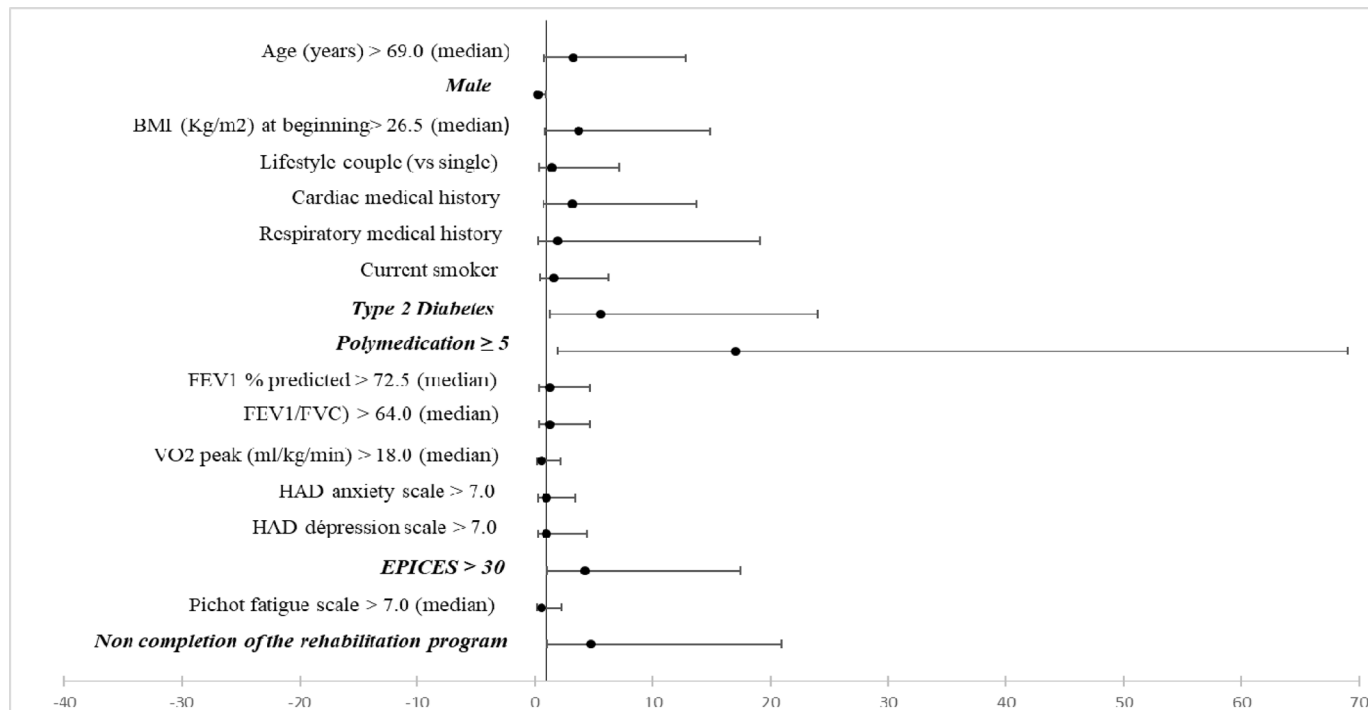
Figure 2 Forests plots: ORs related to one adverse event or more (univariate analyses). BMI, body mass index; EPICES, Evaluation of Deprivation and Inequalities in Health Score; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HAD, Hospital Anxiety and Depression; VO_2, oxygen consumption.

to complete such a pre-surgical pulmonary rehabilitation programme.

One of the main patient-related factors that prevented the completion of the home-based programme was polypharmacy. Polypharmacy indicates the presence of multimorbidity, which can be burdensome for individuals to manage (drug management, self-monitoring, visits to the doctor, laboratory tests, etc). In a very elegant modelling approach, Buffel du Vaure et al[30] showed that people who have diabetes and hypertension could spent about 40 hours/month managing their pathologies. It is therefore reasonable to expect that the diagnosis of cancer, along with the examinations and appointments involved, considerably increases this burden and limits engagement in a rehabilitation programme. However, it was surprising that engagement did not seem to be limited by mood in this study, since there was no relationship between non-completion of the programme and anxiety-depression

or fatigue scores. Furthermore, the results also showed that both patients with multimorbidity and those in precarious social situations were also at risk of late postsurgical complications. In the light of these important results, we suggest that inpatient presurgical rehabilitation programmes might be more appropriate for patients with multimorbidity and those in precarious social situations than home-based programmes to enhance postsurgical recovery. This issue should be the object of future research.

Several studies have shown that family support and encouragement enhance participation and adherence to pulmonary rehabilitation[31 32] particularly when the partner is able to participate in the patient's care.[33] In the present study, all but one of the participants who completed the full programme lived with a partner, which explains why the upper limit of the CI for this variable was very high (table 3; OR). In contrast with recent results

Table 4 Early postsurgical complications (before discharge) and length of hospitalisation in patients who completed the H-RP versus those who did not

Variables	Patients who completed H-RP (n=20)	Patients who did not complete H-RP (n=22)	OR (95% CI)	P value
Pleuro-pulmonary complications, n (%)	12 (60.0)	9 (40.9)	0.46 (0.13 to 1.59)	0.22
Chest-wall complications, n (%)	1 (5.0)	2 (9.1)	1.90 (0.16 to 22.71)	0.61
Cardiovascular complications, n (%)	3 (15.0)	3 (13.6)	0.90 (0.16 to 5.04)	0.90
Neurological complications, n (%)	1 (5.0)	1 (4.6)	0.91 (0.05 to 15.49)	0.94
Length of postoperative hospitalisation, days (median (25th–75th))	7.5 (6.0–9.5)	7.0 (6.0–12.0)	0.69 (0.20 to 2.35)	0.56

published on non-adherence to home-based pulmonary rehabilitation, neither depression nor anxiety scores were found to be associated with the risk of not completing the home rehabilitation programme.[34]

This study has several limitations. First, from a methodological point of view, although the planned sample size was recruited, the sample was small and thus the power of this exploratory study was limited. Second, the criterion on which completion of a rehabilitation programme was defined was arbitrary and we did not collect information relating to the reasons for non-completion and at which point in the process non-completion occurred. However, no recommendations regarding this type of programme have been published and most of the studies evaluating rehabilitation programme adherence only considered the number of exercise sessions performed, but not others components of rehabilitation.[35] Third, it could be argued that some of the participants could have been considered at a low risk of postoperative complications,[8] however, our aim was not to estimate the effect of the programme on postoperative risks but to assess the barriers to completion of the home-based programme. Fourth, we did not collect information relating to the number and the reasons for refusal, therefore, we cannot we be sure there was no selection bias.

Finally, this study was not controlled and thus conclusions cannot be drawn as to the effectiveness of the home-based programme regardless of whether it was completed by the patient or not.

CONCLUSION

The presence of multiple comorbidities and living alone were found to be the main obstacles to the completion of a home rehabilitation programme. Although other factors relating to non-completion may not have been identified, these results provide important information for clinicians to identify patients who are at risk of failure of a home-based programme and thus would benefit more from supervised pre-surgical rehabilitation programmes.

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