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REVIEW

The role of physiotherapy in patients undergoing pulmonary surgery for lung cancer. A literature review

F. Kendall[a,b,c,*], **P. Abreu**[d], **P. Pinho**[a], **J. Oliveira**[c], **P. Bastos**[a]

[a] *Department of Cardio-Thoracic Surgery, Centro Hospitalar de São João, Porto, Portugal*
[b] *CESPU, Polytechnic Health Institute of the North, Gandra, Portugal*
[c] *CIAFEL, Faculty of Sports, University of Porto, Porto, Portugal*
[d] *Department of Physiotherapy, Escola Superior Saúde Dr. Lopes Dias, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal*

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Abstract This review aims to appraise the role of physiotherapy care in patients submitted to pulmonary surgery, in preoperative, perioperative, and postoperative phases.

Pulmonary surgery is the *gold standard* treatment for patients with lung cancer if it is completely resectable. However, the major impairments and complications induced by surgery are well known. Physiotherapy has been regularly used both in the preparation of the surgical candidates; in their functional recovery in the immediate postoperative period, and in the medium/long term but there is a lack of concise evidence-based recommendations. Therefore, the aim of this review is to appraise the literature about the role of physiotherapy interventions in patients undergoing lung surgery for lung cancer, in preoperative, perioperative, postoperative and maintenance stages, to the recovery and well-being, regardless of the extent of surgical approach.

In conclusion, physiotherapy programs should be individually designed, and the goals established according to surgery timings, and according to each subject's needs. It can also be concluded that in the preoperative phase, the main goals are to avoid postoperative pulmonary

Abbreviations: NSCLC, non-small cell lung cancer; PPC, postoperative pulmonary complications; COPD, chronic obstructive pulmonary disease; PO, postoperative predictive; FVC, forced vital capacity; FEV_1, forced expiratory volume in first second; ERS/ESTS, European Respiratory Society and the European Society of Thoracic Surgery; DLCO, diffusion capacity for carbon monoxide; CPET, cardiopulmonary exercise test; O_2, oxygen; VATS, video-assisted thoracic surgery; RVATS, robotic video-assisted thoracic surgery; MIP, maximal inspiratory pressure; IMT, inspiratory muscle training; LOS, length of stay; RCT, randomized controlled trial; IS, incentive spirometry; VO_{2max}, maximal oxygen consumption; V/Q, ventilation/perfusion ratio; PET, preoperative exercise therapy; BMI, body mass index; PEP, positive expiratory pressure; NIV, non-invasive ventilation; TENS, transcutaneous electrical nerve stimulation.

* Corresponding author.
E-mail address: fckendall@gmail.com (F. Kendall).

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complications and reduce the length of hospital stay, and the therapeutic targets are respiratory muscle training, bronchial hygiene and exercise training. For the perioperative period, breathing exercises for pulmonary expansion and bronchial hygiene, as well as early mobilization and deambulation, postural correction and shoulder range of motion activities, should be added. Finally, it can be concluded that in the postoperative phase exercise training should be maintained, and adoption of healthy life-style behaviours must be encouraged.

Introduction

For the early stages of non-small cell lung cancer (NSCLC) surgical resection is undoubtedly the *gold standard* treatment for candidates who are eligible; however, this procedure is associated with the occurrence of postoperative pulmonary complications (PPC) such as atelectasis and pneumonia, as well as pleural complications, which apart from the economic repercussions, may have an immediate impact in patients' recovery with long-term consequences on their quality of life.[1]

Only 15–20% of those patients diagnosed with lung cancer are candidates for surgery; it depends not only upon the histological characteristics of the tumour but also the preoperative staging according to the classification of malignant tumours TNM.[1–3] However, it is still necessary to assess the surgical risk, which is influenced by several factors, including age, co-morbidities, and cardiopulmonary function.

Physiotherapy has been widely used preoperatively and/or postoperatively to avoid surgical complications and enhance the recovery of these patients. However, there is a huge heterogeneity regarding the components of the proposed physiotherapy programs and the timing for their implementation (before and/or after surgery). Unfortunately, the available evidence regarding the effectiveness of physiotherapy interventions is heterogeneous, probably due to the variability in the program contents, along with the questionable quality of the studies design. Therefore, considering the inherent economic costs, physiotherapy intervention programs based on robust scientific evidence are required.

Taking into account the physiopathological changes induced by pulmonary surgery, this review aims to provide a literature and clinical overview of the role of physiotherapy interventions in patients undergoing lobectomy or pneumectomy, considering the preoperative, perioperative and the post-hospital discharge phases.

Pulmonary surgery and risk factors for postoperative complications

Most often patients with lung cancer are smokers or ex-smokers and, therefore, presenting chronic obstructive pulmonary disease (COPD) and impaired pulmonary function.[1] Indeed, many patients with localized lung cancer up to IIIA stage, are excluded from pulmonary surgery due to their impaired pulmonary function and increased risk for PPC.[4] Moreover, low postoperative predictive (ppo) values of forced vital capacity (FVC) and forced expiratory volume in first second (FEV_1) are also used to exclude patients from surgery.[5,6] According to the joint ERS/ESTS clinical practice guidelines, the single evaluation of the predicted postoperative FEV_1 (ppo-FEV_1) is not a strong predictor for PPC, especially in patients with $FEV_1 < 70\%$. Despite the ppo-FEV_1 with cut-off of higher risk set at 40%, the recent improvements in surgical technique and in perioperative care lead experts to suggest changing the cut-off to 30%.[7] Traditionally, the diffusion capacity for carbon monoxide (DLCO) was only evaluated in patients with obstruction, but recent studies showed that even in patients with normal FEV_1 the DLCO is a strong predictor of PPC. The ppo-DLCO cut-off was 40%, and currently the experts suggest changing it to 30%.[7]

A recent meta-analysis concludes that increased exercise capacity is associated with less PPC, even in COPD patients.[8] According to Brunelli et al.[5] exercise testing can be divided into two types: the low-technology tests and the cardiopulmonary exercise test (CPET), being the later the gold-standard for the assessment of surgical candidates, especially for *borderline* patients. The authors[5] found that the correlation between the exercise capacity both with FEV_1 and DLCO is weak probably due to the existence of cardiovascular compensatory mechanisms to enhance tissue oxygen (O_2) extraction. Indeed, the FEV_1 reduction induced by the lobectomy is significantly less marked in COPD patients than in those with normal pulmonary function, suggesting that, compared to exercise capacity, the pulmonary function parameters are not so sensitive and accurate in predicting the occurrence of PPC.[9–11] The surgical approach commonly used was the posterolateral thoracotomy, though in recent decades video-assisted thoracic surgery (VATS) has gained progressive popularity, despite the initial reservations concerning its oncologic reliability.[12–14] Seder et al.[15] clearly show in their retrospective study that VATS has been widely accepted in lung resections, probably due to the weakness of arguments about oncologic outcomes or the required prolonged periods of training to practice this surgical approach, as there are several important advantage of muscle-sparing techniques like VATS compared to the traditional posterolateral thoracotomy, related not only to fewer postoperative complications, shorter chest tube duration, with less pain and shoulder impairment, but also with higher overall annual survival rates.[16,17] Furthermore, VATS has shown to be advantageous for reduction of postoperative

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