The key questions in rehabilitation in thoracic surgery

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Abstract: Enhancing the recovery of patients undergoing Thoracic Surgery is the raison d'être of a pulmonary rehabilitation (PR) process. Benefits of a PR program have been shown to include reduced postoperative complications, hospital length of stay (LOS) and improved exercise and lung function parameters. Identifying which groups of patients benefit most and the constituency of the perfect PR program is subject to ongoing research. Providing PR to patients in a manner acceptable to their lifestyle and disease timeline within economic limitations is the challenge.

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What is it?

Rehabilitation from the Latin to ‘again make fit’ differs from prehabilitation (PR) which is defined as ‘enhancing the functional capacity of an individual before an operation to enable him or her to withstand the stress of surgery (1). The outcome is a faster return to normal function, not just physical, but emotional and mental well-being too. Recovery after surgery can be impeded by the development of complications which aggravate the stress of surgery. Thus, measures to avoid these or reduce the impact of them are equally important. Conceptually PR is a functional process including optimising medical conditions, nutrition status and smoking cessation. An underpinning principle of enhanced recovery and fast track pathways, PR is diverse but, for this review, we will focus mainly on physical training which is usually considered to be a combination of aerobic exercises and strength training.

Why is it important?

Despite the advances in patient selection, surgery and perioperative care, short term complications and long-term sequelae from Thoracic surgery remain prevalent. Postoperative pulmonary complications (PPC) like pneumonia or respiratory failure lead to significantly longer length of hospital stay, intensive care admission and death (2). Patients who develop a PPC have worse overall and disease-free survival (3). Furthermore, patients undergoing major lung resection, when compared to age and gender matched controls, have significantly reduced mental and physical quality of life scores two years after surgery (4).

The importance of returning patients after surgery “back to normal” is brought into perspective by the massive task facing thoracic surgeons. On the topic of lung cancer alone worldwide there are 1.8 million new cases (5). Overall 5-year survival remains low between 8 and 17%, this despite modest improvements in care over the last few decades (6). Surgical resection remains the gold standard curative treatment, but resection rates remain low and widely variable (9–35%) between nations even within Europe (7). The peak incidence of age of diagnosis for lung cancer has risen from 60 in 1984 to 70–74 in 2008; an older population has a higher incidence of comorbid conditions (8). Thus, the challenge is to increase the proportion of patients we deem fit for surgery whilst reducing the postoperative morbidity.

Risk factors for complications include age, smoking status, poor lung function tests, malnutrition and co-morbidities (2,9). The prevalence of major comorbidities in thoracic surgery patients is especially high in lung cancer resection patients due to the strong association with age and smoking, chronic obstructive pulmonary disease (COPD).
Exercise capacity is a key element in the selection process of patients suitable for thoracic surgery. Survival is also linked to exercise capacity at diagnosis of non-small cell lung cancer (10) and measures of response to exercise predict survival in lung disease (11,12). Complication rate, survival and success of surgery are linked to preoperative exercise capacity in various fields of thoracic surgery, including lung cancer (13-15) and lung volume reduction (16). Therefore, improving exercise capacity prior to surgery may be a means to improving outcomes afterwards.

**(Does it work?)**

Current clinical practice guidelines recommend that PR is considered for high risk patients undergoing a variety of thoracic surgical operations (17-19). PR is an important component of care in the management of patients with lung disease and has been shown to reduce the risk and impact of complications and enhance recovery after acute exacerbations (20).

Several recent systematic reviews and a meta-analysis have concluded that PR is beneficial but, because of heterogeneity of studies, the exact duration, intensity, structure and patient selection to achieve maximum efficacy is uncertain (21-23). Table (online: http://jtd.amegroups.com/public/system/jtd/jtd.2018.03.147-1.pdf) (24-42), summarises the key findings, in brief, studies reported a statistically significant improvement in peak oxygen consumption (VO2max) or in functional capacity measured with the 6-minute walk test from baseline to post-intervention. Lung function too is significantly enhanced after PR compared with baseline. Pooled estimates of effect sizes show a significant increase for both forced expiratory volume in 1 second (FEV1) [standardized mean difference (SMD) =0.27, 95% CI: 0.11–0.42] and FVC (SMD =0.38, 95% CI: 0.14–0.63).

Postoperative outcomes, specifically hospital length of stay (LOS) and morbidity, are significantly reduced in comparison with standard care. Pooled estimates of effect sizes show a significant reduction in both hospital LOS (mean difference = -4.83, 95% CI: -5.90 to -3.76) and PPCs (relative risk =0.55; 95% CI: 0.34–0.89; I² =27%) (23). The effect on PPC seems to be particularly to patients with poor lung function. Assessment of PR on Health-related quality of Life are limited by small numbers of studies and by the diversity and validity of tools used to assess. Currently there is no evidence to support that the addition of respiratory exercises to an exercise intervention provides any additional benefit in patients with COPD.

A further indicator of PR’s benefit is presumed from measurements of exercise capacity. VO2max evaluation using cardiopulmonary exercise testing (CPET) represents the best independent predictor of surgical complication rate (43). When exercise capacity was poor (metabolic equivalents of <4) LOS nearly doubled in patients undergoing lung resection for cancer (44). Preoperative exercise programs improve VO2max. Increasing physical performance may result in better quality of life and reduce perceived dyspnoea in lung cancer resection patients (26,31).

The suggestion that exercise programs in patients with moderate to severe COPD are associated with less air leak thus significantly reducing chest tube days is an interesting idea. However, this was a finding of a small study, so findings will have been corroborated further (27).

PR can increase resection rates of lung cancer by improving measured characteristics of patients initially not considered fit for surgery based on pulmonary function and exercise test parameters (32,33). Morbidity was 15% and 25% respectively with no mortality in either of the small cohorts in these prospective studies.

Whilst the evidence for PR prior to thoracic surgery is generally supportive it has so far been cumulatively of low quality. Significant improvements in exercise capacity, lung function, complication rates and hospital LOS are seen. This data concurs with the emerging evidence in other areas of surgery that PR is beneficial (45,46).

**(What does the ideal PR program involve?)**

The ideology of a good program should be to physically and emotionally prepare the patient for surgery to enhance short and long term postoperative outcomes. Most of discussion thus far has centred around the exercise parameters of PR. Whilst supervised exercise programs form the cornerstone of PR, a comprehensive multidisciplinary approach which includes smoking cessation, nutrition, chronic disease optimisation, ensuring informed consent as well as ongoing patient selection are important components.

Complete smoking cessation is considered crucial by many surgeons. Risk of death and pulmonary complications is higher in smokers than those who have never smoked, and risk reduces with length of smoking cessation (47). LOS, ITU admission and risk of PPCs are significantly higher in smokers (48). Smokers who quit have a
higher abstinence rate when undergoing a supervised pulmonary rehabilitation (PR) program compared to usual treatment (49). However, access to smoking cessation programs can be poor. Providing smoking cessation care as part of the surgical pathway is preferred by patients (50).

Understanding and therefore engaging in the recovery process by the patient is an essential part of the consent process. Having multiple interactions with the multidisciplinary extended surgical team can certainly enhance the process of information giving and processing (51).

Preoperative nutritional status is an important predictor of morbidity and mortality in renal, bladder and oesophageal cancer surgery (52-54). In COPD patients' nutritional parameters are often deranged, and protein metabolism is improved by supplementation with branched chain amino acids more than aged matched controls (55). Many patients who undergo lung surgery have COPD. A prospective randomised study comparing a ten-day high nutrition diet to normal diet in patients undergoing lung cancer resection found significantly improved postoperative albumin levels with resultant lower complication rates and length of chest tube drainage time (56). A thorough nutritional assessment and intervention if required is a sensible adjunct to a PR programme.

What sort of exercise training?

In the five randomised controlled trials (RCT) and 15 other studies focusing on pre-rather than postoperative rehabilitation, the intervention was delivered mainly on an outpatient basis or in a training facility. The types of prescribed exercises included are summarised in Table (online: http://jtd.amegroups.com/public/system/jtd/jtd.2018.03.147-1.pdf) and generally involved aerobic training (lower and/or upper limbs) with addition in some studies of strength training. Respiratory exercises were included in most of studies. The addition of other elements such relaxation techniques, educational sessions etc. were inconsistent. The median duration was 4 (range, 1–10) weeks with a frequency of five sessions per week (range, 2–14) of moderate to high intensity generally tailored according to the patient's tolerance (21-23).

When should PR start and for how long?

A balance must be achieved between deriving the most benefit from a PR programme whilst not delaying surgery for cancer which could potentially progress. The rehabilitation programme should be instituted as early as possible even before a definitive decision for surgery has been made to maximize time on PR pathway.

The Swedish Lung cancer study group prescribed the ideal length of a rehabilitation programme to be 4–6 weeks (57). Treatment delays of up to 48 days have been shown not to impact survival - independently of cancer stage (58). However, Benzo et al. found that a four-week exercise program was not feasible due to patients and surgeons not willing to delay lung cancer surgery and therefore changed to more intense 1-week program (27). In the initial intervention group of 5 patients no improvement was seen in postoperative parameters and thus the study was stopped prematurely due to poor recruitment.

However other investigators have shown benefit in exercise regimes as short as 1 week (59) in terms of reduction in postoperative complications, hospital LOS and exercise parameters but without any demonstrable improvement in pulmonary function, emotional or dyspnoea scores (26,59).

Understanding that each patients' needs are different means that a PR programme may need to be tailored to the individual. For example, in one study 27 patients, initially considered unfit for surgery based on predicted postoperative FEV1, TLCO and VO2max, underwent a planned 4-week PR program. A third (9) of these patients required an extra two weeks before parameters met inclusion criteria for surgery (33).

Postoperative rehabilitation may also be important in improving patients’ recovery. Lung resection patients who had rehabilitation starting 5–7 weeks after surgery for 20 weeks demonstrated improved exercise tolerance, functional fitness, muscle mass and strength compared to patients given standard postoperative hospital advice only on discharge (60).

Timing of rehabilitation is crucial, but it must be tailored to the individual patient and their disease process. When urgency of disease treatment is high, more intensive short regimes may be necessary to obtain the balance between surgical risk and benefit. Whilst the focus on reducing perioperative risk is high, postoperative rehabilitation must remain high on the agenda to help patients recover long term.

Which patients benefit from rehabilitation programs?

Several groups of patients may derive more benefit from rehabilitation programs.
A subgroup analysis of patients without impaired pulmonary function from a systematic review of patients undergoing lung cancer surgery showed the risk reduction for developing postoperative pulmonary complications was not significant. This reduced heterogeneity of results when this subset was removed from analysis (23).

From the general COPD cohort, patients demonstrate improved exercise capacity, arterial oxygenation, anxiety/depression scores after completing a course of rehabilitation. Patients with a higher exacerbation risk score benefitted from reduced frequency of exacerbations and hospital admissions (61). In operative lung cancer patients even mild COPD is associated with significantly higher risk of postoperative complications than those with normal lung function (62).

Patients with non-COPD related lung disease including Asthma, interstitial lung disease and cystic fibrosis/bronchiectasis also benefit from PR including measures of exercise capacity and quality of life (63). However, there is no evidence that rehabilitation is beneficial in patients with these conditions undergoing thoracic surgery.

Patients with advanced age and frailty index can safely undergo rehabilitation programs and show measurable benefit (64). In patients over 70 with no significant comorbidities exercise training can reduce postoperative complications and reduce hospital LOS (59).

Even ‘fit young’ patients undergoing thoracic surgery can benefit from rehabilitation. For example, patients undergoing the NUSS procedure for pectus excavatum were found to have significantly improved exercise parameters if they underwent early postoperative rehabilitation. However, there was no significant difference in pain or lung function tests from control patients who did not have PR (65).

Conclusions
A pre and postoperative rehabilitation program can improve outcomes in patients undergoing thoracic surgery. Whilst this benefit has been shown in patients undergoing lung cancer surgery and lung volume reduction surgery, evidence is not robust. Heterogeneity among the studies in terms of participants and intervention make it difficult to draw definitive exact recommendations.

All patients can glean some benefit from tenets of a rehabilitation program, but it has not been delineated whether those at highest risk require longer periods of rehabilitation or whether the alternative of a more intense shorter program is equivalent. This is controversial where pathological stage, cultural and economic pressures impact on the timing to surgery. We cannot recommend delaying surgery to undergo PR in patients fit for surgery but in most health environments a period of 2 to 4 weeks is usually available between presentation to surgery to deliver this intervention.

With the advent of social media and app-based patient interaction across the population we are in a position to expand rehabilitation beyond current limitations of funding and facilities into the patients’ home and to a wider variety of patient populations, pathologies and operations.

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Footnote
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