Effectiveness of Preoperative Physical Therapy for Elective Cardiac Surgery
Reed Humphrey and Daniel Malone
PHYS THER. 2015; 95:160-166.
Originally published online October 24, 2014

The online version of this article, along with updated information and services, can be found online at:  http://ptjournal.apta.org/content/95/2/160

Collections
This article, along with others on similar topics, appears in the following collection(s):
   Airway Clearance
   Cardiac Conditions
   Cardiovascular/Pulmonary System: Other
   Evidence-Based Practice
   LEAP: Linking Evidence And Practice
   Pulmonary Conditions: Other
   Therapeutic Exercise

e-Letters
To submit an e-Letter on this article, click here or click on "Submit a response" in the right-hand menu under "Responses" in the online version of this article.

E-mail alerts
Sign up here to receive free e-mail alerts
Effectiveness of Preoperative Physical Therapy for Elective Cardiac Surgery

Reed Humphrey, Daniel Malone

<LEAP> highlights the findings and application of Cochrane reviews and other evidence pertinent to the practice of physical therapy. The Cochrane Library is a respected source of reliable evidence related to health care. Cochrane systematic reviews explore the evidence for and against the effectiveness and appropriateness of interventions—medications, surgery, education, nutrition, exercise—and the evidence for and against the use of diagnostic tests for specific conditions. Cochrane reviews are designed to facilitate the decisions of clinicians, patients, and others in health care by providing a careful review and interpretation of research studies published in the scientific literature.

Each article in this PTJ series summarizes a Cochrane review or other scientific evidence source on a single topic and will present clinical scenarios based on real patients to illustrate how the results of the review can be used to inform clinical decisions. This article focuses on the effectiveness of preoperative physical therapy for elective cardiac surgery. More specifically, does preoperative physical therapy prevent postoperative pulmonary complications in patients undergoing elective cardiac surgery, and, if so, what types of interventions are most effective, and do patients with certain characteristics benefit from therapy?

The American Heart Association has reported that the total number of inpatient cardiovascular operations and procedures increased 28% between 2000 and 2010, to 7,588,000 in 2010. Despite a decrease in coronary artery bypass graft (CABG) surgery, this surgery remains common; almost 400,000 CABG procedures were performed in the United States in 2010. Although there has been a reduction in overall postoperative mortality, there is ample evidence that the risk of pulmonary complications increases morbidity and mortality.

Depression of the respiratory center due to preoperative and postoperative anesthesia and analgesia may result in altered breathing patterns, which can be complicated by restrictive lung volumes secondary to the median sternotomy and decreased chest wall movement. Decreases in essential parameters of vital capacity, functional residual capacity, and forced expiratory volume may directly contribute to atelectasis, which can contribute to postoperative pulmonary complications. Pulmonary function is further compromised by hypoventilation, decreased mucous clearance, decreased respiratory muscle function, increased work of breathing, and hypoxia—all ramifications of the surgical procedure. Additionally, walking ability is limited after CABG surgery, and persistent limitations in the performance of activities of daily living often accompany acute care hospitalization. The deterioration in walking ability after cardiac surgery has been noted especially in women, elderly people, and people diagnosed with diabetes. Therefore, preoperative physical therapy that directly targets these postoperative complications while improving functional status would seem to be a logical intervention for patients scheduled to undergo cardiac surgery.

Although the literature regarding postoperative physical rehabilitation is substantial, reports of well-controlled preoperative trials are limited. It was the intent of Hulzebos et al to undertake a rigorous review of the available literature evaluating the effectiveness of preoperative physical therapy that included an exercise regimen in the reduction of postoperative pulmonary complications. Moreover, Hulzebos et al were interested in knowing whether certain patient characteristics might provide a differential benefit and what, if any, interventions might be most effective. The review included studies that compared inspiratory muscle training (IMT) and mixed-exercise interventions with usual care (control) in patients who were more than 18 years of age and were awaiting cardiovascular surgery that included CABG or valve surgery.

The primary outcomes examined were the occurrence of postoperative pulmonary complications of grade 2, 3, or 4 on the grading scale developed by Kroenke et al (Appendix 1), mortality from all causes, and adverse events. Hulzebos et al made the distinction between pulmonary dysfunction—expected alterations in pulmonary function (eg, hypoxia, increased work of breathing, and ineffective cough)—and pulmonary complications—a clinical finding that is secondary to symptomatic pulmonary dysfunction and that
Take-Home Message
The Cochrane review by Hulzebos et al8 comprised an electronic database search of literature through December 2011. The review included 8 randomized controlled trials with a total of 856 participants; participant characteristics are described in Appendix 2. Five studies used IMT as the intervention,10–14 and the remaining 3 used mixed interventions, including aerobic exercise training, breathing exercises, or both15–17; intervention parameters are described in Appendix 2. The study sizes varied: 4 studies had fewer than 50 participants11,13,14,17; 1 study, by Weiner et al,12 had between 50 and 100 participants (n=84); and the remaining 3 studies had more than 100 participants—the largest trial, by Hulzebos et al, had 276 participants.10,15,16 The numbers allocated for the experimental and control groups in each study are shown in Appendix 2. The duration of the interventional phase in the studies ranged from 2 to 8 weeks. All studies defined “control” as usual care, with the singular exception of Weiner et al,12 who used a sham therapy (no-resistance inspiratory muscle trainer) control group.

Hulzebos et al8 did not grade the level of evidence for any of the outcomes. Each domain of risk bias was assessed for each study with 1 of 3 categories: low risk, high risk, and unclear risk. Only masking of participants and personnel showed a high risk of bias, allocation concealment was judged to be more unclear risk than low risk, and all other domains were judged to be low risk. Hulzebos et al8 were unable to complete any subgroup or sensitivity analyses because of the small number of studies and the lack of studies with inadequate random sequence generation.

A summary of the findings for the primary and secondary outcome measures is shown in the Table. Hulzebos et al8 concluded that the evidence remained incomplete for different risk groups (low versus high risk of pulmonary complications) or different types of physical therapy with an exercise component. Despite this limitation, it appeared that the available evidence, albeit from relatively limited and small trials, demonstrated that preoperative physical therapy reduced atelectasis and pneumonia and specifically reduced the length of postoperative hospitalization for patients undergoing elective cardiac surgery. Limited data showed preserved or improved physical function, as measured with a 6-minute walk assessment, relative to that in controls.13 In addition, although the data suggested improvements in measures of physical function on the Medical Outcomes Study 36-Item Health Survey Questionnaire, the degree of change may not have been clinically significant.16 Postoperative pneumothorax, prolonged (>48 hours) mechanical ventilation, and mortality from all causes did not appear to be influenced by preoperative physical therapy.

How did the results of the Cochrane systematic review apply to Mrs Brown?
Using the PICO (Patient, Intervention, Comparison, Outcome) format, Mrs Brown’s home care physical therapist asked the following question: What physical therapist interventions can improve mobility status and functional reserve while reducing the risk of postoperative pulmonary complications for patients undergoing CABG surgery? The
Patient relevance. Mrs Brown’s characteristics matched the inclusion criteria noted in the studies mentioned in the Cochrane review. Specifically, she was diagnosed with stable angina and was scheduled for elective CABG surgery. Additionally, she had several of the patient-related preoperative risk factors for postoperative pulmonary complications identified in the review, including her age (>70 years old) and her diagnoses of type 2 diabetes mellitus and obesity, which classified her as being at high risk of postoperative pulmonary complications.

Intervention and comparison relevance. The Cochrane review mentioned studies in which multimodal interventions, including IMT, functional training, and aerobic exercise, were used. Because Mrs Brown had limited mobility as a result of a combination of deconditioning, rheumatoid arthritis, and heart failure, aerobic exercise training of sufficient intensity and duration might be difficult to implement. The Cochrane review highlighted the importance of individually prescribed aerobic exercise training, 4 times per week (both performed with supervision and independently performed), for 2 to 8 weeks, at 40% to 70% of a person’s functional capacity. A home care physical therapist can implement a lower-intensity (eg, 40%-50% of heart rate reserve) progressive mobility program with the ultimate goal of 30 to 40 minutes of continuous activity. The Cochrane review also highlighted the potential for IMT as an efficacious intervention modality. Several IMT protocols, which emphasized strength or endurance of the respiratory muscles, were...
mentioned in the review. The protocols in the review included a threshold loading device and the following workloads:

For strength protocols, workloads started:

- at 30% of peak inspiratory pressure, for 2 weeks, 7 d/wk, 2 times per day, 3 sets of 10 repetitions
- at 40% of peak inspiratory pressure, for at least 2 weeks, 7 d/wk, 3 times per day, 5 sets of 10 repetitions

For endurance protocols, workloads started:

- at 30% of peak inspiratory pressure and then increased incrementally, for at least 20 minutes daily, for at least 2 weeks
- at 15% of peak inspiratory pressure for 1 week and then increased 5% at each session up to 60%, for 30 minutes daily, for 2 to 4 weeks

These protocols were based on a physical therapist measuring a patient’s maximal inspiratory pressure. This measurement requires a pressure manometer, a device that is not commonly available to a home care therapist. An alternative strengthening protocol that can be implemented when a pressure manometer is not available starts at the highest pressure tolerated by the patient and progresses as the patient is able. A common starting training intensity is 10 to 20 cm of the threshold load, with a goal of advancing the load by 1 to 2 cm of H2O pressure daily. The patient performs 4 sets of 8 to 10 repetitions, with a 2-minute rest period between sets, 6 or 7 d/wk. The load is continuously advanced on the basis of the patient’s symptoms and successful completion of the prescribed numbers of repetitions and sets. The alternative protocol takes approximately 10 minutes per session to complete, allowing time to complete the functional training and aerobic exercise components of the home program.

Additional interventions mentioned in the Cochrane review included health education about disease management, breathing retraining (diaphragmatic breathing and pursed-lip breathing), nutritional counseling, energy conservation, work simplification techniques, stress management, and instruction in common postoperative rehabilitation interventions, such as incentive spirometry, directed and braced coughing, and early mobility.

Outcome relevance. Considering that Mrs Brown had significant risk of postoperative morbidity and mortality, several key outcomes examined in the Cochrane review could be specifically applied directly to this case study. The review noted a reduced risk of postoperative pulmonary complications, including atelectasis and pneumonia, and a significant reduction in the length of stay for patients treated with preoperative physical therapy before undergoing CABG surgery. Additionally, the review noted that physical therapists can safely provide preoperative rehabilitation to patients with known risk of cardiovascular events, as no adverse events were recorded in the 3 studies that addressed this measure.

How well do the outcomes of the intervention provided to Mrs Brown match those suggested by the systematic review?

Mrs Brown underwent successful CABG surgery 4 weeks after the initiation of home-based physical therapy. Her postoperative course was noteworthy for rapid extubation and initiation of physical therapy in the intensive care unit but was complicated by fever related to an intravenous line infection that required prolonged antibiotic treatment. She was discharged to a skilled nursing facility for completion of the intravenous antibiotic treatment and continued rehabilitation services. She was ultimately discharged to home.

Can you apply the results of the systematic review to your own patients?

The findings of this Cochrane review can be applied to patients who have limited functional capacity and are awaiting surgery. The review highlighted the benefits of presurgical physical therapist services, such as the ability to reduce pulmonary complications and hospital length of stay. Prehabilitation and preoperative physical fitness and activity levels have been shown to influence the outcomes of patients awaiting not just cardiac surgery but also thoracic, abdominal, and orthopedic surgeries. Increasing a patient’s functional capacity and breathing reserve through increased physical activity, aerobic training, resistance exercise, and therapeutic interventions directly targeting the respiratory system is important because poor physical condition and poor functional status reduce the ability of patients to cope mentally and physically with hospitalization and surgery.

What can be advised based on the results of this systematic review?

A prehabilitation program consisting of multiple interventions may reduce postoperative pulmonary complications and shorten the hospital length of stay for patients awaiting cardiac surgery. The plan of care should consist of aerobic and functional training as well as therapeutic exercises including breathing retraining and IMT. Aerobic and functional training should be based on an individualized exercise prescription (eg, exercise intensity of 40%–70% of heart rate reserve for a
goal duration of 30 minutes). Physical therapists may not often include IMT as a component of their plan of care, but the evidence indicates that IMT has a beneficial role. The IMT exercise prescription can focus on strength or endurance, as noted in the Cochrane review. Inspiratory muscle training may offer unique advantages: patients can easily perform IMT after proper instruction, and IMT can be performed daily as part of an independent home exercise program. Patients with known cardiac and pulmonary diseases can safely perform this intervention.

Additional research on prerehabilitation programs and IMT could focus on identifying patients who are appropriate candidates, exploring interventions necessary for an optimal plan of care, clarifying the optimal IMT prescription, and identifying the optimal setting (ie, outpatient versus home care). Despite the need for additional research, prerehabilitation programs appear to offer significant promise for improving outcomes for patients after elective CABG.

R. Humphrey, PT, PhD, School of Physical Therapy and Rehabilitation Science, University of Montana, 32 Campus Dr, Missoula, MT 59812 (USA). Address all correspondence to Dr Humphrey at: reed.humphrey@umontana.edu.

D. Malone, PT, PhD, CCS, Department of Physical Medicine and Rehabilitation, University of Colorado-Denver, Denver, Colorado.


© 2015 American Physical Therapy Association

Published Ahead of Print: October 24, 2014
Accepted: October 9, 2014
Submitted: July 17, 2013

References
Appendix 1.
Operational Definitions of Postoperative Pulmonary Complications

**Grade 1**

Cough, dry

Microatelectasis: abnormal lung findings and temperature of \( >37.5^\circ C \) without other documented cause; results of chest radiograph either normal or unavailable

Dyspnea, not due to other documented cause

**Grade 2**

Cough, productive, not due to other documented cause

Bronchospasm: new wheezing or preexistent wheezing resulting in a change in therapy

Hypoxemia: alveolar-arterial gradient of \( >29 \) and symptoms of dyspnea or wheezing

Atelectasis: radiological confirmation plus either a temperature of \( >37.5^\circ C \) or abnormal lung findings

Hypercarbia, transient, requiring treatment, such as naloxone or increased manual or mechanical ventilation

Adverse reaction to pulmonary medication

**Grade 3**

Pleural effusion, resulting in thoracentesis

Pneumonia, suspected: radiological evidence without bacteriological confirmation

Pneumonia, proved: radiological evidence and documentation of pathological organism by Gram stain or culture

Pneumothorax

Postoperative intubation or reintubation, with the period of ventilator dependence not exceeding 48 hours

**Grade 4**

Ventilatory failure: postoperative ventilator dependence exceeding 48 hours or reintubation with the subsequent period of ventilator dependence exceeding 48 hours
Appendix 2.
Overview of the Cochrane Review by Hulzebos et al*

Eight randomized controlled trials involving a total of 856 participants and published up to December 2011.

Studies were carried out in Australia (n=1), Brazil (n=2), Canada (n=1), India (n=1), Israel (n=1), and the Netherlands (n=2).

Intervention parameters and participants in 3 studies with a mixed-exercise approach:

- 1 study (Arthur et al15): 40% to 70% intensity, 2 times per week, for 8 weeks; participants (123 in the experimental group and 123 in the control group) were at low risk and were awaiting coronary artery bypass surgery (CABG)
- 1 study (Rosenfeldt et al16): 50% intensity, 2 times per week, for 2 weeks; participants (60 in the experimental group and 57 in the control group) were scheduled for CABG or valve surgery
- 1 study (Rajendran et al17): participants attended daily multifaceted instructional sessions for 1 week and then were advised to practice 10 minutes every waking hour; participants (25 in the experimental group and 20 in the control group) had chronic obstructive pulmonary disease and were scheduled for CABG

Intervention parameters in 5 studies with inspiratory muscle training:

- 1 study (Carvalho et al13): 30% of peak inspiratory pressure (PIP), twice daily, 3 sets of 10 repetitions, for 2 weeks; participants (16 in the experimental group and 16 in the control group) had been referred for CABG and were at high risk for pulmonary complications
- 1 study (Ferreira et al14): 40% of PIP, 7 d/wk, 3 times per day, 5 sets of 10 repetitions, for 2 weeks; participants (15 in the experimental group and 16 in the control group) were 50 years old or older and were awaiting CABG or valvuloplasty
- 2 studies (Hulzebos et al10,11): starting at 30% of PIP and increasing incrementally, a minimum of 20 minutes daily, for 2 weeks; participants (139 in the experimental group and 137 in the control group10; 14 in the experimental group and 12 in the control group11) were at high risk and were scheduled for CABG
- 1 study (Weiner et al12): starting at 15% of PIP for 1 week and increasing incrementally at each session up to 60% of PIP, for 30 minutes daily, for 2 to 4 weeks; participants (42 in the experimental group and 42 in the control group) were scheduled for CABG
Effectiveness of Preoperative Physical Therapy for Elective Cardiac Surgery
Reed Humphrey and Daniel Malone
*PHYS THER.* 2015; 95:160-166.
Originally published online October 24, 2014

| References | This article cites 19 articles, 7 of which you can access for free at:  
| http://ptjournal.apta.org/content/95/2/160#BIBL |
| Subscription Information | http://ptjournal.apta.org/subscriptions/ |
| Permissions and Reprints | http://ptjournal.apta.org/site/misc/terms.xhtml |
| Information for Authors | http://ptjournal.apta.org/site/misc/ifora.xhtml |