Smith Seminars
Online Continuing Education
AARC-Approved for 2 CRCE
Pulmonary and Cardiac Rehabilitation

Objectives

Identify the goals, indications, and program components of rehabilitation for the pulmonary and cardiac patients.
Recognize the benefits, risks, and safety issues of the rehabilitation programs.
List the members of the team, the components of exercise training, outcome measures, and monitoring patients in rehabilitation programs.
Identify factors that are important to improve patient adherence to the rehabilitation programs.

Pulmonary rehabilitation is an integral part of the clinical management and health maintenance of those patients with chronic respiratory disease who remain symptomatic or continue to have decreased function despite standard medical treatment. Cardiac rehabilitation aims to reverse limitations experienced by patients who have suffered the adverse pathophysiologic and psychological consequences of cardiac events.

Rehabilitation has been defined as a multidimensional continuum of services directed to persons with cardiac and/or pulmonary disease and their families, usually by an interdisciplinary team of specialists, with the goal of achieving and maintaining the individual's maximum level of independence and functioning in the community. Rehabilitation programs have been consistently shown to improve objective measures of exercise tolerance and psychosocial wellbeing without increasing the risk of significant complications.

Pulmonary Rehabilitation

Pulmonary rehabilitation is an integral part of the clinical management and health maintenance of those patients with chronic respiratory disease. The program helps patients who remain symptomatic or continue to have decreased function despite standard medical treatment.

Consequences of respiratory disease may include:

Peripheral muscle dysfunction
Respiratory muscle dysfunction
Nutritional abnormalities
Cardiac impairment
Skeletal disease
Sensory deficits
Psychosocial dysfunction

Mechanisms for these morbidities:

Deconditioning
Malnutrition
Effects of hypoxemia
Steroid myopathy or ICU neuropathy
Hyperinflation
Diaphragmatic fatigue
Frequent hospitalizations
Effects of various medications
Psychosocial dysfunction resulting from anxiety, depression, guilt, dependency, and sleep disturbance

Principal Goals of Pulmonary Rehabilitation

Pulmonary rehabilitation aims to reduce symptoms, decrease disability, increase participation in physical and social activities, and improve the overall quality of life (QOL) for patients with chronic respiratory disease. These goals are achieved through patient and family education, exercise training, psychosocial and behavioral intervention, and outcome assessment. The rehabilitation intervention is geared toward the unique problems and needs of each patient and is implemented by a multidisciplinary team of health care professionals.

Benefits of Pulmonary Rehabilitation

The benefits of pulmonary rehabilitation are seen even in irreversible pulmonary disorders, because much of the disability and handicap results not from the respiratory disorder per se but from secondary morbidities that often are treatable if recognized.

Although the degree of airway obstruction or hyperinflation of chronic obstructive pulmonary disease (COPD) does not change appreciably with pulmonary rehabilitation, reversal of muscle deconditioning and better pacing enables patients to walk farther and with less dyspnea.

Pulmonary rehabilitation programs include prevention, early recognition and treatment of morbidities, and inpatient, outpatient, and extended care of patients with chronic respiratory illness.

The anticipated patient outcomes of a comprehensive pulmonary rehabilitation program include increased independence and improved QOL, as well as fewer hospitalizations or shorter hospitalization time.

According to the international classification of impairments, disabilities, and handicaps developed by the World Health Organization, a patient's specific outcomes are described as:

Disease is a pathologic condition of the body with a unique set of symptoms and signs, often resulting in impairment. The impairment may lead to functional deficit.

Impairment is any loss or abnormality of psychological, physical, or anatomic structure or function.

Disability is any restriction or lack of ability (as a result of an impairment) with regard to the performance of an activity in the manner or within the range that is considered normal for a human being.

Impairment of activities of daily living (ADL) has an impact on the capacity of the individual to live independently. A handicap is a disadvantage for a given individual, resulting from an impairment or a disability that limits or prevents the fulfillment of a role that is normal for that individual. For patients with pulmonary impairment, disability can be due to muscle dysfunction, primary skeletal or cardiopulmonary pathology, poor endurance, or some combination of impairments. The patient can be handicapped further by inadequate finances, inadequate family support or education, and various public policies.

Benefits

A successful rehabilitation program identifies and differentiates the disease process (impairments, disabilities, handicaps) so that remedial strategies can be determined. The functional consequences of these impairments are addressed so that the person with chronic respiratory impairment is returned to the fullest possible physical, mental, social, and economic independence.

The effectiveness of a comprehensive pulmonary rehabilitation program has been established by controlled clinical trials. In the only randomized study that has been conducted, survival benefit was not demonstrated, possibly because of the inability to detect the difference. Controlled trials have shown a decrease in health care resource use after rehabilitation, indicated by reduction in the number of

hospitalizations and emergency department or physician office visits. Although not conclusively proven, the effect of pulmonary rehabilitation on outcomes in patients without COPD may be substantial. Retrospective study has shown no significant difference in improvement in exercise tolerance or QOL following pulmonary rehabilitation in COPD versus non-COPD patients. Therefore, pulmonary rehabilitation is effective for patients with disability due to any chronic respiratory disease, not just COPD. Respiratory rehabilitation may improve prognosis in patients who develop COPD exacerbation.

Patient Selection and Assessment

Pulmonary rehabilitation is indicated for patients with chronic respiratory impairment who, despite optimal medical management, are dyspneic, have reduced exercise tolerance, or experience a restriction in activities. Indication for pulmonary rehabilitation is based not on the severity of physiologic impairment of the lungs but on the persistence of symptoms, disability, and handicap. Although COPD remains the major disease involved in referral for rehabilitation services, patients with other conditions may be appropriate candidates for pulmonary rehabilitation, because the same principles of improving secondary morbidity apply.

Examples include:

Asthma
Chest wall disease
Cystic fibrosis
Bronchiectasis
Interstitial lung disease
Lung cancer
Selected neuromuscular diseases
Post-polio syndrome
Perioperative conditions (thoracic or abdominal surgery, lung transplantation, lung volume reduction surgery).

Exclusion criteria include conditions interfering with rehabilitative processes or that could cause risk during exercise training. These include cognitive dysfunction, severe pulmonary hypertension, unstable angina, and recent myocardial infarction.

Assessment

Comprehensive assessment of the candidate for pulmonary rehabilitation is necessary for developing an appropriate, individualized plan of care. The clinical history, physical examination, and review of pertinent investigations (pulmonary function tests) are necessary to determine the severity of respiratory impairment. The determination of baseline exercise capacity is essential in formulating the exercise training prescription and in evaluating for hypoxemia during exercise. The assessment of exercise capacity may be performed using either incremental exercise testing or a timed, 6-minute walk test.

Other assessments that may be performed include:
Measurements of respiratory muscle strength (maximum inspiratory and expiratory pressures)
Measurement of peripheral muscle strength
Assessment of performance of ADL
Health status
Cognitive function
Emotional and mood state
Nutritional status and body composition

Questionnaires may be used to screen for anxiety and depression.
Beck depression inventory (BDI)
Geriatric depression scale (GDS)
Nutritional assessment is important, because changes in body weight, body composition, or eating habits are common in patients with advanced respiratory disease.
Body composition can be evaluated using anthropometry, bioelectrical impedance analysis, or dual-energy radiographic absorptiometry (DRA), which estimates lean body mass.

Pulmonary Rehabilitation Setting

Despite a substantial variability in program structure, the efficacy of pulmonary rehabilitation performed in inpatient, outpatient, or home settings has been documented. The structure and components of the program, rather than the setting itself, determine the effectiveness of pulmonary rehabilitation.
The choice of setting often depends on the variability and distance to the program, insurance payer coverage, patient preference, and the physical, functional, and psychosocial status of the patient.
Inpatient rehabilitation generally is recommended for patients affected to the greatest degree, because intensive rehabilitative services and specialized training for the patient and/or family will be available.
Outpatient rehabilitation, which can be hospital or community based, has the potential to benefit most patients but nonetheless requires a certain level of functional ability.
Although outcomes have not been well studied, home-based pulmonary rehabilitation is convenient for the patient and family members and may provide sustained motivation for continued exercise training.

Rehabilitation Team

Because rehabilitation offers a holistic and comprehensive approach to medical care, the combined expertise of an interdisciplinary team is necessary. The rehabilitation team is led by a physician specialist skilled in evaluating the neuromuscular, musculoskeletal, cognitive, and cardiopulmonary systems. The physician should be trained in cardiopulmonary and exercise fitness, ventilator management, and treatment of functional deficits. The physician should be skilled in working with a team of professionals, because he/she is responsible for the medical treatment and rehabilitation program.

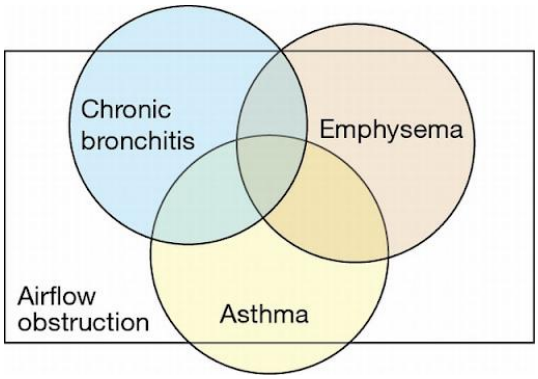
The other members of the rehabilitation team include:

Physical therapist
Occupational therapist
Rehabilitation nurse
Social worker
Respiratory therapist
Vocational counselor
Psychologist

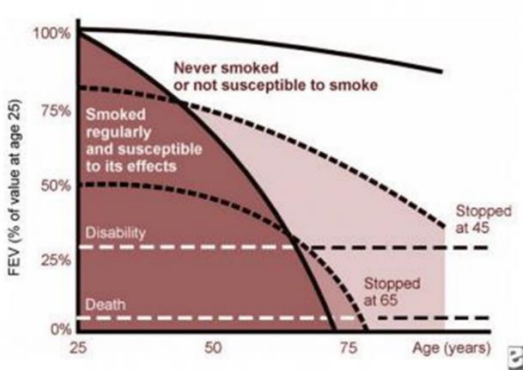
A successful team maintains coordination, cooperation, and open communication.
Each member also needs to have knowledge of the general principles of other members' approaches.

Medical Care Optimization

The goal of treatment is to preserve optimal lung function, thereby preventing symptoms and recurrence of exacerbations and, as a result, improving function in daily living, as well as QOL.
Once the diagnosis of COPD has been established, educate the patient about the disease. Encourage the patient to actively participate in therapy.



A Venn diagram shows that COPD is actually a combination of emphysema and chronic bronchitis. Many patients with COPD also have an asthmatic component.
Smoking cessation continues to be the most important therapeutic intervention. Many patients with COPD have a history of smoking, and many currently smoke.



The Fletcher and Peto diagram demonstrates the natural history of chronic obstructive pulmonary disease (COPD) and the benefits of smoking cessation, even when lung disease is advanced. A smoking cessation plan is an essential part of a comprehensive management strategy. The success rates of smoking cessation plans are low because of the addictive potential of nicotine, the conditioned response of individuals who smoke to smoking-associated stimuli, forceful promotional campaigns by the tobacco industry, poor education, and psychological problems faced by patients who attempt to quit smoking, including depression. Any smoking cessation program must involve multiple interventions.
One study that among 440 patients with COPD who attended a pulmonary rehabilitation program, cigarette smoking at enrollment was the lone independent risk factor for dropping out of the program.
In patients with stable disease, oral and inhaled medications are used to reduce dyspnea and improve exercise tolerance. Most of the medications employed are directed at 4 potentially reversible causes of airflow limitation in a disease state with largely fixed obstruction.

The following factors may be present:
Bronchial smooth muscle contraction
Bronchial mucosal congestion and edema
Airway inflammation
Increased airway secretion

The transition from smoking to abstention from smoking occurs in the following 5 stages:

1. Precontemplation
2. Contemplation
3. Preparation
4. Action
5. Maintenance

Smoking intervention programs include self-help, group, physician-delivered, workplace, and community programs.
Setting a quit date may be helpful.
Physicians and other health care providers should participate in setting the target date and should follow up with respect to maintenance.

Successful cessation programs usually employ such tools as:

Patient education
Establishment of a quit date
Follow-up support
Relapse prevention
Advice for healthy lifestyle changes
Social support systems
Adjuncts to treatment (medications)

According to the US Preventive Services Task Force (USPSTF) guidelines, healthcare team members should ask all adults about use of tobacco products and provide cessation interventions to current users.

The guideline engages a "5-A" approach to counseling that includes:

1. Ask about tobacco use.
2. Advise to quit through personalized messages.
3. Assess willingness to quit.
4. Assist with quitting.
5. Arrange follow-up care and support

Brief behavioral counseling (under 10 min) and medications are each effective alone, but they are most effective when used together.

Smoking Cessation Treatment Interventions

Nicotine replacement therapy:
Supervised use of pharmacologic agents is an important adjunct to self-help and group smoking cessation programs. Nicotine is the ingredient in cigarettes that is primarily responsible for addiction. Withdrawal from nicotine may cause adverse effects, including anxiety, irritability, difficulty concentrating, anger, fatigue, drowsiness, depression, and sleep disruption. These effects usually occur during the first several weeks of any attempt at smoking cessation. Nicotine replacement therapies after smoking cessation reduce withdrawal symptoms. A smoker who requires his/her first cigarette within 30 minutes of waking up is most likely to be highly addicted and could benefit from nicotine replacement therapy.
Several nicotine replacement therapies are available.
Nicotine polacrilex is a chewing gum with better quit rates than counseling alone.

Transdermal nicotine patches are available readily for replacement therapy. Long-term success rates range from 22-42%, compared to 2-25% with a placebo. These agents are well tolerated, and the adverse effects are limited to localized skin reaction. The usual drug-dosing schedule is the same for all 3 brands. Individuals who smoke more than 1 pack per day initially need a 21-mg patch, followed by 14-mg and 7-mg patches.

Nicotine replacement therapy chewing pieces are marketed in 2 strengths, 2 mg and 4 mg. An individual who smokes 1 pack per day should use 4-mg pieces. The 2-mg pieces are to be used by individuals who smoke less than 1 pack per day. Instruct patients to chew hourly, as well as at the time of their initial cravings for 2 weeks. Gradually reduce the amount chewed over the next 3 months.

The use of an antidepressant medication (bupropion) also is effective for smoking cessation. A study recorded sustained cessation at 1 year for 23% of smokers using bupropion (which enhances central nervous system non-adrenergic function), as opposed to sustained cessation for 12% of smokers using a placebo. Bupropion also is effective in patients who have not succeeded with nicotine replacement therapy.

The smoking cessation drug, varenicline (Chantix), is a partial agonist selective for alpha 4 beta 2 nicotinic acetylcholine receptors. Action is thought to result from activity at a nicotinic receptor subtype, where its binding produces agonist activity while simultaneously preventing nicotine binding. Agonistic activity is significantly lower than that of nicotine. Gradually titrate the dose upward within 1 week before the quit date to 1 mg twice a day orally after meals. Decrease the dose with severe renal impairment or end-stage renal disease.

Serious neuropsychiatric symptoms have been reported during post-marketing surveillance and may include changes in behavior, agitation, depressed mood, suicidal ideation, and attempted and completed suicide. These adverse events have been exhibited in patients without preexisting psychiatric illness, and patients with preexisting psychiatric illness have reported worsening symptoms during varenicline treatment.

Anti-inflammatory agents (inhaled steroids):

The minority of patients who respond to oral corticosteroids could be maintained on long-term inhaled steroids. Despite a lack of conclusive evidence to support the role of inhaled corticosteroids in the management of COPD, the use of these agents is widespread. Researchers have completed 3 large, placebo-controlled trials investigating the use of these agents in severe, mild, and very mild disease. Based on the rate of decline in the FEV1, results suggest that inhaled corticosteroids do not slow the decline in lung function but do decrease the frequency of exacerbations and improve disease-specific and health-related QOL. Inhaled corticosteroids have fewer adverse effects than do oral agents. Although effective, these agents improve expiratory flows less than oral preparations do, even at high doses. These agents may be beneficial in slowing the rate of progression in a subset of COPD patients who demonstrate rapid decline in pulmonary function.

Bronchodilators:

Inhaled beta 2–agonist bronchodilators activate specific B2-adrenergic receptors on the surface of smooth muscle cells. This raises levels of intracellular cyclic adenosine monophosphate (AMP) and increases smooth muscle relaxation. Patients, even those who have no measurable increase in expiratory flow, benefit from treatment using beta 2 agonists.

Methylxanthines have decreased in popularity because of their narrow therapeutic range and frequent toxicity. Their mechanism of action may involve increased intracellular calcium transport, adenosine antagonism, and inhibition of prostaglandin E2. Additionally, methylxanthines may improve diaphragm muscle contractility.

Beta-2 agonists:
Beta-2 agonists produce less bronchodilation in patients with COPD than they do in patients with asthma. Spirometric changes may be insignificant, despite symptomatic benefit. Patients primarily use beta-2 agonists for relief of symptoms of COPD. Inhaled beta-2 agonists are the initial treatment of choice for acute exacerbations of COPD. In stable patients, beta-2 agonists have an additive effect when used with an anticholinergic agent (ipratropium bromide).
Although oral preparations of beta-2 agonists are available, the preferred route of administration is inhalation. Use a spacer, if indicated, to improve aerosol delivery and reduce adverse effects.

Long-acting bronchodilators:
Two long-acting beta-2 agonists, formoterol and salmeterol, are available. They improve symptoms and morning peak flows and may be useful when bronchodilators are used frequently. More studies should establish the best role for these agents.

Anticholinergic agents:
Treatment with aerosolized anticholinergic agents (ipratropium bromide) may be more effective than a beta-2 agonist would be in patients with COPD. Ipratropium bromide has bronchodilatory activity with minimum adverse effects and is administered by a metered dose inhaler. Studies in patients with stable COPD have shown that ipratropium bromide has equivalent or superior activity when compared with a beta-2 agonist. In combination with a beta-2 agonist, there is an additional 20-40% bronchodilation. This medication has slower onset and a longer duration than a beta-2 agonist and is less suitable for use as needed. Inhaled anticholinergic bronchodilators do not influence the long-term decline of FEV1. Initiate regular therapy with an ipratropium at 2-4 puffs 4 times a day and add a beta-2 agonist as needed.
Anticholinergic drugs compete with acetylcholine for postganglionic muscarinic receptors. These agents thereby inhibit cholinergically mediated bronchomotor tone, resulting in bronchodilation. They block vagally mediated reflex arcs that cause bronchoconstriction. The onset of action is slower (30-60 min).
Long-acting bronchodilators:
Theophylline improves respiratory muscle function, stimulates the respiratory center, and promotes bronchodilation, in addition to demonstrating anti-inflammatory effects. Adding theophylline to the combination of bronchodilators can be of further benefit to patients with stable COPD. The response to theophylline therapy may vary among patients with severe COPD. Patients metabolize theophylline primarily with the hepatic enzyme system, in a process that is affected by age, as well as by heart and liver abnormalities. Because of theophylline's potential for toxicity, monitor serum levels of theophylline during therapy. Adverse effects include anxiety, tremors, insomnia, nausea, cardiac arrhythmia, and seizures.

Oral steroids

The use of corticosteroids requires a careful evaluation for individual patients who, despite being on adequate bronchodilator therapy, develop an exacerbation or fail to improve sufficiently. Most studies suggest that 10-20% of patients with COPD improve if given chronic oral steroid therapy. Carefully document the effectiveness of such therapy (>20% improvement in FEV1) before giving a patient prolonged daily or alternate-day treatment. Researchers found a positive correlation between bronchial eosinophilia and bronchodilator response in patients who had mild to moderate airflow obstruction. Outpatients have successfully used oral steroids to treat acute exacerbations. However, after stabilization, gradually weaning the patient off oral corticosteroids is suggested because of the potential adverse effects of these agents.

In a meta-analysis of 16 controlled trials in patients with stable COPD, researchers found that approximately 10% of these patients responded to these drugs. An increase in FEV1 of more than 20% has been used as a surrogate marker for steroid response. In acute exacerbation of COPD, use steroids routinely to improve symptoms and lung function.

Antibiotics

In patients with COPD, chronic infection or colonization of the lower airways is common from Streptococcus pneumoniae and Haemophilus influenzae. Empiric antimicrobial therapy must be comprehensive and should cover all likely pathogens in the context of the clinical setting. The goal of antibiotic therapy in COPD is not to eliminate the organisms, but to treat acute exacerbations. Exacerbations are indicated by increased sputum purulence and volume, as well as by the development of dyspnea along with other features, including fever, leukocytosis, or infiltrate on a chest x-ray.

The first-line treatment choices include amoxicillin, cefaclor, and trimethoprim/sulfamethoxazole. Second-line antibiotic regimens are the more expensive antibiotics, including azithromycin, clarithromycin, and fluoroquinolones. The use of antibiotics in patients with COPD is supported by the results of a meta-analysis showing that patients who receive oral antibiotic therapy have a small, but clinically significant, improvement in peak expiratory flow rate and a rapid resolution of symptoms.

Mucolytic agents

Mucolytic agents reduce sputum viscosity and improve secretion clearance. Viscous lung secretions in patients with COPD consist of mucus-derived glycoproteins and leukocyte-derived DNA. The oral agent N-acetylcysteine has antioxidant and mucokinetic properties. It is used to treat patients with COPD.

Oxygen therapy

COPD commonly is associated with progressive hypoxemia. Oxygen reduces mortality rates in patients with advanced COPD because of the favorable effects on pulmonary hemodynamics. Studies showed that long-term oxygen therapy improves survival 2-fold or more in hypoxemic patients with COPD. Hypoxemia is defined as PaO2 of less than 55 mm Hg or as oxygen saturation of less than 90%. Oxygen was used from 15-19 hours per day.

Long-term oxygen therapy for patients with a PaO2 of less than 55 mm Hg and a PaO2 of less than 59 mm Hg with evidence of polycythemia or cor pulmonale is recommended. These patients need to be reevaluated 1-3 months after initiating therapy, because some patients may not require long-term oxygen. The condition of many patients with COPD who are not hypoxemic at rest worsens during exertion.

Determining the long-term benefit of oxygen solely for exercise is inconclusive, home supplemental oxygen commonly is prescribed for these patients. Oxygen supplementation during exercise can reduce dyspnea, improve exercise tolerance, and prevent increases in pulmonary artery pressure.
Oxygen therapy generally is safe. Oxygen toxicity from high-inspired concentrations (more than 60%) is well recognized. Little is known about the long-term effects of low-flow oxygen.
The increased survival and QOL benefits of long-term oxygen therapy outweigh the possible risks.
PaCO2 retention from depression of hypoxic drive has been overemphasized. PaCO2 retention is more likely a consequence of ventilation/perfusion mismatching rather than of respiratory center depression. Although this complication is not common, it is best avoided by titration of oxygen delivery in order to maintain PaO2at 60-65 mm Hg.
The major physical hazards of oxygen therapy are fires and explosions. Patients, family members, and other caregivers must be warned not to smoke. Overall, however, major accidents are rare and can be avoided by good patient and family training.

Comprehensive Pulmonary Rehabilitation

Comprehensive pulmonary rehabilitation programs generally have the following 4 major components:

1. Exercise training
2. Education
3. Psychosocial/behavioral intervention
4. Outcome assessment

These interventions are provided by a multidisciplinary team that often includes physicians, nurses, respiratory therapists, physical therapists, occupational therapists, psychologists, and social workers.

Exercise Training

Exercise training is the foundation of pulmonary rehabilitation. Exercise does not alter underlying respiratory impairment, but it does improve dyspnea and other outcome measures. Exercise prescription emphasizes endurance training targeted at 60% of maximal workload for about 20-30 minutes, repeated 2-5 times a week. Generally, this training is well tolerated.
An interval training regimen consisting of 2-3 minutes of high-intensity training (60-80% maximal exercise capacity) alternating with equal periods of rest might be a substitute for patients who cannot tolerate sustained activity. Dyspnea ratings during maximal graded exercise testing may offer reliable predictions of exercise intensity during training. Consequently, most pulmonary programs for the improvement of aerobic capacity use dyspnea targeting to guide training intensity. The training specificity refers to the benefit gained only in those activities involving the specific muscle groups that are trained. Because the performance of many ADL involves the use of the arms, endurance training of the upper extremities to improve arm function is important. Supported arm exercises are prescribed with ergometry or unsupported arm exercises by lifting free weights or stretching armbands.
Because peripheral muscle weakness contributes to exercise limitation in patients with lung disease, strength training is a rational component of exercise training during pulmonary rehabilitation. Even low-intensity leg and arm muscle conditioning has led to reduced ventilatory equivalent for oxygen and carbon dioxide.

A regular walking schedule is an important component of pulmonary rehabilitation. Walking distance is increased progressively, and oxygen supplementation often is used in a patient who desaturates with exercise. Lower extremity exercise by stationary bicycling improves strength and endurance.
The reversibility of training effects is well known. The effects of training are maintained only as long as exercise is continued. Therefore, efforts at improving long-term adherence with exercise training at home are necessary for the long-term effectiveness of pulmonary rehabilitation.
In patients with COPD who have undergone pulmonary rehabilitation, participation in an exercise maintenance program leads to improvements in exercise capacity, QOL, and dyspnea. Six months after pulmonary rehabilitation, persons who engaged in increased physical activity in the intervening time improved by 62 meters on the six-minute walk distance test.

Respiratory Muscle Training

Respiratory muscle training using adequate loads improves the strength of the inspiratory muscles in patients with COPD. However, it remains unclear whether this improvement results in a decrease in symptoms, disability, and handicap. Although improvement in inspiratory muscle strength is accompanied by decreased breathlessness and increased respiratory muscle endurance, the benefits have not been well established.

Education

Education is an integral part of comprehensive pulmonary rehabilitation programs, encouraging active participation in health care, which leads to a better understanding of the physical and psychological changes that occur with chronic illness. With education, patients can become more skilled at collaborative self-management and have improved compliance.
In small groups or on an individual basis, the following topics generally are covered:

- Energy conservation and work simplification
  - These principles assist patients in maintaining ADL and in performing job-related tasks. The methods include paced breathing, optimization of body mechanics, advanced planning, prioritization of activities, and use of assisted devices.
- Medications and Other Therapies
  - Education about types of medication and about the action, adverse effects, dose, and proper use of all oral and inhaled medication is an important part of a comprehensive pulmonary rehabilitation program.
  - Instructions in metered-dose inhaler technique and spacer devices, as well as appropriate use of oxygen, are particularly important.
- End-of-life education
  - Because of the progressive nature of COPD, risk of respiratory failure increases over time.
  - Unfortunately, clinical factors that are assessable at the onset of respiratory failure caused by COPD are poor predictors of the outcome of mechanical ventilation.
  - The decision to initiate life support, therefore, requires patients to determine the acceptability of life-sustaining care by combining their own personal values and life goals with their physician's uncertain estimates of a meaningful recovery.

Education during pulmonary rehabilitation provides patients with an understanding of life-sustaining interventions and of the importance of advanced planning.

Psychosocial and Behavioral Intervention

Anxiety, depression, difficulties in coping with chronic lung disease, and the inability to cope with illness contribute to the handicap of advanced respiratory disease. Psychosocial and behavioral interventions in the form of regular patient education sessions or support groups focusing on specific problems are very helpful. Instructions in progressive muscle relaxation, stress reduction, and panic control may help to reduce dyspnea and anxiety. Because of the effects of chronic respiratory disease on the family, participation of family members or friends in pulmonary rehabilitation support groups is encouraged. Depression is often comorbid with COPD. The prevalence rate for morbid depression in patients with COPD ranges from 20-60%. The etiologies for this elevated rate include genetic predisposition, grief reaction, and the effects of COPD on the central nervous system. Once depression develops, patients are less likely to follow treatment plans. They lose function and there is a potential for them to suffer worse outcomes in exacerbations. Few data demonstrate the efficacy of antidepressants in this population, although some studies suggest selective serotonin reuptake inhibitors to be effective. Other interventions, including psychotherapy, physical rehabilitation, and improved social support, may also be effective, but additional study is needed before their effectiveness can be proven.

Chest Physical Therapy and Breathing Techniques

Controlled breathing techniques and chest physical therapy are the 2 major components of the multidisciplinary approach to the rehabilitation of patients with COPD, bronchiectasis, and cystic fibrosis. Although only smoking cessation and long-term oxygen therapy prolong life in patients with COPD, it is likely that chest physical therapy does the same for persons with cystic fibrosis and diffuse bronchiectasis. The 3 major breathing techniques include the following:

Pursed-lip breathing

Patients exhale slowly for 4-6 seconds through pursed lips held in a whistling position. This technique relieves dyspnea by increasing expiratory airway pressure, thereby inhibiting dynamic expiratory airway collapse.

Patients also shift their breathing pattern from a rapid respiratory rate, which is under involuntary respiratory center control, to a slower, more controlled pattern governed by voluntary cortical function. The overall work of breathing does not change and, in fact, may increase slightly.

The pursed-lip breathing shifts a major portion of the inspiratory work of breathing from the diaphragm to the ribcage muscles, resting the diaphragm and reducing dyspnea.

Posture techniques

Leaning-forward postures frequently relieve dyspnea in patients with COPD by reducing respiratory effort. The shifting of abdominal contents elevates the depressed diaphragm cranially, resulting in improved performance.

The most benefit occurs in patients with severe hyperinflation, who have paradoxical inward movement of the upper abdomen.

Diaphragmatic breathing

Some patients may benefit from this technique. The patient is taught to employ only the diaphragm during inspiration and to maximize abdominal protrusion.
During expiration, the patient may contract the abdominal wall muscles to displace the diaphragm more cephalad.
Not all patients with COPD benefit from this technique. Close clinical monitoring to ascertain efficacy is required.

Chest physical therapy, along with postural drainage, enhances mucus clearance from central and peripheral lung airways. The value of this therapy in stable patients with COPD and in acute COPD exacerbation is uncertain. For patients who produce more than 30 mL of sputum every 24 hours or who have difficulty with sputum expectoration, chest physical therapy combined with postural drainage and effective coughing techniques enhances sputum expectoration.
Chest physical therapy remains an essential component of therapy for bronchiectasis and cystic fibrosis. The frequency of treatments must be individualized based on the severity of disease and on the quantity of airway secretions that must be cleared. Standard chest physical therapy with postural drainage, cough, and the forced expiratory technique is the cornerstone of such treatment regimen. Newer modalities, such as mechanical chest percussion and mask positive airway pressure, warrant further clinical trials before they can be used routinely. Chest physiotherapy is essential for the management of atelectasis in postoperative or seriously ill patients with COPD who are hospitalized. A flutter device is sometimes used to aid in sputum expectoration in patients with bronchiectasis or chronic bronchitis who have a large amount of sputum production.

Outcome Assessment

Outcome assessment is an important component of a comprehensive pulmonary rehabilitation program, being used to determine individual patient responses and to evaluate the overall effectiveness of the program.
Measurement of outcomes should be incorporated into every comprehensive pulmonary rehabilitation program. Minimal requirements include the assessment of the following measures of the patient's recovery before and after rehabilitation:

Dyspnea
Exercise ability
Health status
Activity levels

Consideration also should be given to follow-up measurements after longer periods of time, such as 6 and/or 12 months.

Measures of Disability

Exercise testing

Progressive exercise testing on a stationary bicycle or treadmill is performed to a heart rate of 85% of predicted maximum.
Dyspnea during exertion can be rated using a visual analogue scale.
This test is reproducible and is sensitive to improvements from pulmonary rehabilitation.

Instead of an incremental increase in work rate, endurance capacity can be measured at a constant fraction of maximal work rate.
A longer exercise time indicates greater exercise endurance and leads to a reduction in ventilatory requirements.

Walking Tests

The 6-minute and 12-minute walking tests, as well as shuttle walking tests, correlate positively to peak exercise performance on graded exercise tests. The minimal increase that is clinically meaningful in 6-minute walking distance is about 54 meters.

Exertion and Overall Dyspnea

Dyspnea is the most common symptom of individuals with chronic pulmonary disease and is frequently the major reason for seeking acute care.
Dyspnea during exercise usually is measured with a category scale, such as the Borg scale or the visual analogue scale.
The effect of dyspnea on daily activities can be measured with the Medical Research Council dyspnea questionnaire or with the dyspnea component of the chronic respiratory disease questionnaire.
The relief in dyspnea correlates with a fallen ventilatory demand during exercise, indicating a training effect.

Respiratory Specific Functional Status

Functional capacity is what the patient is capable of doing, whereas functional performance is what the patient actually does on a day-to-day basis.
Functional reserve is the difference between the two of these.
Pulmonary rehabilitation improves a patient's functional reserve.
Functional status usually is measured by a questionnaire, which estimates the impact of the program on various activities.

Measures of Handicap and QOL

A health-related QOL (Quality of Life) instrument can assess the overall benefit of improvements in the patient's symptoms, disability, and handicap.
QOL has been described as a person's satisfaction or happiness with life in demands that the patient considers important.
QOL may be considered a balance between what is desired in life and what is achieved (although these indicators are difficult to measure).

In rehabilitation, the following instruments have been used:

General health questionnaires, such as sickness impact profile and short form
Disease-specific scales, such as the chronic respiratory disease questionnaire
The St George respiratory questionnaire

Chronic Respiratory Disease Questionnaire (CRQ)

An interviewer-administered questionnaire measuring both physical and emotional aspects of chronic respiratory disease.
4 categories: dyspnea, fatigue, emotional function, mastery.
20 items, 15-25 minutes
Numerical, 7-point scale
Total score; higher score indicates better Health-related quality of life (HRQOL)
A change in score of 0.5 on the 7-point scale reflects a Minimal Clinically Important Difference (MCID)
1.0 – moderate change
1.5 – large change

St George Respiratory Questionnaire
The patient with fixed and reversible airway obstruction
Three domains:
Symptoms (frequency, severity)
Activity (activities that cause or are limited by breathlessness)
Impacts (social functioning, psychological disturbances resulting from airway disease)
Symptoms (5-point scale), Activity and Impacts (yea/no)
76 items, 10 minutes
Self, face-to-face, telephone interview
Scoring rand from 0 to 100 (worst score)
A change of 4 units is deemed clinically significant Minimal Clinically Important Difference (MCID)
The disease-specific measures demonstrate greater sensitivity to change from baseline after rehabilitation intervention.
The cost-effectiveness of pulmonary rehabilitation is largely unknown. One study determined the cost-effectiveness of a community-based pulmonary rehabilitation program for COPD. Over 1 year, pulmonary rehabilitation was associated with decreased health service use, reduced direct costs, and improved health status for patients with COPD. Thus, pulmonary rehabilitation is cost-effective for patients with a relatively high use of emergency and hospital-based services.

Patient Adherence

A study indicated that among patients with COPD, adherence to a pulmonary rehabilitation program can be improved by:

- Building patient confidence such as by helping patients to manage feelings of fear and vulnerability that a diagnosis of COPD can engender.
- Helping patients achieve immediate, tangible results from the program such as teaching patients breathing and walking techniques that produce immediate improvements in mobility.
- Helping patients become mentally ready to engage in the program and aiding them in gaining access to it such as introducing patients slowly to the program and clearly explaining to them the importance of pulmonary rehabilitation, as well as by helping them to deal with issues, such as transportation, that may limit their access to the program.

Cardiac Rehabilitation

Cardiac rehabilitation aims to reverse limitations experienced by patients who have suffered the adverse pathophysiologic and psychological consequences of cardiac events.

Cardiovascular disorders are the leading cause of mortality and morbidity in the industrialized world, accounting for almost 50% of all deaths annually. The survivors constitute an additional reservoir of cardiovascular disease morbidity. In the United States alone, over 14 million persons suffer from some form of coronary artery disease (CAD) or its complications, including congestive heart failure (CHF), angina, and arrhythmias. Of this number, approximately 1 million survivors of acute myocardial infarction (MI), as well as the more than 300,000 patients who undergo coronary bypass surgery annually, are candidates for cardiac rehabilitation.

Traditionally, cardiac rehabilitation has been provided to somewhat lower-risk patients who could exercise without getting into trouble. However, astonishingly rapid evolution in the management of CAD has now changed the demographics of the patients who can be candidates for rehabilitation training. Currently, about 400,000 patients who undergo coronary angioplasty each year make up a subgroup that could benefit from cardiac rehabilitation. Approximately 4.7 million patients with CHF are also eligible for a slightly modified program of rehabilitation, as are the ever-increasing number of patients who have undergone heart transplantation.

The major goals of a cardiac rehabilitation program are:

- Curtail the pathophysiologic and psychosocial effects of heart disease
- Limit the risk for reinfarction or sudden death
- Relieve cardiac symptoms
- Retard or reverse atherosclerosis by instituting programs for exercise training, education, counseling, and risk factor alteration
- Reintegrate heart disease patients into successful functional status in their families and in society

Cardiac rehabilitation programs have been consistently shown to improve objective measures of exercise tolerance and psychosocial wellbeing without increasing the risk of significant complications.

Phases of Cardiac Rehabilitation

Cardiac rehabilitation services are divided into 3 phases, as follows:

Phase 1 - Initiated while the patient is still in the hospital

Phase 2 - A supervised ambulatory outpatient program spanning 3-6 months

Phase 3 - A lifetime maintenance phase in which physical fitness and additional risk-factor reduction are emphasized

Patient Selection

Cardiac rehabilitation encompasses short-term and long-term goals that are to be achieved through exercise, education, and counseling.

Patients generally fall into following categories:

- Lower-risk patients following an acute cardiac event
- Patients who have undergone coronary bypass surgery
- Patients with chronic, stable angina pectoris
- Patients who have undergone heart transplantation
- Patients who have had percutaneous coronary angioplasty

Patients who have not had prior events but who are at risk because of a remarkably unfavorable risk factor profile
Patients with stable heart failure
Patients who have undergone noncoronary cardiac surgery
Patients with previously stable heart disease who have become seriously deconditioned by intercurrent, comorbid illnesses

The short-term goals of cardiac rehabilitation include the restoration of the physical, psychological, and social condition, while the long-term goals involve the promotion of heart-healthy behaviors that enable the individual to return to productive and/or joyful vocational and avocational activities.
The cardiac rehabilitation programs benefit women and men equally. Elderly patients also can derive significant benefit from rehabilitation programs.

Risk Stratification

The risk stratification process is very valuable for cardiac patients. It serves as the basis for individualizing the prescription of exercise training and for assessing the need and extent of supervision required. The risk stratification process is based on the assessment of the patient's functional capacity, on the patient's educational and psychosocial status, on whether alternatives to traditional cardiac rehabilitation can be used, and on whether the patient is suffering from myocardial ischemia, ventricular dysfunction, or arrhythmias.

Functional Capacity

The term functional capacity refers to the maximum ability of the heart and lungs to deliver oxygen and the ability of the muscles to extract it. Functional capacity is measured by determining the maximal oxygen uptake (VO2 max) during incremental exercise.
In most patients, a rough calculation of functional capacity can be performed by using multiples of 1 MET (metabolic equivalent, 3.5 mL O2 uptake/kg/min). In complicated patients, such as those with severe left ventricular (LV) dysfunction and congestive heart failure (CHF), the functional capacity can be ascertained with greater accuracy by using cardiopulmonary exercise (CPX) testing. Most cardiac rehabilitation facilities, however, are not currently equipped for CPX.

The following factors influence functional capacity:

Age
Precardiac event physical capacity
Treatments and bed rest during the event
Fluid volume, such as relative dehydration or volume overload in patients with CHF
LV dysfunction
Residual myocardial ischemia
Skeletal muscle performance, such as deconditioning or in the presence of concurrent, noncardiac illness
Autonomic function, such as diabetic neuropathy
Peripheral vascular status
Pulmonary status
Other systemic illnesses, especially orthopedic problems limiting flexibility and locomotion

Every attempt should be made to recognize the potential effects of these factors on functional capacity in order to minimize risk of the individualized reconditioning program that is being formulated.

Myocardial Ischemia

Symptomatic or asymptomatic (silent) myocardial ischemia may limit the patient's exertional capacity by causing limiting angina, dyspnea, or fatigue.

Ventricular Dysfunction

Fixed LV dysfunction or damage may be present in the absence of angina. Patients with LV dysfunction develop early dyspnea and easily become fatigued.

Cardiopulmonary exercise testing preferably should be performed to determine the functional capacity in an objective manner.

Exercise intolerance in patients with LV dysfunction is due to skeletal muscle hypoperfusion resulting from inadequate cardiac output that can be better quantified by measuring VO2 max. [18]

Arrhythmias

Ventricular irritability and complex ventricular arrhythmias require assessment through the use of signal-averaged electrocardiogram (ECG) or electrophysiologic studies.

Appropriate medical or device treatments should be undertaken whenever feasible prior to beginning phase 2 of the cardiac rehabilitation program.

Very close surveillance is necessary in patients with significant cardiac arrhythmias during their exercise training routines. Concomitant rhythm monitoring with telemetry, Holter or event monitoring should be considered. In many cases of serious arrhythmias, therapy remains controversial and the safety of exercise is unclear; such uncertainties complicate the decision-making process.

Patients with severe ventricular arrhythmias and uncontrolled supraventricular arrhythmias should be excluded from exercise training unless proper evaluation and effective therapy has been instituted.

Patients with devices, such as pacemakers and defibrillators, should be carefully monitored during exercise. Rate-responsive pacemakers are quite helpful even for those patients who are completely pacemaker-dependent. In case of implantable cardioverter defibrillators (ICDs), exercise training can be provided as long as underlying arrhythmias are controlled with pharmacotherapy. Heart rate should be kept well below the threshold at which the antitachycardia algorithm of the ICD begins.

Educational and Psychosocial Status

Approximately 20-25% of acute myocardial infarction (MI) patients demonstrate severe psychological stress or major depression. These patients also show higher morbidity and mortality. Clinically significant depressive symptoms are found in 40-65% of patients after an MI.

Exercise does provide some benefit, but severe cases may require specific therapy that has been shown to enhance the benefits derived from subsequent cardiac rehabilitation.

The promotion of self-efficacy and control over one's activities is of paramount importance for boosting self-confidence.

Coronary-prone behavior (CPB) is known as a cardiac risk factor, but its effect on prognosis is unclear. Some data suggest that the modification of CPB can improve the coronary disease prognosis.

Initially, continuous ECG monitoring is recommended for most patients during cardiac rehabilitation exercise training; however, clinicians may decide whether to use continuous or intermittent ECG

monitoring. After the initial period, the use of electrocardiography depends on the clinical judgment of the supervising physician.

Alternative Approaches to Cardiac Rehabilitation

In carefully selected patients, alternatives to the traditional supervised (group or individual) cardiac rehabilitation program have been examined. These alternatives, which are applicable primarily to very low-risk patients, include the following options:

- Home-based cardiac rehabilitation (effective and safe)
- Exercise with transtelephonic monitoring/surveillance

Cardiac Rehabilitation in Patients with Heart Failure

Heart rate recovery (HRR) following maximal exercise has been found to be a predictor of all-cause mortality. In a 2006 study, Streuber and colleagues hypothesized that aerobic exercise training could improve HRR in patients who have suffered heart failure, because athletes are known to have accelerated HRR, while cardiac rehabilitation has been shown to positively effect such recovery in patients with coronary artery disease (CAD). The authors conducted a retrospective study of 46 patients with heart failure who had completed a phase 2 aerobic cardiac rehabilitation program with entry and exit maximal stress tests. The results indicated that in patients with heart failure who have low exercise capacity, even short-term aerobic training can aid HRR.

Exercise Testing and Exercise Prescription

Cardiac rehabilitation initially was designed for low-risk cardiac patients. Now that the efficacy and safety of exercise have been documented in patients previously stratified to the high-risk category, such as those with congestive heart failure (CHF), the indications have been expanded to include such patients. Exercise training benefits persons with the cardiac conditions such as recent myocardial infarction, coronary bypass, valve surgery, coronary angioplasty, cardiac transplantation, angina, and compensated CHF.

Exercise prescription depends on the results of exercise testing, which often includes cardiopulmonary exercise (CPX) testing.

Modifications of Exercise

Patients with limitations due to chronic obstructive pulmonary disease (COPD), peripheral vascular disease (PVD), stroke, and orthopedic conditions still can be trained in the exercises through special techniques and adaptive equipment (such as use of arm-crank ergometer).

Contraindications

Cardiac rehabilitation services are contraindicated in patients with the following conditions:

- Severe residual angina
- Uncompensated heart failure
- Uncontrolled arrhythmias
- Severe ischemia, LV dysfunction, or arrhythmia during exercise testing
- Poorly controlled hypertension
- Hypertensive or any hypotensive systolic blood pressure response to exercise
- Unstable concomitant medical problems (such as poorly controlled or "brittle" diabetes, diabetes prone to hypoglycemia, ongoing febrile illness, active transplant rejection)

In such patients, every effort should be made to correct these abnormalities through optimization of medical therapy, revascularization by angioplasty or bypass surgery, or electrophysiologic testing and subsequent antiarrhythmic drug or device therapy. Patients should then undergo retesting for exercise prescription.

Exercise Testing

Two forms of exercise tests are performed in patients following an acute cardiac event: submaximal exercise testing and symptom-limited exercise testing. CPX also may be performed, particularly in patients with cardiomyopathy or CHF, to determine objectively the patient's exercise capacity.

Submaximal Exercise Testing

In this strategy, the patients exercise enough to achieve 70% of maximum predicted heart rate for their age (70% of 220 minus age in years).

This test is commonly performed prior to discharge and is followed by maximal exercise testing 6-8 weeks later (when patients aim to achieve 90% of maximum predicted heart rate).

Symptom-Limited Exercise Testing

The patients exercise soon after a cardiac event.

A representative schedule might begin exercise at intervals, such as 7-21 days following uncomplicated acute myocardial infarction (MI), 3-10 days following angioplasty, or 14-28 days after bypass surgery.

Submaximal exercise testing is not necessarily safer than symptom-limited testing. In fact, the submaximal strategy may have certain disadvantages. It can lead to inappropriate limitation in the patient's routine activities and exercise training and to a significant delay in the patient's return to work. The use of submaximal exercise may also result in a failure to elicit important factors in prognosis, such as ischemia, cardiac dysfunction, and arrhythmia.

CPX Testing

Incremental exercise is employed, using modified Naughton protocol for treadmill or modified protocols on a bicycle ergometer. Concomitant minute-to-minute breath analysis and measurement of oxygen consumption and elimination of carbon dioxide are performed to determine VO2 max, which is the most objective method of determining functional capacity in patients with cardiac dysfunction, valvular disease, or recent acute cardiac event.

Modified Bruce or Naughton protocols typically are used during the testing phase, because the standard Bruce protocol has been modified to avoid too abrupt an increase in METs (by 2-3 METs per stage).

The modified Naughton protocol starts at a lower MET workload and increases by 1 MET per stage, thus allowing better-tolerated gradual progression in exercise and a more accurate assessment of exertional capacity.

The usual symptomatic endpoints are fatigue and breathlessness.

Severe abnormalities found on stress testing may contraindicate exercise training until they have been corrected. Less severe abnormalities, such as the development of symptoms at high workloads, may not necessarily contraindicate exercise training. However, certain modifications and closer surveillance may be required, including ECG monitoring.

Some reports have questioned early exercise training following acute anterior MI, suggesting that it may lead to abnormal scar formation. Evidence is strong that moderate exercise training is not associated with worsening LV function in patients following acute anterior MI.

Exercise Prescription and Surveillance

Phase 2 of a cardiac rehabilitation program is initiated based on the result of the exercise testing, and the exercise prescription is individualized.

The minimum frequency for exercising to improve cardiovascular fitness is 3 times weekly.

Patients usually need to allow 30-60 minutes for each session, which includes a warm-up of at least 10 minutes

The intensity prescribed is in relation to one's target heart rate. Aerobic conditioning is emphasized in the first few weeks of exercise. Strength training is introduced later. The Borg scale of Rate of Perceived Exertion (RPE) is used. Patients usually should exercise at an RPE of 13-15.

BORG'S RPE 6-20 SCALE		
6	20% effort	Very, very light (rest)
7	30% effort	
8	40% effort	
9	50% effort	Very light – gentle walking
10	55% effort	
11	60% effort	Fairly light
12	65% effort	
13	70% effort	Moderately hard – steady pace
14	75% effort	
15	80% effort	Hard
16	85% effort	
17	90% effort	Very hard
18	95% effort	
19	100% effort	Very, very hard
20		Exhaustion

Cardiac rehabilitation is an important component of the current multidisciplinary approach to the management of the patients with various presentations of coronary heart disease. Cardiac rehabilitation involves exercise training, education, counseling regarding risk reduction and lifestyle modification, and, frequently, behavior interventions.

The goals of cardiac rehabilitation services are to improve the physiologic and psychosocial condition of patients. Physiologic benefits include the improvement of exercise capacity and the reduction of risk factors (such as cessation of smoking and lowering of lipid levels, body weight, blood pressure, blood glucose), with the exercise component provided through rehabilitation possibly reducing the progression of atherosclerosis. Psychological improvements include the reduction of depression, anxiety, and stress. All of these improvements enable the patient to acquire and maintain functional independence and to return to satisfactory and appropriate activity that benefits the patient and society.

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