

Pulmonary Rehabilitation for Patients with Chronic Airways Obstruction

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Pulmonary rehabilitation is a patient-centered and interdisciplinary intervention with major components of exercise training and self-management education. Although having no direct effect on lung function, this intervention often results in substantial improvements in respiratory symptoms, functional status, and health status. It probably also reduces subsequent health care utilization, especially when provided after a hospitalization for an exacerbation of airways disease. The beneficial effects of pulmonary rehabilitation reflect its ability to reduce the impact of systemic consequences of chronic respiratory disease and to improve patients' self-efficacy through promoting collaborative self-management. Pulmonary rehabilitation is indicated for patients with respiratory diseases (regardless of specific diagnosis) who have persistent symptoms or functional or health status limitation despite otherwise optimal medical therapy. Those patients with severe asthma (particularly those with airways remodeling) or asthma-chronic obstructive pulmonary disease overlap who have daily symptoms and substantial functional/health status limitation despite controller and bronchodilator therapy would be appropriate candidates for pulmonary rehabilitation. © 2015 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2015;3:512-8)

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The 2 major categories of airways obstruction—asthma and chronic obstructive pulmonary disease (COPD)—are usually easily distinguishable pathologically, physiologically, and clinically. However, these 2 common diseases are often present in the same individual. Furthermore, some patients with asthma go on to develop fixed airflow limitation (airways remodeling), with resultant decreased variability in symptoms, less response to bronchodilator therapy, more chronic exertional dyspnea, a higher frequency of exacerbations, and greater health care

utilization.¹ In other words, these particular patients behave functionally more like patients with COPD than like patients with typical asthma. Although COPD remains the most common referral diagnosis to pulmonary rehabilitation, those with the overlap syndrome of asthma and COPD are also candidates for traditional, comprehensive pulmonary rehabilitation, with its major components of exercise training and promotion of self-efficacy.

Pulmonary rehabilitation is not a one-size-fits-all intervention; rather, it addresses the symptoms, functional limitations, educational needs, and therapeutic requirements of the individual patient. As such, rehabilitation for severe asthma or asthma-COPD overlap will by convention be tailored to the unique requirements of this patient. Examples might include promotion of adherence to disease-modifying therapy such as inhaled corticosteroids, implementation of an exacerbation action plan in frequent exacerbators, and promotion of a healthy lifestyle, including regular exercise and physical activity.

The following discussion will consider the rationale for pulmonary rehabilitation in those individuals with obstructive airways disease who remain symptomatic or have reduced functional or health status despite otherwise optimal medical therapy. The need for distinguishing the entities—asthma and COPD—is less important than referring appropriate patients to this intervention.

CASE PRESENTATION: MRS CD

A 76-year-old woman with no history of cigarette smoking was referred to pulmonary rehabilitation because of gradually increasing exertional dyspnea over about 1 year. By the time of her referral, her dyspnea had progressed to the point where she became breathless when walking 100 m on level ground at her own pace. Her medical history includes systemic hypertension and hyperlipidemia. She had no history of respiratory disease and, until her symptoms progressed, would walk regularly with her husband (at his pace) for 2 miles several times a week. By the time of her arrival at pulmonary rehabilitation, she had given up regular exercise and some activities, such as shopping, because of the dyspnea.

She had 2 respiratory exacerbations treated with antibiotics and corticosteroids in the preceding year. She had no history of paroxysmal wheeze or dyspnea and no history of chronic cough. A cardiac evaluation, including a cardiac catheterization, was negative. Her physical examination was unremarkable other than for signs of hyperinflation, a generalized decrease in breath sounds, and a prolonged expiratory phase.

Her chest x-ray showed flattened hemidiaphragms. Severe airways obstruction was present on spirometry, with a post-bronchodilator FEV₁/forced vital capacity of 0.43 and an FEV₁ of 0.66 L, which was 33% of predicted. Her FEV₁ in 2009 was

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Abbreviations used

COPD- chronic obstructive pulmonary disease

FVC- forced vital capacity

2.33 L or 109% of predicted. A computed tomographic scan of the chest showed only trivial cylindrical bronchiectasis, without emphysema or interstitial lung disease. Her severe dyspnea persisted despite treatment with an inhaled long-acting beta agonist-inhaled steroid combination and a long-acting antimuscarinic bronchodilator. A course of oral corticosteroids had no effect on her airflow limitation.

DEFINITION AND CONCEPT OF PULMONARY REHABILITATION

Issues confronting the clinician in this patient include determining the etiology of this woman's rapidly developed, severe, fixed airways obstruction; optimizing therapy to alleviate her dyspnea and improve her health status; reducing the frequency and impact of exacerbations; evaluating for the presence of significant comorbidity; and initiating therapy aimed at preventing further disease progression. Pulmonary rehabilitation is an important component to this patient's medical management, with demonstrable effects in alleviating dyspnea, improving health status, reducing the impact of exacerbations, and decreasing subsequent health care utilization. This indication for pulmonary rehabilitation for this patient stands despite semantic issues of whether her disease should be considered asthma with airways remodeling, COPD, or asthma-COPD overlap syndrome. Pulmonary rehabilitation in this case should be considered complementary to her pharmacologic treatment and an integral part of standard medical care for many patients with chronic respiratory disease.

The 2013 Statement on Pulmonary Rehabilitation from the American Thoracic Society and the European Respiratory Society defines it as

...a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies, which include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence of health-enhancing behaviors.²

Exercise training and behavioral therapies, the 2 major components of pulmonary rehabilitation, require the efforts of an interdisciplinary team. Although the membership of this team often varies among centers, a physician (not necessarily a subspecialist) and a rehabilitation coordinator are necessary. In the United States, the pulmonary rehabilitation coordinator can be a nurse, a respiratory therapist, or a physical therapist. Other team members may include nurse practitioners, physiotherapists, behavioral specialists, exercise physiologists, nutritionists, occupational therapists, and social workers. Although, conceptually, pulmonary rehabilitation is a comprehensive intervention delivered by an interdisciplinary team, its components are often provided in a piecemeal fashion as part of conventional medical care.

TABLE I. Patient-centered outcomes from pulmonary rehabilitation

• Reductions in exertional dyspnea ^{3,4}
• Increases in exercise tolerance ⁵⁻⁷
• Improved health-related quality of life ^{7,8}
• Increased functional status ⁹
• Reduced health care utilization ¹⁰

Although pulmonary rehabilitation does not directly affect standard respiratory physiologic measurements (such as FEV₁) in patients with chronic airway disease, it often leads to substantial and significant benefits across several outcome areas of importance to the patient: dyspnea, exercise capacity, health status, functional status, and health care utilization. Its effectiveness despite not having direct physiologic benefit in the lungs is explained by the fact that systemic manifestations and comorbidities, which are addressed by pulmonary rehabilitation, contribute substantially to the symptom burden and prognosis of the individual with chronic respiratory disease.

GENERAL OUTCOMES OF PULMONARY REHABILITATION

Table I lists some of the beneficial outcomes of pulmonary rehabilitation. Compared with otherwise standard therapy, including long-acting inhaled bronchodilators, pulmonary rehabilitation typically provides stronger positive effects across multiple important outcome areas, including symptom reduction, exercise tolerance, functional status, health status, and (arguably) health care utilization.

Despite the outcomes listed in the table, the demonstrable benefit in exercise tolerance and—to a lesser extent—health status tends to wane over months to years after the patient completes the program.⁵ This dropoff in effectiveness probably reflects the fact that a short-term intervention (eg, 8 weeks of pulmonary rehabilitation) is being used to treat a chronic disease with its often deep-seated maladaptive behaviors.¹¹ Promoting behavior change to sustain these benefits seems to be the best way to prolong the benefits from pulmonary rehabilitation, although more research is needed to determine the best way to do this.

A BRIEF HISTORY OF PULMONARY REHABILITATION

Pulmonary rehabilitation has a relatively short history, dating back only to the 1960s. Table II outlines some of the key developments in the science behind pulmonary rehabilitation. Early on, research and scholarly activity focused on the benefits of pulmonary rehabilitation, especially because there was initial skepticism that an intervention that does not affect lung function could produce real beneficial effects. Because the beneficial effects of pulmonary rehabilitation across several outcome areas are now established, attention has shifted to determining mechanisms underlying these beneficial effects and how the comprehensive intervention might be modified to maximize outcomes.

TABLE II. A brief history of the science behind pulmonary rehabilitation

1960s-1980s:

- The concept of pulmonary rehabilitation for COPD became developed and clinical programs were started,¹² although its scientific underpinnings had yet to be determined.
- A measure of functional exercise performance, the timed walk test,¹³ and a questionnaire that assesses health-related quality of life for COPD, the Chronic Respiratory Questionnaire (CRQ),¹⁴ were introduced. Although these developments do not pertain directly to pulmonary rehabilitation, unlike pulmonary function, they are highly responsive to the intervention.

1990s

- A small clinical trial that demonstrated physiologic benefits from exercise training is published.¹⁵ This study demonstrated that “ventilatory pump limitation” is not the sole mechanism underlying exercise limitation in COPD.
- Pulmonary rehabilitation, compared with usual care, was demonstrated to reduce dyspnea in a small trial.³
- The first trial of comprehensive pulmonary rehabilitation was published. Compared with an education-only control group, the rehabilitation patients showed significant benefits in peak exercise capacity, exercise endurance, dyspnea, and self-efficacy for walking.⁵
- Studies were published demonstrating that (1) the oxidative capacity of lower extremity skeletal muscles in patients with COPD is reduced; (2) this reduction correlates with lactic acid production during exercise; and (3) oxidative enzymes can be increased with pulmonary exercise training.^{16,17}
- The American Thoracic Society published a statement on pulmonary rehabilitation.¹⁸

2000-2010

- A randomized trial (200 patients) of pulmonary rehabilitation demonstrated its benefits over multiple outcome areas.¹⁹
- Self-management, now considered one of the major components of pulmonary rehabilitation, was demonstrated to reduce health care utilization and improve quality of life.²⁰
- Bronchodilator therapy was demonstrated to enhance the beneficial effects of pulmonary rehabilitation of patients with COPD, underscoring the additive effects of these 2 treatment approaches.²¹
- A large population-based study showed that physical activity in COPD was associated with a lower risk of subsequent hospitalizations and mortality years.²² This has led to an additional focus of pulmonary rehabilitation on increasing physical activity.
- One study demonstrated that home-based exercise training, initiated after initial education sessions given at rehabilitation centers, was equivalent to hospital-based pulmonary rehabilitation exercise training in its beneficial effects on dyspnea.²³
- Pulmonary rehabilitation was shown to be effective in patients with COPD with moderate spirometric severity, thereby expanding its indication.²⁴

2011-Present

- A Cochrane analysis that reviewed 9 small studies demonstrated that pulmonary rehabilitation, provided after exacerbations for COPD, reduced subsequent health care utilization and mortality.¹⁰
- A large prospective randomized trial of pulmonary rehabilitation intervention (including 6 wk of unsupervised walking-based home exercise) initiated within 48 h after hospitalization for a COPD exacerbation failed to demonstrate a reduction in hospitalization at 12 mo.²⁵ The authors conceded, however, in a subsequent response letter to an inquiry that the intervention was not comprehensive pulmonary rehabilitation as defined by international guidelines.

CURRENT ISSUES IN PULMONARY REHABILITATION

Selection criteria

A patient with respiratory disease should be considered a candidate for pulmonary rehabilitation if he or she has persistent symptoms (such as dyspnea or fatigue), exercise performance limitation, or functional status limitation despite otherwise optimal medical therapy.² Note that a specific disease (such as COPD or asthma) or even spirometric severity is not included in these criteria. A brief listing of diseases or conditions that are appropriate for pulmonary rehabilitation providing the above criteria are met is provided in [Table III](#).

A spirometric severity threshold criterion for COPD was suggested in a 2011 Clinical Practice Guideline published by the American College of Physicians. This recommended referral to pulmonary rehabilitation if patients were symptomatic *and* had an FEV₁ of less than 50% of predicted. This more restrictive inclusion was based on their review of randomized trials demonstrating a mean FEV₁ below this threshold. This was tempered a bit by subsequent text stating that this intervention could also be considered for symptomatic or exercise-limited patients with COPD with an FEV₁ of greater than 50% of predicted.²⁶ The latter, more-liberal, approach is supported by a randomized clinical trial of 199 patients with COPD with a combination of airflow limitation of moderate severity (mean FEV₁ > 50%) and

impaired exercise performance. Compared with usual care, a 4-month, community-based pulmonary rehabilitation intervention showed benefit across several outcome areas.²⁴

On the other end of the disease spectrum, a patient with severe COPD and a high symptom burden would still stand to benefit from a pulmonary rehabilitation intervention tailored to meet the specific needs and limitation of that particular individual.²⁷ Some interventions for severe COPD might include pacing techniques, breathing techniques, dealing with anxiety and depression, issues with long-term oxygen therapy, low-intensity exercise training, and the need for regular physical activity.

Exclusion criteria include a disease state or comorbidity that (1) would place the patient at undue risk for participating in exercise training (such as unstable cardiac disease) or (2) would substantially interfere with the patient's ability to achieve benefit from the intervention (such as major orthopedic problems or cognitive deficit). Current smoking is generally not considered an absolute exclusion criterion; it simply would direct some of the self-management process toward eliminating this maladaptive behavior.

Settings: Center-based, inpatient, and home-based pulmonary rehabilitation

In the United States, pulmonary rehabilitation is most commonly provided in a hospital-based outpatient setting. This

TABLE III. Respiratory conditions typically present in pulmonary rehabilitation patients

• COPD
• Asthma (usually severe asthma, often with airways remodeling or asthma-COPD overlap syndrome)
• Interstitial lung disease
• Chest wall disorders, such as scoliosis
• Restrictive lung disease associated with obesity

is generally of lower cost compared with that of an inpatient setting, taking advantage of the availability of the varied interdisciplinary staff and sufficient space for a comprehensive intervention. Inpatient pulmonary rehabilitation in the United States is most commonly used for patients with more severe disease and/or severe comorbidity. However, in other health care systems in other parts of the world, community and inpatient settings are more commonly used.

Home-based pulmonary rehabilitation offers potential advantages to the outpatient hospital-based model, including more convenience, greater accessibility, and (possibly) lower cost. The most compelling data supporting home-based pulmonary rehabilitation come from a randomized trial conducted in Canada, comparing home-based with center-based interventions. The study was powered to demonstrate noninferiority. Compared with standard center-based pulmonary rehabilitation, the home-based intervention resulted in similar improvements in dyspnea, exercise capacity, and health status, with no signal for increased adverse events.²⁷ However, it should be noted that patients randomized to home-based rehabilitation were initially given educational sessions at the rehabilitation center; only the exercise training on cycle ergometers was given at home. So, in one sense, this intervention was more of a supervised home-based exercise training session than a comprehensive intervention including the dual pillars of exercise training and self-management education. Furthermore, the patient with COPD with substantial comorbidity and severe disease burden might be better treated in a hospital-based setting. Further research is needed in this important area, including not only effectiveness of the intervention but also the relative costs of providing it.

Timing: Stable disease versus postexacerbation

Traditionally, patients with COPD referred to hospital-based outpatient programs have substantial disease burden (symptoms and functional status limitation), yet they are often relatively stable, clinically. Recent attention has rightly focused on those patients hospitalized with an exacerbation of their disease because they have severe symptoms, significant functional limitations, and—importantly—are at inordinate risk for subsequent health care utilization and mortality. An important systematic review, incorporating data from 9 trials and 432 patients,¹⁰ evaluated the effectiveness and safety of pulmonary rehabilitation initiated during or shortly after a hospitalization for an exacerbation of COPD. Compared with usual care in this posthospitalization setting, pulmonary rehabilitation resulted in fewer subsequent hospital admissions, a reduction in mortality, and enhanced health-related quality of life (health status). The beneficial effect on health care utilization was considered to be large, with an odds ratio of hospital readmission being 0.22 and the number needed to treat to prevent a subsequent readmission being 4.

Tempering the enthusiasm generated by this systematic review are the results from a clinical trial of rehabilitation in the United Kingdom, involving 389 patients who had been hospitalized for respiratory disease.²⁵ Eighty-two percent had diagnoses of COPD. Randomization was either to standard care or to pulmonary rehabilitation. In those randomized to pulmonary rehabilitation, the intervention was initiated within 48 hours of hospital admission and continued out to 6 weeks. Strikingly, pulmonary rehabilitation led to no significant benefit in the study's primary outcome: hospitalization rate at 12 months. In addition, there was no mortality benefit at 12 months in the rehabilitation group. However, careful review of this study, brought out in subsequent correspondence, indicated that the supervision and intensity of exercise training after discharge and the self-management component were probably significantly less than that of traditional programs.

Without question, results from this largest-to-date clinical trial of pulmonary rehabilitation are disappointing. Assuming that the systemic review of traditional rehabilitation given in the post-exacerbation period did indeed show a true positive benefit in health care utilization, and that the (perhaps) somewhat less than complete program did not, further research is needed to determine just what would be the necessary duration, intensity, education, and supervision to realize this most important health benefit.

The double-edged sword of self-management in COPD

As stated earlier, collaborative self-management is a major component of comprehensive pulmonary rehabilitation, providing the necessary skills required to change health behavior to optimize and sustain health outcomes.²⁸ Typically, self-management in COPD centers on an action plan for the exacerbation. This includes the early recognition by the patient of the exacerbation, prompt initiation of appropriate therapy using already-filled prescriptions of antibiotics and corticosteroids, and timely communication with the health care professional. However, despite this seemingly straightforward concept, there is only limited evidence that this approach is associated with reduced morbidity and health care utilization.²⁹

Because self-management is typically embedded in the pulmonary rehabilitation program, determination of its effectiveness has to come from studies outside of pulmonary rehabilitation. A systematic review of self-management for COPD³⁰ concluded that it reduced hospital admissions. Subsequently, 2 large, similarly designed, multicenter US Veterans Administration trials of disease management in COPD, centering on a self-management action plan, tested this intervention, comparing health care outcomes with those from usual care. Quite strikingly, the 2 studies had polar opposite results!

In the study by Rice et al,³¹ patients with COPD at high risk of health care utilization had a 41% reduction in the combined end point of hospitalizations and emergency visits resulting from disease management. There was also a trend for decreased mortality in the treatment group. In the other study, Fan et al³² also tested a disease management plan that appeared to provide even more comprehensive self-management training. The study was terminated after only 44% of its enrollment target because of increased mortality in 1 group. After unblinding, it was determined that it was the disease management group, not the usual-care group, with the excessive mortality: 28 patients in the

disease management group and 10 in the usual-care group died, with a hazard ratio of death of 3.00 and a *P* value of .003. Subsequent analyses, including a post hoc evaluation of medical records, could not identify the reasons for this excess mortality.

The causes responsible for the discordant results associated with self-management for COPD in the Rice et al study and the Fan et al study are not known.³³ One potential confounding factor is that the case management in the Fan et al study did not go as expected: contrary to the protocol, patient contact with the health care team took place in only 27 instances of the 600 self-reported exacerbations. Furthermore, the time interval from the beginning of the exacerbation to the initiation of steroid or antibiotic therapy was not significantly different in the 2 groups. Thus, it turns out that successful self-management is not a given, even when apparently intensive and well-thought-out education is provided. Supporting this is a study by Bucknall et al that concluded that only 42% of the patients with COPD given what appeared to be good self-management education actually became successful self-managers.³⁴ This low percentage was similar to that of another study by Bischoff et al,³⁵ which showed that only 40% of their patients adhered to a written action plan during exacerbations. Thus, it appears that successful self-management is not as easy to effect in patients with COPD as might have been originally anticipated.

Putting aside the lack-of-benefit issue, the increased mortality associated with self-management (disease management) in the Fan et al study has to be considered. Although minor differences in the prevalence of cardiovascular disease and marital status were present in the groups, these differences were probably not sufficient to account for the difference in mortality that was observed in this study. One possible explanation is that the high-risk patient with COPD needs more than simply an early intervention with antibiotics and steroids per action plan.³³ This high-risk patient also needs an assessment by professionals experienced in managing severe disease. An analogy is that the patient with acute coronary syndrome needs more than early institution of aspirin. Perhaps the initial management by a case manager delayed this assessment. In addition, promoting self-efficacy may result in patient overconfidence (ie, too much self-efficacy), resulting in delays in receiving appropriate medical treatment.

Promoting physical activity

Exercise capacity and physical activity are different constructs: the former refers to what individuals can achieve at maximal output, whereas the latter refers to what they actually do in the home and community settings. Both exercise capacity and physical activity are important because lower levels of either (or both) are independently predictive of poor outcome in COPD.^{22,36,37} Pulmonary rehabilitation is very good at increasing exercise endurance capacity in patients with COPD. However, its effect on increasing physical activity has been mixed to date, with about one-half of randomized trials showing a significant benefit in this outcome area.^{38,39} This discord is probably due to the fact that although exercise capacity is permissive of physical activity, the latter is undoubtedly affected by many other variables, including social factors, degree of motivation, self-efficacy beliefs, and comorbid conditions. Simple exercise training, which would increase exercise capacity, therefore might not have similar results in physical activity if these confounding variables are strong. This has led thought

TABLE IV. Pulmonary rehabilitation outcomes for Mrs CD

Outcome	Baseline	After pulmonary rehabilitation	Change
Six-minute walk distance (m)	302	358	56
Arm lifts (reps/min)	53	68	15
CRQ Dyspnea	2.5	3.2	0.7
CRQ Fatigue	3.4	3.8	0.4
CRQ Emotion	4.2	4.4	0.2
CRQ Mastery	3.1	3.6	0.5
HAD Anxiety	4	3	-1
HAD Depression	3	2	-1
MRC Dyspnea (0-4)	2	2	0

CRQ, Chronic Respiratory Questionnaire (self-administered version).⁵¹ This 20-item instrument assesses health status in 4 domains: Dyspnea, Fatigue, Emotion, and Mastery. Higher scores indicate better health status. A per-item increase of 0.5 units is generally considered clinically meaningful; *HAD*, a short self-report rating for anxiety and depression symptoms.⁵³ Lower scores indicate fewer symptoms. A decrease of one 1.5 unit is generally considered clinically meaningful; *MRC Dyspnea*, Modified Medical Research Council dyspnea rating.⁴⁶ Higher scores indicate greater dyspnea. A decrease of 1 unit probably indicates a clinically meaningful change.

leaders in pulmonary rehabilitation to consider novel ways to enhance physical activity. More research is needed in this area.

Technology-assisted pulmonary rehabilitation

Home telemonitoring as an adjunct in COPD management holds promise, although more research in this area is necessary.⁴⁰⁻⁴² For pulmonary rehabilitation, this approach may be beneficial in 2 areas. First, the ongoing electronic transmission of objectified symptoms or physiologic measurements (such as oxygen saturation from pulse oximetry) to the pulmonary rehabilitation team may help in enhancing collaborative self-management. This is potentially important, because, as stated earlier, it appears that only about 40% of the patients with COPD become successful self-managers using current approaches.³³ Second, feedback (both ways) from telemonitoring may help promote regular exercise and physical activity after pulmonary rehabilitation. Ongoing adherence with the postrehabilitation exercise prescription is considered an important factor in maintaining the long-term benefits from pulmonary rehabilitation, especially in exercise performance.

CASE PRESENTATION CONTINUED: MRS CD

After initial evaluations by the rehabilitation nurse coordinator and the medical director, Mrs CD participated in 16 pulmonary rehabilitation sessions at a hospital-based outpatient program. This intervention was covered, in part, by her insurance.⁴⁵ Sessions were held twice-weekly, each lasting about 2 1/2 hours. Approximately half this time was spent in educational sessions, focusing on self-management; the other half was spent in exercise training. A considerable portion of the self-management education was on adherence with her asthma-controller medications and bronchodilators, and the implementation of an exacerbation action plan that included teaching on what the exacerbation was, instructions on starting filled prescriptions for oral corticosteroids and (if necessary) antibiotics, and the need to contact the health care provider if this action was taken. Self-management education also included instructions on regular exercise and physical activity. Exercise, which was tailored to this patient's ability,

included classroom calisthenics, resistance training of the upper and lower extremities with light weights, lower extremity training using a treadmill and cycle ergometer, and upper extremity training using an arm ergometer. Supplemental oxygen therapy was provided in the pulmonary rehabilitation area during the exercise to prevent exercise-associated hypoxemia and as an exercise performance enhancer.^{44,45} Evaluation before pulmonary rehabilitation discharge indicated that she did not need supplemental oxygen with moderate physical activity at home.

Outcomes measured before and immediately after pulmonary rehabilitation are provided in Table IV. The timed walk test (six-minute walk test) is a strong predictor of survival in COPD, independent of the degree of airflow limitation,^{47,48} and this patient's initial performance (302 m) places her below the 350-m threshold for increased mortality in this disease.⁴⁹ In addition, her increase in the six-minute walk distance (56 m) is considered to surpass the clinically meaningful threshold for this outcome. Her increase in arm-lift repetitions indicates that she also increased her upper extremity muscle capacity, although this type of testing has not had extensive validation.⁵⁰ The health status instrument used in this rehabilitation program was the self-report form of the Chronic Respiratory Questionnaire, a 20-item instrument,⁵¹ with domains of Dyspnea, Fatigue, Emotion, and Mastery. This instrument is considered very responsive in detecting change from pulmonary rehabilitation. Each response can range from 1 (severe limitation) to 7 (little or no limitation), and a per-item change of 0.5 or greater is considered clinically meaningful. This patient met or surpassed this clinically meaningful threshold in dyspnea and mastery (the feeling of control over the disease). Screening for anxiety and depression symptoms is also frequently performed in pulmonary rehabilitation because they are prevalent in this setting⁵² and respond to the intervention.⁵³ This patient did not have an abnormally high HADS (Hospital Anxiety and Depression Scale) anxiety or dyspnea score, and did not show improvement in these scores after the intervention. In addition, she did not show a change in dyspnea, as assessed by the Medical Research Council 5-point dyspnea rating, although this is rather insensitive to detecting changes in this symptom. Of note, the Chronic Respiratory Questionnaire dyspnea rating, which is considered more responsive than the Medical Research Council rating to detecting changes in dyspnea, did show a clinically meaningful change. Thus, as shown in Table III, outcomes were generally improved in this patient, several of which surpassed clinically meaningful thresholds. It should be emphasized that these improvements occurred presumably without a corresponding improvement in lung function, which had been maximized before this patient's entry into pulmonary rehabilitation.

After completion of the formal pulmonary rehabilitation program, she was given a postrehabilitation prescription for maintenance exercise training, offered continued maintenance exercise training in the center at a minimal additional cost, and was referred back to her primary care provider. The beneficial effects of exercise training on exercise physiology wane after exercise training is discontinued, so the optimal duration of maintenance exercise training is lifelong. However, this lifelong change in lifestyle is not attained in most of the patients. To help counter this trend toward entropy, pulmonary rehabilitation programs incorporate home exercise training early on in the formal intervention and direct a substantial portion of the self-management training toward this goal. A potentially important

event in declining adherence to maintenance of ongoing exercise training is the respiratory exacerbation; accordingly, "booster shots" of exercise training (without necessarily the education) in pulmonary rehabilitation may be indicated as soon as the patient recovers enough to resume exercise,⁵⁴ although this has not been unequivocally proven to be beneficial and third-party reimbursement issues may be a problem.

Summary

Pulmonary rehabilitation is an effective treatment for COPD and should be part of the management of those who still have burdensome symptoms, exercise limitation, or health status impairment remaining after pharmacologic therapy. Its beneficial effects result from reduction in the impact of systemic manifestations and comorbidity, which are common in this disease and contribute to its burden. Although individual pulmonary rehabilitation programs vary worldwide in setting, participating health professionals, program duration, and specific interventions all share certain common traits. These include a patient-centered approach using an interdisciplinary team, with exercise and self-management training geared to the needs of the patient. Referral to pulmonary rehabilitation should be considered when burdensome symptoms or reduced functional status or health status limitations persist despite otherwise optimal therapy. Patients with severe asthma, especially if they have airways remodeling and daily symptoms, are appropriate referrals to pulmonary rehabilitation provided they have symptoms or functional or health status limitation despite therapy. The posthospitalization period after an exacerbation of airways disease is also an appropriate time for pulmonary rehabilitation referral because the intervention at this time reduces subsequent health care utilization and, possibly, even mortality risk.

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