*Pulmonary rehabilitation in chronic respiratory insufficiency · 1*

*Series editors: J-F Muir and D J Pierson*

# Pulmonary rehabilitation in perspective: historical roots, present status, and future projections

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## Pulmonary rehabilitation as a process

Pulmonary rehabilitation is not a single form of therapy but rather a systematic and often personally orientated approach to comprehensive treatment for patients with advanced impairment and disability primarily from chronic obstructive pulmonary disease (COPD). The techniques and approaches to pulmonary rehabilitation, however, are applicable to other chronic respiratory disease states such as those associated with interstitial pneumonitis or fibrosis, cystic fibrosis, thoracic deformities, and less common disorders. In brief, pulmonary rehabilitation should be considered a form of integrative care which goes beyond "ordinary care" that is provided in outpatient clinics for most patients with these disorders.

Pulmonary rehabilitation was defined by a committee of the American College of Chest Physicians in 1974 as "an art of medical practice wherein an individually tailored multidisciplinary program is formulated which, through accurate diagnosis, therapy, emotional support and education, stabilizes or reverses both the physio- and the psychopathology of pulmonary diseases and attempts to return the patient to the highest possible functional capacity allowed by his pulmonary handicap and overall life situation."

## Essential components of a pulmonary rehabilitation programme

Pulmonary rehabilitation has been appropriately considered as comprehensive care for patients with chronic respiratory disorders. The salient features of comprehensive care (pulmonary rehabilitation) are presented in table 1. Each of these features requires coordination with each component of a pulmonary rehabilitation programme.

### PATIENT AND FAMILY EDUCATION

Education is important in all chronic disease states. Both the patient and the family should understand the objectives, methodologies, and realistic goals of care. Patient education can be individually taught but is most commonly offered in small group sessions. A review of the disease states, anatomy and physiology of the lung, pharmacological therapies employed, and the rationale behind the various techniques of breathing, retraining, and exercise is demonstrated. When appropriate the techniques of home oxygen therapy are taught. Pamphlets and short books are used to supplement these personal instructions.[1–3]

### PHARMACOLOGICAL AGENTS

Pharmacological agents used in rehabilitation programmes are summarized in table 2 and include bronchoactive and strategic drugs.

*Bronchoactive drugs*

The inhaled $\beta$ agonists are by far the most widely used agents to help people reduce dyspnoea through bronchodilatation, even in advanced stages of COPD. A substantial number—indeed most patients with COPD—have some measurable improvement in forced expiratory volume in one second ($FEV_1$, flow), forced vital capacity (FVC, volume), or sometimes both.[4] Many patients use $\beta$ agonists throughout the day, whenever they face troublesome dyspnoea. This may occur as often as every one to two hours, which is the duration of the peak effect of the commonly available inhaled $\beta$ agonists delivered by metered dose inhalers (MDIs) used in the United States. Oral $\beta$ agonists are no more effective than inhaled agents and, in fact, are less effective in providing immediate improvement. The major side effects of tremor and tachycardia limit their usefulness.

Anticholinergic drugs generally produce a

*Table 1 Components of pulmonary rehabilitation programmes*

| |
|---|
| Patient and family education |
| Pharmacological agents |
| Breathing training and exercises |
| Systemic exercise |
| Oxygen (selected patients) |
| Patient support groups |

*Table 2 Pharmacological agents used during pulmonary rehabilitation*

| *Bronchoactive drugs* | *Strategic drugs* |
|---|---|
| Beta agonists | Antibiotics |
| Anticholinergics | Nicotine replacement |
| Theophyllines | Gum |
| Corticosteroids | Transdermal |
| Mucoactive agents | Vaccines |
| | Influenza |
| | Pneumococcal |
| | Amantadine |

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greater and longer period of sustained bronchodilatation than the $\beta$ agonists.[5] Ipratropium bromide (Atrovent), the only anticholinergic available in a metered dose inhaler, has become a cornerstone agent. Inhaled anticholinergics do not produce tremor and, since they are poorly absorbed, have few side effects. Urinary retention, glaucoma, and the drying of bronchial secretions do not occur with these agents.

The theophyllines are the most widely used bronchodilators in the United States. They are relatively weak bronchodilators compared with either the inhaled $\beta$ agonists or anticholinergics. Although theophyllines were shown in controlled clinical trials to provide small improvements in airflow and volume, as well as an improvement in levels of blood gases, the magnitude of these changes was modest.[6] It is likely that the benefit achieved in most patients results from the extrabronchial activities of theophylline such as improving respiratory muscle function.

Corticosteroids are also widely used with various strategies in COPD. They are most commonly used to help deal with exacerbations of disease that result in respiratory insufficiency. One controlled clinical trial showed that corticosteroids could improve ventilatory function to a statistically significant degree but the clinical impact was modest.[7] Whether or not corticosteroids can forestall the progress of moderate or severe disease has been the subject of extensive observations,[8 9] but so far no controlled clinical trials have been performed. Most experts in the field believe that corticosteroids can favourably modify the course of some patients with COPD. Corticosteroids have also been shown to identify patients with a reversible component of disease. This is true even in advanced cases, including patients requiring long term home oxygen therapy.[10]

Mucoactive drugs are widely used in Europe, but until recently have been sparsely used in North America.[11] One extensive controlled clinical trial showed a significant reduction in cough severity, cough frequency, chest tightness, and dyspnoea, and an improved global feeling of wellbeing on the part of patients.[12] Most North American chest physicians consider iodinated glycerol, the only adequately studied drug in this class, to be adjunctive therapy and not a replacement for any other drugs in the so-called bronchoactive class.

*Strategic drugs*

Heading the list of strategic drugs are antibiotics. Although many patients with COPD suffer from exacerbations of cough, dyspnoea, increased and coloured sputum, and have bacterial pathogens in the sputum, the exact role of microorganisms in these exacerbations remains unclear. It is most likely that virus infections are the inciting cause of the exacerbations, with bacterial invasion a secondary phenomenon. One well designed, controlled clinical trial showed clinical effectiveness with the use of antimicrobial agents in some, but not all, patients with exacerbations of chronic bronchitis.[13] An alternative theory is that these exacerbations of COPD are due to nonmicrobial inflammatory processes. This may well be the reason for the value of corticosteroids in exacerbations of disease.

Nicotine replacement, of course, must be considered in all patients who are still smoking as they enter a pulmonary rehabilitation programme. Hopefully most patients requiring pulmonary rehabilitation have decided to abstain from the product that caused the disease process in the first place. A discussion of all of the strategies of nicotine replacement is beyond the scope of this article. Beyond question, the patient's commitment to give up smoking, the assistance of a physician or other health worker in helping the patient to alter behaviour patterns that sustain the smoking habit or addiction, and nicotine replacement to deal with withdrawal symptoms offer an effective strategy in smoking cessation. Nicotine polacrilex and four different preparations of transdermal nicotine are now available. Controlled clinical trials have indicated considerable success when transdermal nicotine replacement is added to behavioural modification.[14]

Influenza virus vaccination is advised each autumn to deal with real or potential epidemics of an infection which often devastates patients with moderate to severe forms of chronic respiratory insufficiency. A polyvalent vaccine is prepared from the expected strains, based upon worldwide epidemiological considerations. In general a single injection of the polyvalent vaccine is given each October or November to all patients with respiratory insufficiency and should be given to everyone over the age of 50.[15] Although controversial, pneumococcal vaccine should be offered once in a lifetime and perhaps as often as every five years to help reduce the risk of complications from this common bacterial pathogen.[16] Amantadine is an effective oral preventive agent against influenza for patients who will not or cannot take the vaccine, when there has been insufficient time to vaccinate in the face of an epidemic, or in patients who are institutionalised along with others suffering influenza.

BREATHING EXERCISES AND RETRAINING

Much work has been carried out on the techniques of breathing, strengthening the breathing muscles, and coordinating the breathing process. More studies of pursed lip breathing have been reported than other controlled breathing techniques. Pursed lip breathing slows respiration and increases the depth of each breath. It helps improve oxygen transfer across the lung[17 18] and also mitigates dyspnoea during exercise. Various techniques of breathing exercises have been employed including maximum voluntary ventilation manoeuvres, the use of progressive inspiratory resistive devices (both flow and threshold resistors), and other techniques.[19 20]

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SYSTEMIC EXERCISE

It has long been known that patients can learn to walk greater distances with less dyspnoea and at a lower heart and respiratory rate than before exercise training.[21 22] The mechanisms behind these improvements are complex. Part of the physiological benefits of systemic exercising include a reduction in exercise related lactic acidosis probably, in part at least, via improved cardiovascular responses.[23] However, the exercise tolerance of many patients with advanced COPD is limited by intolerable dyspnoea. Some with milder forms of disease have cardiovascular limitations or are limited by the mechanics of breathing and generalised muscle weakness. Impaired pulmonary mechanics and a heightened sense of dyspnoea are the greatest limiting factors in most patients with moderate to severe COPD. Patients can be trained to tolerate dyspnoea by various exercise techniques.

OXYGEN

Oxygen is the only therapy often employed, both with and without the other techniques of pulmonary rehabilitation, that has been shown to alter favourably the outcome in chronic stable patients with hypoxaemia associated with advanced stages of COPD.[24 25] Two major multicentre trials, when taken together, indicate that survival of patients in chronic stable hypoxaemia with advanced COPD is poor without oxygen. Survival is improved when oxygen is given 12–15 hours per day, including the hours of sleep, from stationary sources, but is best when given in a more continuous manner using an ambulatory system.[24] Improved survival with ambulatory oxygen might be due to the increased oxygen duration—that is, for a greater portion of the day—or may be a result of the methodology itself. The technique of ambulatory oxygen allows for increased exercise capability and participation in normal activities of daily living including social pursuits. It is distinctly possible, therefore, that the benefits accrued from ambulatory oxygen result from both the *method* of delivery and its *duration*.

Transtracheal oxygen offers a new dimension in oxygen administration and promotes the greatest duration of oxygen therapy as well as its other advantages.[26] Additional advantages include a reduction in litre flow requirements, the relief of nasal congestion and other unpleasant side effects from using nasal cannulae such as irritation of the ears, and the obvious cosmetic benefits of being able to conceal the oxygen delivery system. Whether or not transtracheal oxygen has any further benefit remains the subject of a current study. Since transtracheal oxygen participates in some work of breathing, it is possible that this method of delivery has additional advantages in at least some patients with the greatest degree of airflow obstruction—that is, patients with the greatest work of breathing and degree of wasted ventilation.

STAFFING AND STRUCTURE OF A PULMONARY REHABILITATION PROGRAMME

The staffing and structure of a pulmonary rehabilitation programme can vary tremendously. Today the great majority of pulmonary rehabilitation programmes are on an outpatient basis for practical and economic reasons. Inpatient programmes are much more expensive and tend to foster the dependency needs of patients. Exceptions are patients who need to participate in pulmonary rehabilitation before lung transplantation, which is a subject that goes beyond the scope of this review. Suffice it to say that pulmonary rehabilitation, both before and after lung transplantation, is an important adjunct to this care but certainly would apply to only a small minority of patients.

Every successful pulmonary rehabilitation programme has its spiritual leader. This is often a nurse or respiratory therapist who organises and coordinates all of the activities of the programme. A medical director is required in most programmes and may play the leadership role, but often this is not the case.

Staffing usually includes one or more additional individuals who could be respiratory therapists, physiotherapists, social workers, or anyone with an interest in human beings and their suffering who is willing to learn the fundamentals of pulmonary rehabilitation. Most programmes enrol patients in small groups of four to six. Programmes range in length from 4–8 weeks. The initial sessions focus on goals, objectives, anatomy, physiology, and medications used in pulmonary rehabilitation. Later sessions focus on breathing retraining, breathing exercises, and systemic exercise. Although treadmills and bicycle ergometers are commonly used they are not necessary and, at times, are not very palatable for patients who have limited exercise capabilities. Since exercise training is task specific, improving bicycle riding may not be translated into better activities of daily living. Riding a bicycle or walking on a treadmill will allow for the calculation of work accomplished, but the skills required may not be available to every patient. Normal walking in halls, corridors, or outside buildings, often over a measured course, is a more suitable and practical approach to exercise in most patients. What is taught in pulmonary rehabilitation is the method of breathing and exercising, rather than the accomplishment of training itself.

Daily exercise is continued at home to achieve maximum benefit. It must be continued or the benefit is quickly lost. Most patients can walk longer and sometimes faster at a lower respiratory rate, lower heart rate, lower oxygen consumption, and lower rate of carbon dioxide production. Since numerous studies have established that these objectives can be met by most patients, such measurements are not needed in the ordinary course of a pulmonary rehabilitation programme unless research questions are being asked.

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*Table 3 Comparative demographic data of patients in rehabilitation programme and those on emphysema registry*

| | *Rehabilitation programme* | *Emphysema registry* | *p (two tailed t test)* |
|---|---|---|---|
| Age (y) | 58·5 | 57·9 | NS |
| Height (cm) | 175 | 175 | NS |
| $FEV_1$ (l) | 1·08 | 1·15 | NS |
| $Sa_{O_2}$ (%) | 89 | 88 | NS |

$FEV_1$—forced expiratory volume in one second; $Sa_{O_2}$—oxygen saturation.

Most programmes have social support groups which the author believes to be critically important to the continued success of the rehabilitation process. Patient newsletters, monthly luncheons with informative lectures, and social outings such as bus or train trips, cruises, and annual celebrations in the form of rallies, have become the hallmark of the most successful rehabilitation programmes in the United States.

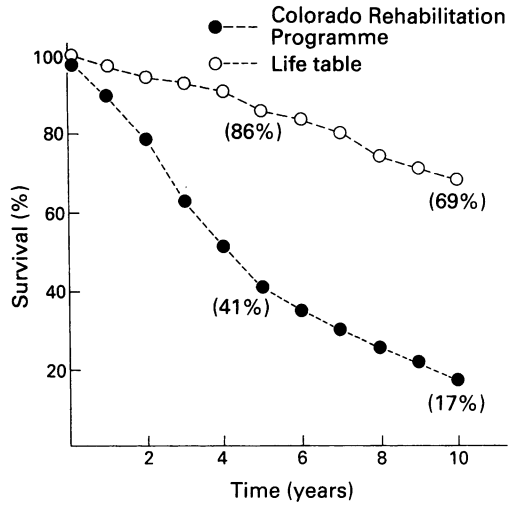


*Figure 2 Survival of all patients enrolled in the Denver pulmonary rehabilitation programme (17%) with prediction of survival in normal men and women at the same age (69%) at 10 year follow up.*[32]

## Outcome of pulmonary rehabilitation

It is virtually impossible to design prospective controlled clinical trials to test the outcome of pulmonary rehabilitation in terms of survival. This is because any control group would require an equal duration of intervention such as music therapy, sunbathing, or other diversionary activities in order to control the additional attention and social interaction that is provided for patients during the conduct of a pulmonary rehabilitation programme. There would also be a high likelihood of a self selection process with the more motivated individuals choosing the more active intervention available via pulmonary rehabilitation.

Comparison of survival curves of patients participating in a pulmonary rehabilitation programme, although interesting, also do not give any substantive impact upon the contribution of pulmonary rehabilitation to survival. The differences in survival curves have to do with the initial selection of patients, including diagnosis, degree of abnormality, presence or absence of reversibility, and perhaps other population differences which can affect survival (see below).

One comparison study conducted in Denver more than 20 years ago suggested a small and almost significant survival benefit for patients participating in a pulmonary rehabilitation programme compared with matched patients in Denver.[27] This study began in the mid 1960s and compared the survival of matched patients who received ordinary care from their private physicians in the same environment with those who received a simple outpatient pulmonary rehabilitation programme.[28] Table 3 presents the demographic and physiological background factors of these two populations. Figure 1 shows the survival curves which slightly favour the pulmonary rehabilitation group. Those patients participating in the pulmonary rehabilitation study were from a lower socioeconomic group than those studied on the emphysema registry.

The entire study group of 182 consecutive patients evaluated at 10 years showed a markedly adverse survival compared with predictions of survival in normal individuals (fig 2). The demographic and physiological background data of this population are listed in table 4. The difference between the survival curves is the excess mortality from COPD

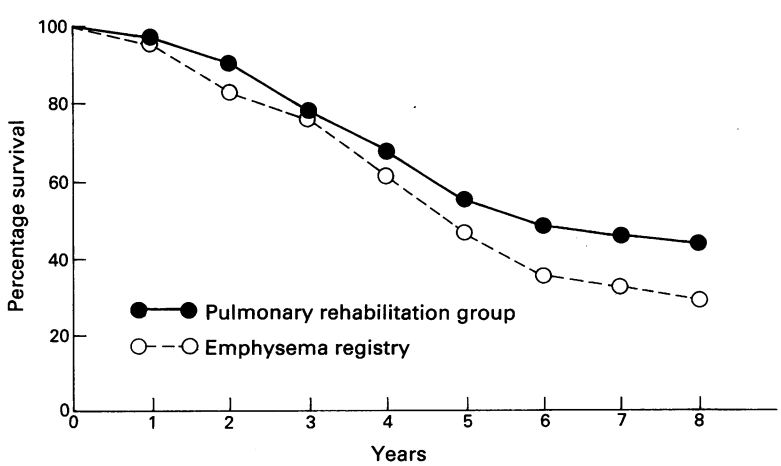


*Figure 1 Comparison of cumulative survival between a group of men in the Denver pulmonary rehabilitation programme and a "historical control" group who were treated by private physicians in Denver for advanced COPD (n = 72).*[27]

*Table 4 Background data of patients in pulmonary rehabilitation programmes in Denver, Colorado, 1966–8*

| | | *Range* | *SD* |
|---|---|---|---|
| n | 182 | — | — |
| % men | 87 | — | — |
| Age (y) | 61 | 33–81 | 9 |
| FVC (l) | 2·58 | 1·22–5·17 | 0·79 |
| $FEV_1$ (l) | 0·94 | 0·26–2·21 | 0·38 |

FVC—forced vital capacity; $FEV_1$—forced expiratory volume in one second.

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*Table 5 Reasons for exclusion of patients enrolled with $FEV_1$ after bronchodilator of <2·0 l*

| | |
|---|---|
| Incomplete data | 7 |
| Bronchiectasis | 2 |
| Restrictive lung disease | 2 |
| Lung cancer | 1 |
| Congenital lung disease | 1 |
| COPD | 240* |
| Total | 253 |

*Selected for outcome analysis

*Table 6 Mean (SD) background data of study group (n = 240)*

| | |
|---|---|
| Men | 129 (53·7%) |
| Women | 111 (46·3%) |
| Age at entry | |
| Total group | 64·9 (8·03) |
| Men | 65·3 (8·05) |
| Women | 64·5 (8·01) |
| FVC (l) | 2·02 (0·71) |
| $FEV_1$ (l) | |
| Before bronchodilator | 0·89 (0·37) |
| After bronchodilator | 0·97 (0·38) |
| $Pao_2$ (mm Hg)* | 66·04 (11·62) |
| $Paco_2$ (mm Hg)* | 41·8 (7·97) |
| Height (cm) | 167·58 (11·3) |
| Weight (kg) | 65·9 (15·3) |
| Smoking (pack years) (n = 221) | 60·77 (37·67) |

FVC—forced vital capacity; $FEV_1$—forced expiratory volume in one second; $Po_2$—oxygen pressure; $Pco_2$—carbon dioxide pressure. *7·5 mm Hg = 1 kPa.

and its complications. Most patients with COPD die of their disease with respiratory and right heart failure as a final event.

In a more recent study conducted in a private hospital in Torrance, California somewhat older patients with even greater degrees of airflow obstruction appeared to have a better rate of survival than patients in the Denver study and other reported results of survival in large groups of patients with advanced COPD.[29] This might reflect the selection of more fit individuals who had survived to an older age because of intrinsic prognostic factors, or perhaps overall care of these patients in the more modern era had an impact.

The outcome of 240 selected patients (for exclusions see table 5) who completed the pulmonary rehabilitation programme is the subject of the survival analyses.[29] The demographic and selected physiological background data of these 240 patients are presented in table 6. At the time of the most recent analyses 105 patients had died and 135 were still alive. The causes of death are listed in table 7. As expected most of the patients died of pulmonary causes, generally classified as respiratory failure. All causes of death were ascertained from hospital records, reports of physicians, death certificates, or inquiry of next of kin. In all there were 77 primary pulmonary deaths and 28 non-pulmonary deaths. The mean (SD) age at death of the 69 men and 36 women who died was 69·5 (8·10) years and 68·9 (6·75) years respectively, with a mean survival of 5·6 years for men and 4·8 years for women.

Figure 3 presents the survival curve of all patients in the Torrance programme by year of follow up, up to nine years. Only five patients were lost to follow up and their survival data were included until they were lost. After that they were censored from the data by the method of Kaplan-Meier.

An attempt was made to analyse survival in relation to $FEV_1$ at the time of entry into the study. No direct relationship was found between $FEV_1$ and survival, but small numbers of patients with the lowest $FEV_1$—for example, two patients with $FEV_1$ 0·2 l had a mean survival of 5·7 years, eight patients with $FEV_1$ 0·3 l had a mean survival of 5·4 years, and 15 patients with $FEV_1$ 0·4 l had a mean survival of 3·4 years. Thus, small numbers of patients stratified by $FEV_1$ may have biased an attempt to analyse this relationship. The best survival was in patients with $FEV_1$ 1·6 l (n = 8) with a mean survival of 8·2 years. Patients with $FEV_1$ of 0·8 l (n = 38), the largest group in the $FEV_1$ stratification, had a mean survival of 7·1 years.

## Comments

The cumulative survival of patients participating in different pulmonary rehabilitation programmes of observation, care, or rehabilitation has been analysed by Hodgkin.[30] Different selection criteria, including various ages on entry and the presence or absence of reversibility, asthmatic features etc, probably explain the considerable survival differences. Figure 4 presents the survival curves of four large series, along with the respective cita-

*Table 7 Causes of death*

| *Pulmonary* | | *Non-pulmonary* | |
|---|---|---|---|
| Respiratory failure | 64 | Cardiovascular | 19 |
| | | Cardiac dysrhythmia/arrest (12) | |
| Lung cancer | 8 | Myocardial infarction (3) | |
| | | Cerebral vascular accident (2) | |
| Pneumonia | 2 | Ruptured dissecting aneurysm (2) | |
| COPD | 2 | Extrapulmonary malignancy | 7 |
| Adult respiratory distress | | Brain (3) | |
| syndrome | 1 | Kidney (2) | |
| | | Liver (1) | |
| | | Acute leukemia (1) | |
| | | Suicide | 2 |
| Total | 77 | | 28 |

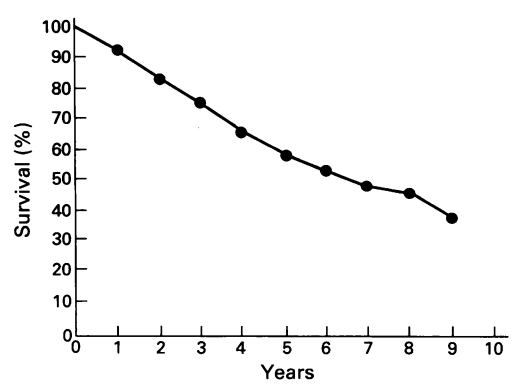


*Figure 3 Survival by year of all patients entering the Torrance pulmonary rehabilitation programme.[29]*

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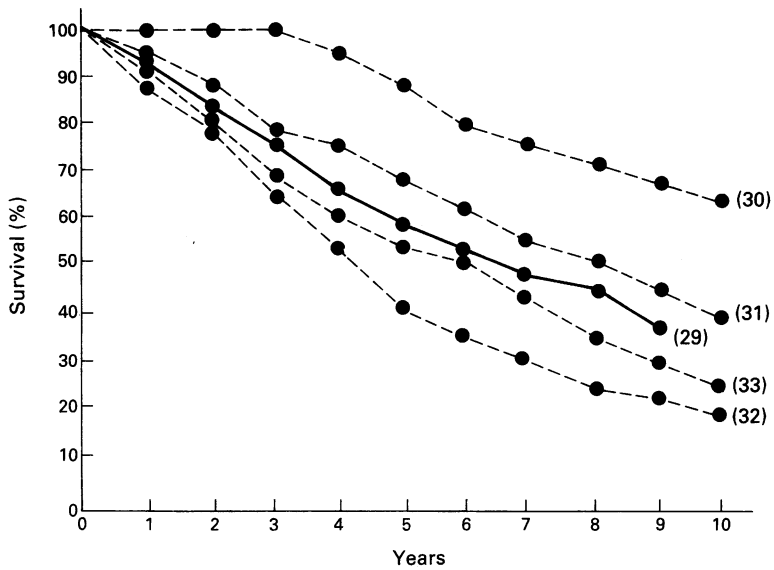


*Figure 4 Composite survival curve comparing outcome from previously reported studies in pulmonary rehabilitation.[30] Figures in parentheses refer to numbers in reference list.*

tions, compared with the results of the Torrance study.[29] The differences in background data of patients enrolled in these studies are listed in table 8.

The Torrance study included patients who were somewhat older than in the other studies. The Postma study included an age group of patients who were nearly a decade younger than in the Torrance study, but her patients had more severe airflow obstruction as judged by $FEV_1$.[31] These patients may have included patients with more asthmatic features. Postma enrolled a significant number of non-smokers, also suggesting that the reason for severe airflow obstruction was likely to be asthma rather than non-asthmatic COPD.[31] This consideration could also explain the apparently favourable effect of corticosteroids in Postma's patients. Corticosteroids were not used in a systematic fashion in the Torrance study, but were given on an individual basis to selected patients by the managing physicians.

The patients in the study by Hodgkin were five years younger than in the present series and they had much milder airflow obstruction than patients in the present study ($FEV_1$ 1·55 *v* 0·89 l).[30] He also included a significant number of non-smokers (33 out of 75 patients).

The studies by Petty *et al*[28] and Sahn *et al*[32] were the first to evaluate the outcome of pulmonary rehabilitation in a non-stable population of patients and revealed a poor survival at 10 years. This was also an outpatient programme of pulmonary rehabilitation which enrolled consecutive patients who did not have significant evident improvement in airflow in response to bronchodilators. This selection resulted in an older population (mean age 61) but 87% of the enrolled patients were men compared with 54% men in the Torrance series. The Torrance study enrolled patients who were four years older than in these studies. The experience in the Denver study resulted in a 17% survival at 10 years compared with 32% in the Torrance study at nine years. Overall, survival in the Torrance series was between that of the Hodgkin study, with much less severe airflow obstruction, and the survival outcome of the study by Sahn *et al*.

An analysis of the study by Diener and Burrows in Chicago on the course and progression in chronic stable patients with advanced COPD is included for comparison.[33] Two hundred patients were enrolled into a prospective study of survival. The techniques of pulmonary rehabilitation described in this article were not employed, but all patients received appropriate care and hospitalisation as needed. Enrolment in the study required a one year period of "clinical stability," and the patients were six years younger than in the Torrance study. These patients had less severe airflow obstruction than those in the Torrance study ($FEV_1$ 1·04 *v* 0·89 l).

When these various survival curves spanning approximately a quarter of a century are reviewed, considerable differences in survival are noted. These differences are most likely to result from different selection criteria, or different population characteristics, or both. In any case, it can be concluded that survival in advanced COPD is generally poor in spite of the enthusistic use of pulmonary rehabilitation. Another conclusion might be that survival must be improving during the pulmonary rehabilitation era since more patients are achieving their expected life duration—that is, mean age nearly 70—as the Torrance study demonstrated.

Other ways of evaluating pulmonary rehabilitation focus on isolated issues such as hospital needs and quality of life issues. In an earlier study from the Denver group a reduction in number of hospitalisations was suggested in patients participating in a pulmonary rehabilitation programme compared with their requirements for hospitalisation before entering such a programme.[34] Although impressive, this reduced hospitalisation may have been a function of the home care aspect of the pulmonary rehabilitation programme making emergency hospitalisation less necessary.

Extensive studies on quality of life during the Nocturnal Oxygen Therapy Trial

*Table 8 Comparison of patients in pulmonary rehabilitation programme and various study groups*

| | *Torrance study*[29] | *Hodgkin*[30] | *Petty et al*[28 32] | *Postma et al*[31] | *Diener and Burrows*[33] |
|---|---|---|---|---|---|
| n | 240 | 75 | 182 | 129 | 200 |
| Mean age (y) | 65 | 60 | 61 | 54 | 59 |
| Mean $FEV_1$ (l) | 0·89 | 1·55 | 0·94 | 0·61 | 1·04 |
| Mean $P_{O_2}$ (mm Hg)* | 66 | 68 | — | — | — |
| Mean $P_{CO_2}$ (mm Hg)* | 42 | 42 | — | 44 | 44 |
| Non-smokers | 0 | 33 | 0 | 36 | 38 |

*7·5 mm Hg = 1 kPa.

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(NOTT), where many rehabilitation techniques were used in background therapy, have shown measurable improvements in brain function and in overall global functioning but these improvements were relatively modest.[35]

In conclusion, pulmonary rehabilitation in selected and motivated individuals has emerged as the standard of care for those individuals who are able and willing to participate. Costs range from $1500 for an approximate 6–8 week programme up to nearly $5000, but these costs must be weighed against the premature morbidity and mortality which is otherwise the lot for patients with advanced COPD.

## Importance of early identification and intervention

The basic nature of COPD is an insidious attack upon alveoli and small airways which covers an approximate 30 year time span. Early identification and intervention therefore appears to be the key to altering the course and prognosis of COPD. It is now established that simple measures of airflow abnormality, including a reduction in $FEV_1$ and $FEV_1$ as a percentage of FVC, accurately predict a population of patients at risk of premature losses of ventilatory function.[36] Accelerated losses of ventilatory function correlate with adverse outcome in COPD.

Ability to stop smoking has been shown to alter the rate of decline of ventilatory function, particularly in younger individuals with only modest degrees of airflow abnormality.[37] Such studies can certainly be taken as important indicators of benefit from early identification and intervention through smoking cessation. Today there is a great interest in techniques for smoking cessation which include behavioural modification, choice of a date to give up, and use of nicotine replacement for the most addicted individuals. Other drugs such as clonidine and certain tranquillisers may ameliorate symptoms of nicotine withdrawal. A discussion of all the approaches that are being tried in smoking cessation is beyond the scope of this article.

A massive multicentre trial known as the Lung Health Study is presently underway in the United States. It focuses on the impact of early identification and intervention in smokers with mild to moderate forms of COPD. In all, 10 centres have now enrolled 5887 patients into a prospective study which is designed to compare outcomes of special care, including behavioural modification and smoking cessation, with ordinary care.[38 39] A subset of patients in the special care group also receive a bronchodilator, ipratropium bromide, designed to deal with the issue of non-specific bronchial hyperreactivity which has been shown to be an adverse prognostic factor in the decline of ventilatory function in mild to moderate stages of the disease.[40] Of those enrolled in this study 37% are women. It has already been shown that women have a greater degree of bronchial hyperreactivity than men with otherwise equal background factors.[39 40] Whether or not this can be reduced with the use of ipratropium and anticholinergic bronchodilators remains to be seen.

When the Lung Health Study is complete much information on the likelihood of altering the course of the early years and prognosis of COPD will be available. It stands to reason that early identification and prevention should become the model for the future. This approach could forestall or replace the method of care for advanced and severe COPD which requires a more aggressive approach known as pulmonary rehabilitation.


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