A progressive care programme for prolonged ventilatory failure: analysis of outcome

I. E. Smith and J. M. Shneerson

Summary

Forty consecutive patients who could not be weaned from mechanical ventilation in the intensive care unit (ICU) entered a multidisciplinary progressive care programme (PCP). The mean number of hours per day of ventilatory support was 19.9 at the time of transfer but only 6.7 at discharge. Eleven patients did not require ventilation after discharge, 24 received ventilation non-invasively and only three via a tracheostomy. Survival at discharge from hospital was 90% compared with the predicted survival of 53% from the Apache II scores on admission to the ICU. Seventy-six percent were alive 1 yr after discharge and 80% of patients were discharged directly from the PCP to their homes. Mental and emotional scores in a quality of life questionnaire (SF 36) were normal, but physical function remained limited. (Br. J. Anaesth. 1995; 75: 399–404)

Key words


Most patients with acute or acute on chronic respiratory failure who require mechanical ventilation in an intensive care unit (ICU) recover sufficiently to breathe independently. A few, however, remain ventilator-dependent for several weeks, months or even years. Such patients have an increased risk of medical complications such as pneumonia [1] and psychological disturbances such as psychosis and depression [2]. They also hinder the throughput of, for instance, elective surgery, by prolonged occupancy of the ICU bed. Over the past 10 years we have received an increasing number of referrals for assistance with such patients and in January 1992 instituted an integrated, multidisciplinary approach, the progressive care programme (PCP). We describe the programme and give details of the management and outcome of the first 40 patients who were accepted.

Patients and methods

The inclusion criteria for the programme were that patients should be in an ICU, high dependency unit or equivalent Unit, and should be failing to progress with weaning from assisted ventilation despite maximal, conventional treatment of any chronic underlying condition or acute pulmonary, cardiovascular or metabolic disorder. Occasional patients were accepted whose trachea had been extubated but had persistent ventilatory failure. Diagnoses included chronic bronchitis and emphysema, neuromuscular diseases such as myopathy and motor neurone disease and chest wall deformity particularly scoliosis. Exclusion criteria were the presence of multisystem failure, organic brain damage or dementia severe enough to make cooperation with non-invasive ventilatory support impossible.

On admission to the programme, the patient’s diagnosis, ventilatory requirements and medication were reviewed. Particular attention was given to nutrition and psychological aspects of care. Swallowing safety was assessed and the patient encouraged to eat and drink if possible. Communication was facilitated using various commercially available aids or with speaking valves and a controlled cuff leak. Sedative medication was withdrawn and a normal day–night routine enforced as far as was practical in order to restore a normal sleep–wake cycle. Attempts at weaning were only initiated when all of these factors had received attention and blood gas tensions were normal. Patients were transferred at the earliest opportunity to one of a range of non-invasive forms of ventilation. This included negative pressure systems using an iron lung or cuirass, or intermittent positive pressure ventilation via a nasal or full face mask. Continuous non-invasive monitoring of ventilatory status with pulse oximetry and transcutaneous carbon dioxide monitoring, calibrated regularly against arterial blood-gas data was used during all changes of ventilatory support.

Patients who failed to wean completely from assisted ventilation were, along with the main carer, trained in the use of the ventilator. A comprehensive discharge package involving the general practitioner, district nurses and social services was prepared to ensure safe return home. There has been an open readmission policy and a 24-h telephone helpline for patients and their families. All patients have been readmitted electively at regular intervals in order to assess their progress and need for any changes in ventilatory support.

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All patients admitted to the PCP between January 1, 1992 and August 31, 1994 were identified. Patient details, including age, sex and previous medical history, were documented. Details of ICU admission were sought including; indications for tracheal intubation and ventilation, trials of extubation, duration before tracheotomy (if performed), drug therapy, especially steroids and sedatives, and time from admission to ICU to transfer to the PCP. The Apache II score was calculated where full data were available for the first 24 h of the ICU admission [3]. From the referring hospital’s records of the day immediately before transfer to the PCP, arterial blood-gas data, details of ventilation used and number of hours of ventilatory support and the working diagnosis were recorded. Duration of PCP admission was recorded, and for the day before discharge, the type of ventilatory support used, number of hours required, arterial blood-gas data and final diagnosis were recorded.

The outcome measures investigated were: survival to discharge from hospital, if patients were discharged home, to nursing home or back to the referring hospital, degree of ventilator dependence at discharge and 3-, 6- and 12-month survival rates. A diagnosis of chronic obstructive pulmonary disease (COPD) was made in the ICU are shown in table 1, together with the final diagnoses at the time of discharge from the PCP. Within the pulmonary disorders group there were 11 patients with chronic bronchitis and four of these had suffered previous pulmonary tuberculosis (one treated by upper lobectomy and one by pneumonectomy). All five patients with a chest wall deformity had scoliosis, one subsequent to a thoracoplasty for tuberculosis. The values in parentheses in table 1 represent the number of changes in diagnosis. In 11 patients (27.5 %) the diagnosis was altered during admission to the PCP. Two diagnoses of asthma, for example, were discarded; in one case extra thoracic airway obstruction was demonstrated because of vocal cord palsy, while in the other there was no evidence of airflow obstruction. In one patient with only moderately severe chronic bronchitis, which on review was not felt to be sufficient to explain ventilatory failure, motor neurone disease was diagnosed. The two diagnoses of polymyositis were altered to one of non-inflammatory myopathy and one of motor neurone disease. As a result of such changes in the main diagnoses and the rejection of secondary diagnoses of asthma, high-dose, systemic steroids were withdrawn in a total of 13 cases. Sedative medication was withdrawn in all 31 patients (77.5 %) receiving it at the time of transfer.

The mean duration of ICU admission was 32 days (SD 30.48, maximum 154 days). In 28 patients there had been no attempt at tracheal extubation. In five patients there had been one failed attempt at extubation, in five there had been two and in two there had been four attempts. Twenty-nine patients had undergone tracheotomy after a mean period of 13 (SD 8.51) days from admission to ICU. The mean duration of admission to the PCP was 27 (SD 16.24) days during which two patients each had one failed trial of extubation while in 28 patients the trachea was extubated successfully at the first attempt (in one patient the trachea had been extubated before transfer, two patients died before extubation was attempted and seven were discharged with a tracheostomy tube in situ).

Details of ventilatory requirements and arterial blood-gas data at the time of transfer to and discharge

### Table 1: Diagnosis at time of referral to PCP and at the time of discharge. The values in parentheses indicate the number of diagnoses which were rejected

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>At transfer to PCP</th>
<th>At discharge from PCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary</td>
<td>17 (5)</td>
<td>12</td>
</tr>
<tr>
<td>Neuromuscular disorders</td>
<td>17 (5)</td>
<td>22</td>
</tr>
<tr>
<td>Chest wall deformity</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Obstructive sleep apnoea</td>
<td>2 (1)</td>
<td>1</td>
</tr>
</tbody>
</table>

Results

In the first 32 months that the PCP was available, we accepted 40 patients (21 M, 19 F), with a mean age of 54 (range 19–75) yr. The reason for tracheal intubation in the referring hospital’s ICU was respiratory arrest in 23 cases and deteriorating arterial blood-gas tensions in the remainder. Mean $P_{CO_2}$ at the time of intubation was 12.6 (SD 3.43) kPa. In 32 patients, an acute cause for ventilatory failure was diagnosed. These diagnoses included pneumonia in 12 patients, bronchitis in nine, asthma in three, polymyositis in two, cerebrovascular accidents in two and pulmonary oedema, fat emboli, myasthenia gravis and neurosarcoïd in one each. In all but five patients it was felt that a second, chronic condition had contributed to the development of ventilatory failure and in those in whom no acute diagnosis was made it was felt that the deterioration was a result of the chronic condition alone. The chronic underlying conditions and acute conditions where no other diagnosis was made in the ICU are shown in table 1.

**Statistical methods**

Differences between the number of hours of ventilation per day and the need for additional oxygen on transfer to the PCP and on discharge were analysed using the Wilcoxon matched pairs signed rank test. Differences between arterial blood-gas data at transfer and discharge were examined using paired t tests. Differences in age, Apache II score, blood-gas data at presentation and at discharge, duration of ICU admission and duration of PCP admission between groups with different outcomes were examined using the Mann–Whitney U test. Significant results were taken at $P < 0.05$. The predicted hospital mortality was calculated using the Apache II score at presentation and adjusted for diagnosis using the method described by Knaus and colleagues [3].
from the PCP are given in table 2. There was a significant reduction in the number of hours per day that the patients required ventilatory support, from a mean of 19.9 to 6.7 h \((P < 0.001)\). On entry into the programme, 30 patients were completely ventilator-dependent but at discharge only seven required more than 8 h of ventilation per day, and only one patient remained completely ventilator-dependent. Four patients were transferred having recently had ventilatory support withdrawn but their mean arterial \(P_{\text{CO}_2}\) was 8 kPa and three required another period of invasive ventilation shortly after admission to the PCP. One was subsequently weaned completely and two were discharged home with NIPPV. Added inspired oxygen was required by 32 patients at transfer but by only two by the time of discharge. In total 11 patients were discharged with no ventilatory support although four retained a tracheostomy tube, 19 with NIPPV and five with a cuirass ventilator. The distribution of the different modes of assisted ventilation among the major diagnostic groups is shown in table 3. This shows that patients with pulmonary disease were least likely to require assisted ventilation at discharge.

Despite the reduction in ventilatory support, there was a trend towards a lower daytime \(P_{\text{CO}_2}\), although this did not reach statistical significance. In part this may be because at transfer in 3 patients the lungs were hyperventilated with an arterial \(P_{\text{CO}_2}\) of less than 4.5 kPa. Conversely, the lungs of 12 patients were hyperventilated at transfer, with a \(P_{\text{CO}_2}\) of greater than 7 kPa. All of these 12 patients had a \(P_{\text{CO}_2}\) of less than 7 kPa at discharge and were self-ventilating in the daytime. Similarly, there was no significant difference between mean arterial \(P_{\text{O}_2}\) at transfer and at discharge, although mean \(F_{\text{I}_{\text{O}_2}}\) was significantly lower \((P < 0.001)\). Patients with a diagnosis of chronic pulmonary disease had a significantly lower mean arterial \(P_{\text{O}_2}\) (8.5 kPa) at discharge than those with a non-pulmonary disease (mean 11.4 kPa; \(P < 0.001)\).

Two patients died before discharge from the PCP and a third who had been converted successfully from tracheostomy ventilation to NIPPV died after transfer to the referring hospital. Two of these patients had motor neurone disease and the other patient had chronic bronchitis and emphysema. The overall hospital survival rate was therefore 92.5 %. Adequate data were available to calculate the Apache II scores on admission to the referring ICU for 30 patients. The mean Apache II score was 26.9, giving a predicted survival, when adjusted for diagnostic group, of 53 %. All three patients who died in hospital were included in the group of 30 with a complete Apache II score, giving an actual hospital survival of 90 % (27 of 30). The mean age of the patients who died was 73 yr, which was significantly older than the survivors \((P = 0.04)\), and their mean Apache II score was 37, which was significantly greater than that of the survivors (mean 25.8; \(P = 0.02)\). No other significant differences were found between the groups.

Of the original 40 patients, 32 were discharged directly to home (80 %) and another two patients were discharged to residential care (5 %). Four patients (10 %) were discharged back to the referring hospital, of whom one died in hospital, one was discharged subsequently to residential care and two to home. Compared with patients who were discharged to home directly from the PCP, patients transferred for further hospital or residential care required assisted ventilation for more hours per day \((P = 0.027)\). There was no relationship between discharge destination and Apache II score, duration of ICU and PCP admissions or arterial blood-gas data at discharge.

The overall survival of the 40 patients, including follow-up, is shown in figure 1. This shows that the

<table>
<thead>
<tr>
<th>Diagnostic group</th>
<th>Self-ventilating</th>
<th>Cuirass</th>
<th>NIPPV</th>
<th>Tracheostomy ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary</td>
<td>5 (45.5 %)</td>
<td>1 (9 %)</td>
<td>5 (45.5 %)</td>
<td>0</td>
</tr>
<tr>
<td>Neuromuscular</td>
<td>5 (24 %)</td>
<td>4 (19 %)</td>
<td>9 (43 %)</td>
<td>3 (14 %)</td>
</tr>
<tr>
<td>Chest wall deformity</td>
<td>1 (20 %)</td>
<td>0</td>
<td>4 (80 %)</td>
<td>0</td>
</tr>
<tr>
<td>Obstructive sleep apnoea</td>
<td>0</td>
<td>0</td>
<td>1 (100 %)</td>
<td>0</td>
</tr>
</tbody>
</table>
majority of deaths occurred in the first 3 months after discharge from the PCP. Eight patients with a neuromuscular disorder (42%) and four with a pulmonary disorder (33%) had died. In the period of follow-up none of the patients with chest wall deformity had died. Mean age at referral of the patients who died was 62 yr, making them significantly older than the survivors (mean age 51 yr; P < 0.02). Apache II scores, arterial blood-gas tensions at presentation, duration of hospitalization, hours of ventilation per day and arterial blood-gas tensions at discharge of the survivors and those who died were not significantly different.

The SF 36 questionnaire was sent to the 28 surviving patients and 20 completed replies were received, giving a response rate of 71.4%. The median interval from discharge from the PCP for these patients was 13 months. The scores for the patient group were compared with normative scores for a sample from the general population with a similar mean age [5]. The scores are shown in figure 2, which demonstrates that the patients had low scores for physical function and physical role limitation, as would be expected from their degree of physical disability. Nevertheless the scores for vitality, mental health and emotional role limitation, which are indicators of mood, were similar to those of the general population.

Discussion

We have developed a multidisciplinary progressive care programme (PCP) to help patients who require prolonged mechanical ventilation in the ICU to return to life in the community. On entering the programme each patient’s medical condition is reviewed, the patient stabilized and the requirements for care after discharge from hospital are assessed. Attention is given to problems of swallowing, cough, speech, psychological adaptation, nutrition, mobilization and the sleep–wake cycle, and each patient progresses through a range of partial ventilatory support techniques to discover the minimum degree of assistance required to prevent the recurrence of ventilatory failure while allowing the patient to be cared for at home.

The results of the first 40 patients accepted onto the programme suggest that this approach is a valuable adjunct to conventional ICU management. In most patients the degree of ventilator dependence was reduced, while two patients who had been removed from ventilatory support were re-estab-

lished on long-term nocturnal ventilation as their blood-gas tensions indicated that they were at risk of recurrence of ventilatory failure. Only one patient remained completely ventilator-dependent at the time of discharge from the programme. The closure of the tracheostomy in 24 patients by the time of discharge, and another two patients at subsequent follow-up admissions greatly simplified their care in the community. Despite the reduction in the degree of ventilator dependence and in the number of patients receiving supplementary oxygen, mean values for arterial Pco2 and Po2 at admission to the programme and at discharge were not significantly different.

The overall hospital survival rate of 92.5% was considerably higher than the range of 39.2–57.6% in other recent series of patients requiring mechanical ventilation [6–13], and in those patients for whom full data were available, the hospital survival rate of 90% was higher than predicted from the Apache II score. These predicted survival values are derived from an American study of ICU outcome [3] and it may be that there are unrecognized systematic differences between the American and United Kingdom health care systems. However, in a study using the Apache II scoring system in the ICU [14, 15] in the United Kingdom, while some variation from the predicted outcome was found, the overall fit of the data was good. In calculating the risk of death from the Apache II scores, we used the final diagnosis on discharge from the PCP which was different from the ICU diagnosis in 11 (27.5%) patients. In five of these patients however, this did not alter the Apache II diagnostic category and in four the chance of survival was greater in the new diagnostic category.

Our high survival rates could in part result from selection bias in the referral and acceptance of patients into the PCP. In general the patients were medically stable on arrival on the programme and none required inotropes or renal support; patients with organic brain damage were excluded. However in 72.5% the trachea had been intubated and the lungs ventilated for more than 14 days and such patients have been shown previously to have a poor prognosis [16]. The high survival rate in our study could also be related to the preponderance of patients with chronic obstructive lung disease and neuromuscular disorders. This seems unlikely however as in previous studies the prognosis worsened progressively from the group of subjects who had taken a drug overdose through postoperative patients, those with asthma, acute left ventricular failure, chronic
airflow obstruction, neuromuscular disorders and skeletal deformity, cerebrovascular diseases and cancer, to those who required mechanical ventilation after cardiopulmonary resuscitation [8, 10, 12, 17]. Our patients would therefore be expected to fall in the middle to poor range of expected survival from these composite series.

While the size of the effect may be in doubt, we believe that the PCP offers an important improvement in hospital survival. The central factor in this is likely to be the successful withdrawal of invasive mechanical ventilation with its associated risks. In the present study this was facilitated by several factors of which the establishment of a normal sleep–wake cycle and a review of diagnosis are two examples. In the conventional ICU, it is difficult to establish a normal day–night cycle and hypnotics are frequently prescribed. Both sleep deprivation [18] and sedative medication affect respiratory drive and may hinder weaning. We withdrew sedation successfully in all 31 (77.5 %) patients requiring this medication at transfer. Changes in diagnosis on admission to the programme led to changes in management; for example, steroids were withdrawn in 13 patients (32.5 %). High-dose steroids may produce a myopathy which affects respiratory muscles [19], a catabolic state, hypokalaemia, fluid retention, immunosuppression, psychosis and sleep disturbance, all of which may lead to failure to progress with weaning.

Survival rates after discharge from the ICU of patients with ventilatory failure have been reported in several previous studies but it is difficult to compare these with each other, and also with the present study, as they have been carried out at different times and in different health care systems. The studies which include a broad range of underlying diagnoses of patients whose ventilatory failure was severe enough to warrant mechanical ventilation in the ICU indicate that the survival rate 1 yr after discharge ranges from 16.0 to 48.9 % [6, 8–12, 17, 20, 21] compared with our survival rate of 76 %. The survival rates in the present study indicate that there is a considerable early mortality followed by a plateau. This pattern has been observed previously [22] and may have resulted from incomplete recovery from the acute illness, progression of the underlying chronic condition or inadequate care resources being provided in the home after discharge.

The overall survival after discharge from the PCP was not related to the Apache II score, which indicates the severity of the acute illness, to the duration of admission to the ICU or the PCP, to the discharge values for $P_{\text{CO}_2}$ or $P_{\text{O}_2}$, or to hours of ventilation per day. The only correlation with survival was the patient’s age, as has been observed elsewhere [8, 13]. The medium-term prognosis of patients with chronic airflow obstruction in previously reported studies varied considerably, but for those requiring mechanical ventilation the survival rate was approximately 60 to 70 % at discharge from hospital, 45 % at 1 yr and 35 % at 2 yr [23]. These rates compare with ours of 92 % at discharge from hospital and 67 % at 1 yr. In some studies the survival rate was related to the pH at presentation but this was not our experience and it has been seen only in reports in which a minority of subjects received mechanical ventilation [24, 25].

Of the total group of 40 patients, 80 % were discharged directly from the PCP to their own homes, which is a higher proportion than previously reported in ICU patients [8, 21] and chronic ventilator-dependent units [26–28]. The ability to return home was not related to the patient’s underlying diagnosis, age or duration of hospitalization but did correlate with the number of hours of mechanical ventilation per day at discharge. It therefore reflects the intensity of support required and the high proportion returning to their own homes in this study reflects the use of non-invasive ventilatory support. This also probably explains the improved medium-term survival in this study compared with other studies where it was not used. The PCP post-discharge care package includes planned readmissions for reassessment of the patient’s progress and this has allowed continual fine tuning of the degree of ventilatory support provided. During the duration of the study none of the patients required a second admission to the ICU.

There are few data in previous reports of the quality of life of patients who have been discharged from the ICU and have required mechanical ventilation [22, 29]. We assessed our subjects with a general health questionnaire which showed that those activities which require physical ability are limited but that measures of emotional function, vitality and mental health are comparable with those for normal subjects. This important finding indicates that a good quality of life can be regained after prolonged admission to an ICU and then the PCP, despite the need for long-term ventilatory support in the home.

We have not carried out a cost analysis of the service but the mean cost of the ventilator for those patients who required one at home was £2680 and subsequent direct maintenance costs in our unit are about £75 per annum. The cost of care in the PCP per day is between 33 and 50 % of that in an ICU and so the programme probably leads to considerable financial savings. The benefits of the PCP to patients after conventional ICU management are, in summary: increase in hospital and post-discharge survival, reduction in the length of stay in the ICU and restoration of a normal quality of life, in several respects, after the acute illness. It should be considered for any patient failing to progress with weaning from assisted ventilation despite maximal conventional ICU treatment when the underlying diagnosis is neuromuscular, a chest wall deformity or chronic obstructive pulmonary disease.

References


