Long-term Outcomes for Patients Discharged From a Long-term Hospital-Based Weaning Unit*

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Background: Because little attention has been given to the long-term outcomes of patients in hospital-based ventilator weaning units, we undertook this assessment of 5-year outcomes of patients discharged from the Respiratory Special Care Unit (ReSCU) of the Cleveland Clinic Hospital.

Methods: The ReSCU consists of six private beds on a pulmonary specialty ward. Features of the unit include noninvasive monitoring with signal output at each bedside and at a central monitoring station. The unit is staffed by nurses with specific pulmonary rehabilitation expertise and has 24-h respiratory therapist supervision. Ongoing prospective data collection in the ReSCU includes monitoring weaning success, demographic features, hospital discharge status, and hospital discharge disposition. Long-term outcomes were ascertained using a review of hospital medical records and direct inquiry to patients and/or family members.

Results: Between August 22, 1993, and August 22, 1996, 162 individuals were admitted to the ReSCU, with 7 persons having repeat admissions during separate hospital admissions. Seventeen percent of these persons (n = 27) died during the hospitalization, while 83% were discharged from the index hospitalization (ie, the hospital stay during which the patient was first admitted to the ReSCU). Kaplan-Meier (KM) mortality rate estimates were as follows: 1 month, 11% (95% confidence interval [CI], 6 to 15%); 1 year, 57% (95% CI, 49 to 65%); 2 years, 68% (95% CI, 61 to 75%); 3 years, 73% (95% CI, 66 to 80%); 4 years, 76% (95% CI, 69 to 83%); and 5 years, 81% (95% CI, 75 to 87%). The 5-year KM mortality rate estimates considered by year of ReSCU admission were as follows: 1993, 92% (95% CI, 77 to 100%); 1994, 84% (95% CI, 73 to 95%); 1995, 87% (95% CI, 77 to 96%); and through August 22, 1996, 66% (95% CI, 51 to 81%).

Conclusions: In this population requiring prolonged inpatient ventilatory support, moderately high acute mortality rates are consistent with data from other series. In this analysis of longer-term follow-up rates, the 5-year survival rates are low, with higher mortality rates within the first 2 years and a slower decline in survival thereafter.

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Key words: chronic ventilator unit; long-term outcomes; survival; weaning

Abbreviations: APACHE = acute physiology and chronic health evaluation; CCF = Cleveland Clinic Foundation; CI = confidence interval; KM = Kaplan-Meier; LTAC = long-term acute care; ReSCU = Respiratory Special Care Unit; VDU = ventilator-dependent unit

Although patients undergoing long-term mechanical ventilation, which is conventionally defined as either > 14 days or ≥ 21 days of mechanical ventilation,1 have been the focus of increased attention, with short-term outcomes assessed in several available series,2–4 little attention has been given to the long-term outcomes of these individuals. In the context of evaluating our Respiratory Special Care Unit (ReSCU), a six-bed hospital-based weaning unit at the Cleveland Clinic Foundation (CCF) Hospital to which ventilator-dependent patients in other CCF ICUs were transferred, we have previously described the short-term outcomes of an initial

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A cohort of 212 patients.\textsuperscript{3} The current study extends this evaluation by assessing the survival rates up to 5 years and the clinical status of patients admitted to the ReSCU.

**Materials and Methods**

Features of the ReSCU include the following: (1) six private beds on a pulmonary specialty ward staffed by nurses with special pulmonary and rehabilitation expertise; (2) 24-h respiratory therapist supervision; (3) noninvasive monitoring (ie, continuous pulse oximetry, end-tidal capnometry [CO\textsubscript{2}SMO model 7100; Novametrix Medical Systems; Wallingford, CT], and ventilator alarms) with signal output at each bedside and at a central monitoring station (Patient Care Monitoring System; Spacelabs Medical; Redmond, WA); and (4) a multidisciplinary approach (involving dieticians, physical therapists, speech pathologists, and social workers) and attention by the team of health-care providers to providing support and encouragement, to patients’ needs in returning to full function, to preserving strength, flexibility, and ambulation (where possible), and to phonation (ie, a rehabilitative focus). Daily weekday visits by speech therapists and physical (or occupational) therapists in addition to daily attention by the managing nurses and physicians were routine aspects of ReSCU care.

Eligibility criteria for ReSCU admission have been consistent since the opening of the ReSCU\textsuperscript{3} and include hemodynamic stability, the absence of an arrhythmia requiring telemetry for at least 3 days, and, in the attending physician’s judgment, the ability to benefit from the ReSCU. When requests for ReSCU transfer exceeded the number of available beds, admission priority was given to patients who were deemed to be weanable, with all patients referred to the ReSCU from ICUs of the Cleveland Clinic Hospital. The attending physician’s assessment of weanability was based on a review of the cause of respiratory failure and an assessment regarding the presence of remediable contributors to ventilator dependence (eg, infection and bronchospasm). Patients with irreversible underlying causes of respiratory failure (eg, advanced amyotrophic lateral sclerosis) were not deemed to be weanable and were admitted to the ReSCU only if training for home mechanical ventilation was being considered. Alternately, in patients for whom long-term ventilator support was planned and going home was not deemed desirable or possible, appropriate long-term facilities were sought.

Ongoing prospective data collection in the ReSCU included monitoring weaning success and ReSCU discharge disposition. In order to allow for the assessment of 5-year follow-up status of all ReSCU patients in this series, the study cohort was restricted to patients admitted to the ReSCU between its opening (August 22, 1993) and August 22, 1996, with 5-year follow-up status determined as of August 22, 2001. Long-term outcomes were ascertained based on a review of hospital medical records, a social security database as of June 2002, and direct inquiry to patients and/or family members. Specifically, postcards containing a short questionnaire were sent to all patients to learn current status, especially regarding the degree of ventilator dependence (if any). Nonresponders and/or family members were called by one of the study investigators to ascertain this information.

The causes of respiratory failure leading to mechanical ventilation and ultimately to ReSCU admission were classified according to a previously described nine-category classification scheme,\textsuperscript{2} as follows: group 1, COPD; group 2, ARDS with or without multiple organ failure in a nonsurgical patient; group 3, ARDS with multiple organ failure in a surgical patient; group 4, post-cardiovascular surgery (without ARDS); group 5, post-thoracic surgery (without ARDS); group 6, respiratory failure without ARDS after any other surgery; group 7, neuromuscular disease; group 8, underlying chronic lung disease other than COPD; and group 9, miscellaneous causes. To permit statistical comparison among groups, several of the nine categories were combined logically and a priori to create five groups of respiratory failure cause, as follows: Group 1, COPD (same group 1 as in the nine-category system); group 2, nonsurgical causes (combines groups 2 and 8 in the nine-category system); group 3, respiratory failure complicating surgical intervention (combines groups 3 to 6 in the nine-category system); group 4, neuromuscular disease (same as group 7 in the nine-category system); and group 5, miscellaneous causes (same as group 9 in the nine-category system).

Criteria for ReSCU discharge, as determined by the attending physician, included the following:

1. Stable ventilator independence for at least 48 h (and generally for $\geq$ 72 h).
2. Consistent failure to sustain spontaneous breathing (characterized by the patient’s developing tachypnea, tachycardia, hemodynamic instability [including evidence of cardiac ischemia], and/or acute rise in end-tidal CO\textsubscript{2} tension or arterial CO\textsubscript{2} that was deemed clinically significant to the managing physicians) with weaning attempts during multiple serial weaning trials over at least 3 days in the absence of identifiable, remediable causes of ongoing respiratory failure; or
3. Acute hemodynamic instability requiring ICU transfer.

Discharge from the ReSCU was to home, to an extended care facility for rehabilitation, to a regular hospital nursing unit in the Cleveland Clinic Hospital (or to another acute care hospital on patient request), or, if the patient was deemed to be unweanable (ie, with repeated failures to wean after experiencing optimized status of remediable causes of respiratory failure), to a long-term facility for ongoing ventilatory care.

Statistical analysis was performed using Kaplan-Meier (KM) survival analysis to estimate overall survival, and to assess the association between survival and the year of ReSCU admission, gender, age as a continuous variable, and cause of respiratory failure. For subjects with multiple ReSCU admissions, the number of months of follow-up for analysis were calculated from the date of first ReSCU admission to the final outcome status date. Cox proportional hazards regression models were used to perform pairwise comparisons among different years of ReSCU admission and to assess the association between survival and age as continuous variables. Multivariable Cox models were used to assess the association between survival and age, gender, year of ReSCU admission, and cause of respiratory failure. Risk factors were adjusted for each other regardless of their significance in the model. The significance level was 0.05 for all hypotheses, and hazards were adjusted for each other regardless of their significance in the model. Factors were adjusted for each other regardless of their significance in the model.

**Results**

Between August 22, 1993 and August 22, 1996, 162 patients were admitted to the ReSCU. As shown in Table 1, 59% of the cohort were women, and the mean age was 65 years. The causes of respiratory failure leading to mechanical ventilation and need for ReSCU among the 162 patients included the following: (1) COPD (13 patients: 8%); (2) ARDS,
with or without multiple organ failure in a nonsurgical patient (47 patients; 29%); (3) ARDS with multiple organ failure in a surgical patient (31 patients; 19%); (4) postcardiovascular surgery (without ARDS) [23 patients; 14%]; (5) postthoracic surgery (without ARDS) [26 patients; 16%]; (6) respiratory failure without ARDS after any other surgery (2 patients; 1%); (7) neuromuscular disease (11 patients; 7%); (8) underlying chronic lung disease other than COPD (2 patients; 1%); and (9) miscellaneous causes (7 patients; 4%).

Table 2 presents the admission history of these 162 patients. Specifically, multiple ReSCU admissions during a single hospitalization occurred in 23 individuals, while 7 patients were readmitted to ReSCU on separate hospitalizations, accounting for a total of 204 ReSCU admissions. The median hospital length of stay before ReSCU admission was 29 days (25th to 75th percentiles, 18 to 45 days; range, 0 to 224 days).

To fully represent the discharge venues for ReSCU patients, the analysis of discharge venues included all 173 hospital admissions (including each readmission for the seven patients with more than one stay in the ReSCU on separate hospitalizations). Among the hospital survivors (145 patients; 84%), 63% (92 patients) were discharged to a skilled nursing facility; 28% (41 patients) were discharged to home, and 8% (12 patients) were discharged to another acute care facility. Of the 41 patients returning home, six received mechanical ventilation for at least part of the day (ie, two patients were receiving continuous mechanical ventilation, two patients were receiving nocturnal ventilation only, and two patients were receiving mechanical ventilation at night and for part of the day).

Twenty-seven of the 162 individuals (17%) died during the hospital stay, and 135 patients (83%) were discharged from the hospital. Two of these 27 decedents expired after ventilator support was withdrawn in response to their directives. The hospital survival rate among the seven patients readmitted to the ReSCU on separate hospitalizations was 86%. As shown in Figure 1, KM survival rate estimates for all 162 patients were as follows: 1 month, 89% (95% confidence interval [CI], 85 to 94%); 1 year, 43% (95% CI, 35 to 51%); 2 years, 32% (95% CI, 25 to 39%); 3 years, 27% (95% CI, 20 to 34%); 4 years, 24% (95% CI, 17 to 31%); and 5 years, 19% (95% CI, 13 to 25%). An additional 7 of the 28 patients still at risk at 5 years were known to have died after the 5-year milestone.

Considered by year of ReSCU admission (Fig 2), the 5-year survival rates (95% CI) by year were as follows: 1993, 8% (95% CI, 0 to 23%); 1994, 16% (95% CI, 5 to 27%); 1995, 13% (95% CI, 4 to 23%); and 1996, 34% (95% CI, 19 to 49%). Univariable KM analysis showed a significant association between the year of ReSCU admission and survival (p = 0.031). Pairwise comparisons showed that survival among patients who were admitted to ReSCU in 1996 was significantly higher than that among patients admitted in 1995 (p = 0.006 [Cox model]). Age was significantly associated with survival in a Cox model (p < 0.001), and the relationship was found to be linear (ie, the quadratic term was not significant). Univariable analysis of survival by age strata (Fig 3) among the elderly (ie, among groups with patients who were < 65 years, 65 to 74 years, 75 to 84 years, and ≥ 85 years) showed that younger age is significantly associated with longer survival (p = 0.001). In the multivariable Cox model, age (as a continuous variable) was significantly associated with survival (p < 0.001; risk ratio per 10 years, 1.3; 95% CI, 1.1 to 1.6) even after adjusting for gender (p = 0.052; risk ratio, 1.4; 95% CI, 1.0 to 2.0), year of ReSCU admission (p = 0.14), and cause of respiratory failure (p = 0.81).

To assess the pattern of mortality over time following ReSCU discharge, we calculated the estimated hazard function for mortality > 5 years following ReSCU discharge (Fig 4). Consistent with the raw survival rates showing a higher risk of dying within 2 years post-ReSCU discharge than later, the analysis shows that a 1-year ReSCU survivor (hazard ratio, 0.04) can expect to live another 25 months (1/0.04), whereas a 3-year ReSCU survivor can expect to live another 71 months (1/0.014).

Among the 28 patients who were still at risk at
5 years post-ReSCU discharge, ventilatory status was known for 17. Among those 17 patients, 13 were ventilator-free (76%; 95% CI, 50 to 93%), 3 required some ventilator assistance at home (18%; 95% CI, 4 to 43%), and 1 was ventilator-dependent in an extended care facility (6%; 95% CI, 0 to 29%).

**Discussion**

In this description of long-term survival in patients in a hospital-based weaning unit, our main findings were as follows:

1. In keeping with the results of the few available earlier reports, rates of 5-year survival among patients admitted to our hospital-based weaning unit were low.
2. The pattern of postdischarge survival rate shows steep declines within the first 2 years (32%) with slower decline thereafter (5-year survival rate, 19%).
3. Survival rates for the patient cohort admitted to ReSCU later (1996) were higher than those for patients admitted earlier (1995).
4. Long-term survival rates were lower for older patients (estimated risk ratio, 1.3 per decade).
5. Although information regarding long-term survivors’ functional status was limited, most (76%) survivors whose status was known were ventilator-independent.

This study extends the limited available experience from long-term weaning units, which is summarized in Table 3. Specifically, we are aware of data regarding survival rates at ≥1 year post-hospital discharge from six other reports, two of which regarded experience with a hospital-based weaning unit like the ReSCU. In the largest series describing long-term outcomes of weaning unit patients, Scheinhorn et al reported a 1-year survival rate of 38% among 1,123 patients admitted to a regional weaning center between 1988 and 1996. As in the current series, survival rates increased over time in
that series, with the 1-year survival rate increasing significantly from 28.8% (for patients admitted to the weaning center in the period between May 1988 and June 1991) to 44.9% (for patients admitted to the weaning center between July 1991 and December 1995) \( p < 0.001 \). In a second study regarding outcomes of patients transferred from the ICUs to a long-term acute care (LTAC) hospital, Carson et al\(^6\) reported that only 23% of 133 patients were alive 1 year following LTAC hospital admission and that only 8% were fully independent. An analysis of the risk factors for 1-year mortality identified a high-risk group consisting of patients who were \( \geq 75 \) years old and those between 65 and 75 years who were not independent prior to ICU admission; the 1-year survival rate in this group was 5% in contrast to 56% \( p < 0.001 \) for the low-risk group (ie, those younger than 65 years or those \( \leq 75 \) years who previously had been independent). In a third series, Nasraway et al\(^7\) reported outcomes in a consecutive series of 97 adult ICU survivors, 73% of whom were ventilator-dependent at the time of discharge to an extended care facility. Survival rates were 50.5% at 1 year and decreased to approximately 35% at 2 years. In keeping with the disappointing long-term outcomes in our series and in that of Carson et al\(^6\), only 11.5% of all patients had returned home at 1 year, and were ventilator-independent with good physical function and at least fair quality of life. Gracey and colleagues\(^4,8\) reported that 53% of 190 patients who survived to discharge from the Mayo Clinic weaning unit were alive at 4 years. They also reported hospital mortality rates of 6% and 10%, respectively, for weaning unit patients for the intervals from 1990 to 1993 and from 1993 to 1998. Finally, Schonhofer et al\(^9\) have reported that the 3-year and 5-year survival rates among patients admitted to a German weaning center were 38% and 33%, respectively.

In keeping with the improving survival rates over time reported by Scheinhorn et al\(^5\), our data indicate improved survival in later years of ReSCU operation than in the initial years. Specifically, the survival of patients admitted to the ReSCU in 1996 exceeded that of earlier years (Fig 2). In the context that the nursing and respiratory therapy staff was stable over the study interval of 1993 to 1996 and that no changes in equipment or weaning strategies were implemented, we suspect that this enhanced survival reflects enhanced experience and ability of the attending physicians to select patients who were more likely to benefit from ReSCU admission. However, we cannot exclude the possibility that other developments or innovations in the ReSCU may have contributed to this enhanced survival (eg, new wean-
ing approaches or greater use of protocols), greater experience accrued by a team of long-term ReSCU health-care providers, or improvements in post-ReSCU care provided to the patients.

The 5-year survival rates in the current study extend the experience of the single available report of 5-year survival by Schonhofer et al.9 In that earlier study, the 5-year survival rate estimated from 21 at-risk patients was 33%, and the survival rate declined steeply from 3 months post-hospital discharge (67%) to 3 years (38%). Similarly, our experience suggests that the steepest decline in survival occurred within the first 2 years following ReSCU admission, with a slower decline between 2 and 5 years.

Although concurrent controlled trials regarding the efficacy of weaning units compared with conventional ICU care are not available, a comparison of outcomes of patients managed in both types of units may permit cautious comment, recognizing the potential biases that patients’ baseline mortality risks are not matched and that unit performance may be importantly affected by medical innovations over time. In an early series by Spicher and White11 regarding outcomes of 250 patients receiving mechanical ventilation for >10 days and discharged from conventional ICUs between 1979 and 1984, the rate of hospital survival was 39.2%. The 1-year and 2-year survival rates were 28.6% and 22.5%, respectively, and were considerably lower than the survival rates in the ReSCU (45% and 34%, respectively). Also, in a 1984 series of 10 COPD patients who received mechanical ventilation for >30 days, Morganroth et al12 reported a 1-year survival rate of 30%, which again was lower than that observed in the ReSCU. Finally, Gracey et al4 compared their experience with 132 patients in the Mayo Ventilator Dependent Unit (VDU) between 1990 and 1992 with 104 patients managed in a conventional ICU at the Mayo Clinic between 1986 and 1988. In support of the efficacy of the weaning unit, the hospital mortality rate was lower in the VDU patients (9.8%) than in the pre-VDU patients (43.3%; p = 0.01). Pooled data for patients whose respiratory failure was attributed to three underlying causes (i.e., previous lung disease, other medical conditions, and postoperative patients) showed that longer term survival (i.e., up to 3 years) was also higher among the VDU patients.

Several important limitations of this study warrant mention. First, although clinical practice in the ReSCU is informed by guidelines from the literature,1 the local features of this unit and of our practice may generalize incompletely to other settings. For example, the hospital-based nature of the unit, and its size and staffing may differ from other
A second shortcoming of this study was that, despite extensive efforts to achieve complete follow-up in this series, the long-term follow-up status of nine patients remained unknown. While this number is small and therefore unlikely to significantly affect overall outcomes in this study, complete follow-up is clearly preferable. Specifically, if all nine patients who were unaccounted for are assumed to...

Table 3—Summary of Available Series Regarding Long-term Outcomes of Patients in Weaning Units*

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Patients, No.</th>
<th>Unit Type</th>
<th>Reported Survival Rates, %</th>
<th>Total Ventilator-Dependent, %</th>
<th>Patients Ventilator-Free, %</th>
<th>Patients Partially Ventilator-Dependent, %</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gracey et al/1995</td>
<td>132</td>
<td>CVDU</td>
<td>76 (1 yr)</td>
<td>NR</td>
<td>87</td>
<td>13</td>
<td>Survival rates reported are based on those who were discharged alive from the hospital</td>
</tr>
<tr>
<td>Scheinborn et al/1997</td>
<td>1,123</td>
<td>RWC</td>
<td>38 (1 yr)</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Carson et al/1999</td>
<td>133</td>
<td>LTAC</td>
<td>23 (1 yr)</td>
<td>NR</td>
<td>21</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Nasraway et al/2000</td>
<td>97</td>
<td>ECF</td>
<td>49.5 (1 yr)</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>Includes non-ventilator-dependent patients at the time of ECF transfer 4-yr survival rates are reported as % of hospital survivors</td>
</tr>
<tr>
<td>Gracey et al/2000</td>
<td>420</td>
<td>CVDU</td>
<td>53 (4 yr)</td>
<td>19</td>
<td>60</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Schonhofer et al/2002</td>
<td>403</td>
<td>RWC</td>
<td>38 (3 yr)</td>
<td>NR</td>
<td>68</td>
<td>NR</td>
<td>Survival rates reported as % of hospital survivors whose follow-up status was obtained</td>
</tr>
<tr>
<td>Current series</td>
<td>162</td>
<td>ReSCU</td>
<td>43 (1 yr)</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>Survival rates reported as % of hospital survivors</td>
</tr>
</tbody>
</table>

*RWC = regional weaning center; ECF = extended care facility; CVDU = chronic VDU; NR = not reported.
have died just after their last known contact, the 5-year survival rate changes minimally, from 19 to 17%. A third limitation is our lack of APACHE (acute physiology and chronic health evaluation) data. Although APACHE scores are meant to stratify risk among short-term ICU patients based on presenting features rather than on later clinical characteristics (ie, at the time of ReSCU admission), the lack of APACHE data in our series hampers the comparison of our experience with those of others.

Overall, our findings suggest that as an example of a hospital-based weaning unit, care in the ReSCU is associated with favorable short-term survival and ventilatory goals, but that long-term survival rates, even among this selected cohort, are disappointing. The possible reasons for poor long-term outcomes may include patients’ overall poor medical condition as well as aspects of their longer-term care, which were beyond the scope of the current study but clearly warrant closer attention based on these results. We hope that these results will prompt further inquiry and analysis of the factors that influence long-term survival in order to effect better long-term outcomes.

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