Outcome of Patients Cared for in a Ventilator-Dependent Unit in a General Hospital*

Douglas R. Gracey, MD, FCCP; James M. Naessens, MPH; Robert W. Viggiano, MD, FCCP; Gary E. Koenig, RN, BA; Marc D. Silverstein, MD; and Rolf D. Hubmayr, MD, FCCP

We describe our initial experience with the admission of 129 patients for 132 episodes of ventilator-dependence to a self-contained ventilator-dependent unit (VDU) in a general hospital and present a survival comparison between VDU patients and a historic control population from the same institution. Forty-three patients were screened and denied admission to the VDU because long-term ventilator dependence was not felt to be a probable outcome (56%); they were medically unstable, often requiring electrocardiographic monitoring (19%), they had poor rehabilitation potential because of markedly depressed mental status (13%), or they preferred to be treated closer to their homes (12%). Thirteen (9.8%) of the VDU patients died in the hospital compared to 44 (42%) in the historic control group. After exclusion of patients with multiorgan failure (who made up 26% of the control group) and using a proportional hazard model to adjust for group differences in age and disease class, the difference in hospital mortality remained highly significant (p ≤ 0.01). Ninety-one of the 119 VDU patients (77%) were ultimately able to return home; 16 (13%) continued to use a ventilator intermittently at night; 26 patients (22%) were permanently placed in nursing homes, all off of the ventilator. Overall, 88% of the 119 patients discharged had been liberated from mechanical ventilation. Ninety-seven (82%) and 86 (72%) remain alive 1 and 2 years after discharge, respectively. Some of the survival benefits may be directly attributed to the VDU. Others reflect a change in treatment philosophy, which was nevertheless reinforced by our VDU experience.

(Chest 1995; 107:494-99)

VDU=ventilator-dependent unit

Key words: prolonged mechanical ventilator; ventilator dependence; ventilator weaning

In January 1990, the Mayo Clinic opened a ventilator-dependent unit (VDU) at Saint Marys Hospital in Rochester, Minn. The mission of the VDU was to create an environment conducive to the rehabilitation of patients with respiratory failure and at the same time lower the cost of providing care to ventilator-dependent patients. In this report, we describe our initial experience with managing patients in the VDU and present a survival comparison between VDU patients and a historic control population from the same institution during a 29-month period from 1986 to 1988.

METHODS

Organization of the Ventilator-Dependent Unit

The VDU is a self-contained area in the hospital with a dedicated medical and paramedical staff. A physician, approximately 14 nurses with expertise in and devotion to the care of patients with respiratory diseases, and a lead respiratory therapist are permanently assigned to the VDU. Additional personnel with shared responsibilities for other hospital services include pharmacists, respiratory therapists, physical and occupational therapists, dieticians, and a social worker. The unit takes a holistic approach to patient care with a strong emphasis on physical rehabilitation. The facility consists of six private patient rooms, a nursing station, a nurses' charting room, and two conference rooms. The number of beds needed for the unit was calculated from the number of patients who were mechanically ventilated for more than 29 days at Saint Marys Hospital between 1986 and 1988. Outside referrals of ventilator-dependent patients were not considered in our estimation of bed requirements.

Admission Criteria

Patients with respiratory failure were admitted to the VDU only if two or more successive ventilator weaning attempts were unsuccessful or if they were in a state of health which, in the opinion of the VDU physician, precluded liberation from mechanical ventilation in the foreseeable future. A tracheostomy and hemodynamic stability were required because neither electrocardiographic nor hemodynamic monitoring are available in the VDU. On January 1, 1992, the Health Care Financing Administration granted a waiver to the Mayo Clinic under the Demonstration Project With Respect to Chronic Ventilator Dependent Units in Hospitals. The waiver stipulates that Medicare patients must have been ventilator-dependent for a minimum of 21 days.
prior to VDU admission and must have had at least two unsuccessful attempts at weaning. Exception to both of these criteria is made if patients are clearly not weanable and are being admitted for home ventilator training. Furthermore, the admitting physician has to attest in writing that in his/her opinion the patient is either capable of being liberated from the ventilator or likely to return to the community despite receiving ventilatory assistance. If the latter circumstance is believed to be certain, the patient can be admitted to the VDU prior to 21 days of ventilator dependence so that the patient and caregivers can be trained in home mechanical ventilation and airway care. The male and female patients with the shortest period of preadmission ventilator dependence (2 and 7 days) had amyotrophic lateral sclerosis with acute decompensation of chronic respiratory failure. Patients with multiple organ failure were not admitted to the VDU unless other organ recovery had occurred, leaving patients ventilator dependent. Patients receiving hemodialysis were accepted in the VDU.

Patient Population

Between January 2, 1990, and December 31, 1992, 129 patients accounted for 332 admissions to the VDU. Three patients were admitted to the VDU on two occasions during two separate hospitalizations. Although some patients had more than one VDU admission during a single episode of care, for statistical purposes, they were considered to have one VDU admission. This occurred when the patient needed to be transferred to a surgical or medical ICU for some acute medical or surgical problem but was later returned to the VDU to complete the hospital stay.

In addition, 43 patients were screened by the VDU staff but did not satisfy admission criteria. Twelve of the 43 patients did not qualify for admission under the Health Care Financing Administration guidelines, were not thought to be truly ventilator-dependent when screened, and were subsequently weaned from mechanical ventilation in one of the ICUs. Eight patients were considered very unstable medically, and all eight died subsequent to our evaluation. Six patients were believed to have no rehabilitation potential because of cognitive deficits or because they had functioned marginally in a nursing home prior to their hospitalization. Five patients were discharged to hospitals closer to their homes rather than admitted to the VDU. Seven were on T-pieces and not considered ventilator-dependent, and the remaining five had not yet received a tracheostomy and did not subsequently require one.

Clinical and Outcome Data

In addition to demographic variables and descriptors of disease type and severity, we collected survival data up through hospital discharge and beyond. Physiologic classification of respiratory impairment was based on measures of interrupter mechanics. Inspiratory and expiratory muscle strength, physiologic dead space, and pulmonary gas exchange were also measured. Patients were assigned to one of six diagnostic groups as described by Gillespie et al. This facilitated the comparison of the VDU data with that of the historic control group. Accordingly, we distinguished between categories of uncomplicated acute lung injury, respiratory failure in conjunction with multisystem failure, preexisting lung disease, trauma, other medical conditions, and postoperative ventilatory failure. Duration of ventilator dependence before and following admission to the VDU, length of hospital stay, disposition and ventilator support status at discharge, and vital status as of March 31, 1993 were measured in all patients.

Statistical Analysis

The VDU outcome data were compared with data from a control population of 104 patients who had been ventilated for 29 days or more at Saint Marys Hospital between 1986 and 1988. Comparisons between the groups were made with χ2 analysis for nominal variables, Wilcoxon rank sum test for skewed continuous variables such as ventilator days, and two sample t tests for other continuous variables. Survival after hospital discharge was compared between groups with a proportional hazards model incorporating adjustments for age and classification distributions of Gillespie et al., restricting the comparison to categories with at least five patients in each time frame.

RESULTS

The 67 females and 62 males who were admitted to the VDU had a mean age of 68 ± 12 (SD) years, with a range of 24 to 90 years, and 65 ± 14 years, with a range of 20 to 87 years, respectively. With the exception of two outpatients who accounted for three admissions, all patients had been cared for by other medical or surgical services of Saint Marys Hospital prior to admission to the VDU, although some patients who had been transferred to Saint Marys from other hospitals were already ventilator-dependent. According to Table 1, 63% of patients, or 83 of 132 admissions, suffered from ventilatory failure that arose as a complication of a surgical intervention.

On average, women and men had been mechanically ventilated for 35 ± 26 (SD) days, with a range of 2 to 165 days, and 49 ± 112 days, with a range of 7 to 910 days, respectively, before admission to the VDU. Their duration of ventilator dependence while in the VDU was 14 ± 11 days for women and 19 ± 16 days for men. One patient had been ventilated at home for 910 days because of end-stage COPD. After excluding this patient, the average duration of ventilator dependence before admission to the VDU was 37 ± 22 days and was extended another 15 ± 14 days during the VDU stay. As a group, patients averaged 67 ± 36 days in the hospital, 31 ± 20 days of which were in the VDU.

Table 2 compares the diagnostic categories previ-
mechanically reported by Gillespie and associates among VDU patients and ventilator-dependent patients. The most striking difference from the historic control group is the lack of patients with multisystem failure in the VDU sample. Furthermore, a greater proportion of the VDU patients had surgery which was complicated by respiratory failure.

Thirteen of 132 (9.8%) patients admitted to the VDU died in the hospital. Six died in the VDU, six in surgical or medical ICUs, and one died after transfer to the Physical Medicine and Rehabilitation Unit. The discharge disposition of the remaining 119 patients is shown in Table 3. Ninety-one of the 119 patients (77%) were either discharged home directly from the VDU or were able to return home after a stay in another facility of the hospital, such as the Physical Medicine and Rehabilitation Unit. Sixteen of them (13% of the hospital survivors) continued to use a ventilator intermittently at night. Twenty-two patients (18%) were permanently placed in nursing homes, all off of the ventilator. Another four patients who had been liberated from the ventilator went to hospitals closer to their homes and were then placed in nursing homes. Two patients went to another hospital and then to a nursing home. Overall, 87% of the 119 patients discharged had been liberated from mechanical ventilation.

Figure 1 shows a Kaplan Meier survival curve of the 119 VDU survivors compared with that of an age- and sex-matched caucasian control population based on the United States 1990 life tables. Thirty-, 60-, and 90-day survival rates for VDU patients postdischarge are 91, 89, and 87%, respectively. Six-, 12-, 18-, and 24-month survival rates are 82, 76, 76, and 72%, respectively. There were not enough patients with more than 3 years of observation to draw conclusions about survival beyond 3 years; only 4 patients had been followed up for 3 years.

Overall, there were few differences in demographics and duration of ventilator dependence between the 132 VDU admissions and the 104 long-term ventilator admissions of 1986 to 1988, who served as historic control subjects (Table 4). The mean age of the pre-VDU patients was also 66±16 years, with a range of 17 to 88 years (p=0.729). There were slightly more females in the VDU group than in the earlier study (51.5 vs 40.4%, p=0.089). The length of hospitalization and the duration of ventilator dependence were also similar (length of stay: pre-VDU; median, 64 days; VDU, median, 58 days (p=0.202); ventila-

Table 2—Distribution of Admissions by Category of Gillespie et al for 104 Patients Mechanically Ventilated More Than 29 Days Pre-VDU (1986 to 1988) and 132 Patients in VDU (1990 to 1992)

<table>
<thead>
<tr>
<th>Classification of Gillespie et al</th>
<th>Pre-VDU Patients</th>
<th>VDU Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncomplicated acute lung injury</td>
<td>6 6</td>
<td>1 1</td>
</tr>
<tr>
<td>Respiratory failure with multisystem failure</td>
<td>27 26</td>
<td>0 0</td>
</tr>
<tr>
<td>Previous lung disease</td>
<td>7 7</td>
<td>17 13</td>
</tr>
<tr>
<td>Trauma</td>
<td>7 7</td>
<td>1 1</td>
</tr>
<tr>
<td>Other medical condition</td>
<td>16 15</td>
<td>30 23</td>
</tr>
<tr>
<td>Postoperative</td>
<td>41 39</td>
<td>83 63</td>
</tr>
</tbody>
</table>

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21708/)
Table 5—Hospital Outcome and Duration of Mechanical Ventilation with Classification of Gillespie et al4: Comparison of Pre-VDU with VDU

<table>
<thead>
<tr>
<th>Hospital Mortality</th>
<th>Pre-VDU</th>
<th>VDU</th>
<th>Total Duration of Mechanical Ventilation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients No. %</td>
<td>No. %</td>
<td></td>
<td>Pre-VDU Patients No. %</td>
</tr>
<tr>
<td>1. Uncomplicated acute lung injury</td>
<td>4 66.7</td>
<td>0 0.0</td>
<td>48.5 ± 14.6 (32-74)</td>
</tr>
<tr>
<td>2. Respiratory failure with multisystem failure</td>
<td>22 81.5</td>
<td>...</td>
<td>62.2 ± 43.6 (29-247)</td>
</tr>
<tr>
<td>3. Previous lung disease</td>
<td>3 42.9</td>
<td>0 0.0</td>
<td>58.7 ± 41.9 (31-147)</td>
</tr>
<tr>
<td>4. Trauma</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>93.7 ± 76.3 (33-202)</td>
</tr>
<tr>
<td>5. Other medical conditions</td>
<td>6 37.5</td>
<td>3 10.3</td>
<td>65.3 ± 31.3 (32-150)</td>
</tr>
<tr>
<td>6. Postoperative</td>
<td>9 22.0</td>
<td>10 12.0</td>
<td>52.5 ± 20.4 (29-111)</td>
</tr>
</tbody>
</table>

*Values are expressed as mean ± SD (range).
†Includes one patient with 910 days of continuous home mechanical ventilation prior to VDU admission.

tor days: pre-VDU, median, 42 days; VDU, median, 46 days (p=0.253). As shown in Table 2, no VDU patients had multisystem failure as their primary reason for respiratory failure, reflecting restrictions in the VDU admission criteria related to rehabilitation potential and medical stability. Because hospital and postdischarge survival differ among categories of Gillespie et al,4 we compared outcomes of VDU patients only across specific categories (Table 5).

Hospital mortality was compared between the pre-VDU group of patients ventilated mechanically from 1986 to 1988 and the VDU group. The hospital mortality rate pre-VDU was much higher than that of the VDU group (43.3 vs 9.8%; p=0.001). If the multisystem failure patients are excluded, the pre-VDU mortality rate is still much higher (28.6 vs 9.8%; p=0.001). Hospital mortality improvements were also noted within most of the groups of Gillespie et al4 where mortalities occurred (previous lung disease: p=0.003; other medical: p=0.025; postoperative: p=0.145).

Figure 2 shows a comparison of Kaplan Meier survival curves for the three categories of Gillespie et al4 with a sufficient number of cases for statistical comparison. These were category 3 (previous lung disease), category 5 (other medical condition), and category 6 (postoperative patients). In the VDU era, the postdischarge survival was significantly greater among patients with previous lung disease (p=0.016), and there was a trend toward improvement among postoperative patients (p=0.068). If the data are pooled and the proportional hazards model is used to adjust for age and category of Gillespie et al,4 the survival in the VDU era appears significantly improved compared with that of historic control subjects (p=0.003).

**DISCUSSION**

There has never been and probably can never be...
a concurrent controlled study of patients treated in ventilator-dependent units and intensive care or other acute care hospital units. Therefore, we compared the outcomes of our VDU patients with those of a similar group of patients receiving long-term ventilation in the same hospital during a 29-month period from 1986 to 1988. Our experience with caring for ventilator-dependent patients in a VDU has been very rewarding. This report focuses on clinical outcome, not cost. Cost analyses are currently being carried out and will be reported subsequently. While caution is required when basing inferences about outcomes compared with historic control subjects, our study nevertheless suggests that the opening of a VDU in a general hospital improves survival of specific patient populations. In our opinion, there are several reasons for the improvement in hospital mortality and long-term survival at our institution. Some can be directly attributed to the VDU; others reflect a change in treatment philosophy which, nevertheless, was reinforced by our early VDU experience.

The staff of a regular ICU is accustomed to dealing with critically ill patients, who either respond to therapy and leave the ICU in a few days or who succumb to their illness. There is considerable pressure to intervene with invasive tests and procedures if day-to-day progress is slow, and inherently aggressive resident physicians and surgeons often lose hope and perspective when improvement does not occur within the usual time frame of ICU care. The physicians, nurses, and respiratory therapists are frequently too busy to spend the time required to physically or mentally rehabilitate the ventilator-dependent patient. Furthermore, the ICU environment is not conducive for rehabilitating medically stable patients whose only reason for being there is ventilator dependency. Such patients often become confused and sleep deprived from noise, frequent vital sign checks, inappropriate analgesic and sedative management, and lack of stimulation through one-on-one interactions. Patients who, other than for respiratory failure, have adequate end-organ function are all too often subjected to the ICU monitoring routine that requires indwelling urinary and rectal catheters, arterial lines, central venous catheters, and nasogastric tubes. During their stay in the ICU, they are exposed to a microbial environment, which includes drug resistant organisms, that places them at increased risk for nosocomial infections.

In contrast, the VDU is staffed with professionals who bring a different perspective to the care of ventilator-dependent patients. These staff are less likely to become impatient when progress is slow and are not compelled to work up every potential problem with costly and invasive tests. Emphasis is placed on minimizing the use of sedatives, spending time with patients to meet their emotional as well as physical needs, and pursuing an intensive program targeted toward respiratory rehabilitation and improving whole body strength. The ventilator weaning program is tailored to the individual patient's capacity and prognosis and differs from general ICU practice more in terms of day-to-day consistency than use of specific technologies and support modes. All of these activities are supported by extensive education programs for patients and their families.

It is difficult to identify a specific cause of ventilator dependence in most postoperative patients, even in the presence of documented obstructive lung disease. Our previous publication has documented the value of lung mechanics studies in this group of patients. However, even though we have the ability to do these studies, it is difficult to identify a single cause of ventilator dependence except in a few medical patients with COPD. Sepsis, prolonged respiratory muscle disuse from mechanical ventilation, nutritional deficiency, and prolonged bed rest are potential causes of respiratory muscle weakness, especially in surgical patients.

The reduction in hospital mortality from 42% in the late 1980s to 10% in the VDU population is somewhat misleading. As is obvious from Table 2, patients with acute lung injury and multiple organ failure (who made up 26% of the control population and had a mortality of 80%) are not suitable candidates for a VDU unless they recover function of their other organs and are left ventilator-dependent. Excluding such patients from analysis reduces the hospital mortality for the pre-VDU reference population to 29%, which is still substantially greater than the 10% hospital mortality of the VDU group. Because the 119 VDU patients who survived hospitalization continued to do better than their historic counterparts 1 and 2 years after discharge, one must consider other sources of selection bias to explain the difference in hospital mortality between the groups. Fourteen of 45 patients who were denied admission to the VDU because of medical instability or lack of rehabilitation potential died in the hospital. Eight of the 14 were very unstable medically when evaluated. Twenty-nine of these 43 patients (67%) survived to discharge. Some of them had been ventilated for more than 29 days and would have been included in the pre-VDU group. Sixteen of 119 VDU patients (13%) used a ventilator intermittently after discharge at home. This was uncommon 5 years ago, except for the occasional patients with neuromuscular disease. Thus, many of these patients would have died of ventilatory pump failure had they been admitted during the 1986 to 1988 time period of the historic control group. Unfortunately, we do not know the
percentage of patients in the pre-VDU group in whom ventilatory support was withdrawn because
the physician then considered the prognosis hopeless.

Our experience with long-term mechanical venti-
lation is considerably more encouraging than some
reports in the literature would suggest. Spicher and
White\textsuperscript{5} reported a hospital mortality of 60.8% and a
one- and two-year survival rate of 28.6 and 22.5%,
respectively, among patients who require mechanical
ventilation for at least 10 days. In contrast, only
9.8% of 129 patients (who had been mechanically
ventilated on average for 53 days) died after admi-
sion to the VDU. Not only were their 1- and 2-year
survival rates 76 and 72%, respectively, 92 of them
returned home as opposed to being “kept alive” in a
long-term care facility. Many of these patients look
to the VDU as a source of information and support
long after their discharge. The extent to which this
service contributes to the high long-term survival rate
is unclear. Morganroth and associates\textsuperscript{6} reported a
70% hospital survival and a 30% 1-year survival in 11
patients requiring 30 to 100 days of mechanical
ventilation. None of the patients who were mechan-
ically ventilated postoperatively were alive a 1 year
afterward. Davis and associates,\textsuperscript{7} in a report on 104
patients mechanically ventilated for more than 48 hs,
found a 56% hospital mortality. The postdischarge
mortality was 63 and 72% at 1 and 2 years, respec-
tively. Patients with pulmonary disease had a 29%
hospital mortality.

Seventeen VDU patients were octogenarians. Both
Swinburne and associates\textsuperscript{8} and Cohen et al\textsuperscript{9}
suggest that the outcome of ventilator-dependent patients
greater than 80 years of age is extremely poor. Swinburne et al\textsuperscript{8} reported a 7% hospital survival rate
among ventilator-dependent octogenarians with pre-
existing renal disease, liver disease, cancer, systemic
illness, or chronic gastrointestinal disease with mal-
nutrition and a 29% survival rate for patients younger
than 80 years with the same premorbid conditions.
Only 38% of octogenarians without premorbid con-
ditions survived hospitalization, while 48% of those
younger survived. Overall, in the series of Swinburne
et al\textsuperscript{8} of elderly patients who required more than 15
days of mechanical ventilation, the mortality was
91%, while it was 64% for younger patients. Cohen
and associates\textsuperscript{9} found a 75% mortality rate in octo-
genarians who were mechanically ventilated for
more than 3 days in a combined medical-surgical
ICU at a large community teaching hospital. Our
experience does not support the temptation to make
management decisions or withhold therapy in venti-
lator-dependent patients solely on the basis of age. Of
the 11 females and 6 males in the VDU who were
older than 80 years, only 1 expired. More impor-
tantly, 10 of the 16 survivors went home and the rest
went to nursing homes, all without mechanical ven-
tilators.

It is clear that multiple types of sites are evolving
outside the ICU for the care of patients who are
ventilator-dependent. One is the aforementioned
VDU located in an acute care hospital. Another is the
free-standing regional weaning center reported by
Scheinhorn and associates.\textsuperscript{10} A third option for long-
term ventilator care includes skilled nursing care fac-
cilities, the home, and a group living facility. A
three-tiered system driven by the availability of
funding has developed.

In summary, our experience over the past 3 years
of managing stable ventilator-dependent patients in
a VDU rather than the ICU has been very rewarding
and educational. As we battle some of the mysteries
and misconceptions about ventilator dependence, we
are reminded every day how difficult it is to find
placement for these patients outside the home. While
we could not study the impact of the VDU on our
practice prospectively, at a minimum we have learned
not to make hasty predictions about the prognosis of
elderly, ventilator-dependent patients.

ACKNOWLEDGMENTS: The authors wish to express their
appreciation to David Hardy, RRT, VDU lead respiratory therapist,
and the dedicated nurses of the VDU for making the VDU a
success.

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