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Original Article

Mortality and Readmission Among Ventilator-dependent Patients After Successful Weaned Discharge From a Respiratory Care Ward

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Background/Purpose: Patients on prolonged mechanical ventilation in Taiwan are stepped down to a respiratory care ward (RCW) for further respiratory care. Only a few patients in the RCW can ultimately be weaned and discharged. In this study, we tried to determine factors that predict mortality and readmission of these patients in the post-discharge period.

Methods: Between May 1, 2004 and October 31, 2006, clinical data were retrospectively analyzed for eligible patients in a RCW. Patients who were successfully weaned from mechanical ventilation were enrolled in this study.

Results: A total of 243 patients were eligible for evaluation, and 67 patients were successfully weaned and discharged. By Kaplan-Meier curve, 36 (67.1%) patients were readmitted within 3 months after discharge, and among these, 23 (63.9%) had mechanical ventilation reinstituted at the time of first readmission. The most common cause of readmission was airway infection (80.5%). Overall mortality and readmission rates at 1 year after weaned discharge were 32.9% and 88.2%, respectively. By multivariate analysis, patients with neurologic causes of ventilator dependency were less likely to be readmitted (hazard ratio = 0.36; $p = 0.034$), and neoplastic diseases (hazard ratio = 4.66; $p = 0.031$) were independently associated with mortality.

Conclusion: Underlying comorbidities and causes of ventilator dependency are important predictors of mortality and readmission among patients after weaned discharge from a RCW.

Key Words: mortality, prolonged mechanical ventilation, readmission, respiratory care ward, weaning

The number of patients dependent on prolonged mechanical ventilation (PMV) after acute critical illness has increased sharply because of improvements in critical care techniques.[1,2] Consequently, studies have shown that 5–15% of patients with acute respiratory failure will progress to reliance on PMV.[3–5] In Taiwan, patients with PMV are assigned to an integrated delivery system, which

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follows a step-down principle outlined by the Bureau of National Health Insurance policy.[6] If patients are considered to be dependent on ventilation in an intensive care unit (ICU) and has remained in the ICU for up to 21 days, they will be stepped down to a respiratory care center (RCC) with the goal of weaning them off ventilation and continuation of subacute care. If a patient fail repeated weaning trials over a period of up to 63 days in the RCC, they will finally be transferred to a respiratory care ward (RCW) for long-term care.[6,7] Patients can be transferred from the ICU to the RCW directly if they are not able to be weaned off ventilators over the short term or if the referral hospitals do not have RCC units.

About half of the patients stepped down to an RCC can be weaned, but one fifth of these patients will remain ventilator-dependent after several weaning trials.[8,9] One tertiary referral medical center in Taiwan has reported 1-year results after the establishment of a RCC. If patients were stepped down successively from the ICU to the RCC and finally to the RCW, fewer than 5% of them were able to be weaned and discharged within 1 year.[8] Patients who can be weaned in the short term after acute illness have better survival than patients who cannot.[8,10]

The characteristics of patients with PMV are heterogeneous.[1] They are primarily elderly with different pathogeneses of respiratory failure and multiple underlying comorbidities.[11,12] Prolonged critical illness leaves them subject to recurring episodes of acute complications with a high risk for readmission and mortality after discharge from long-term care hospitals.[13,14] These studies have reported an ICU readmission rate of 21% at 1 month and a hospital readmission rate of 38% at 6 months among RCC patients.[13,14] In addition, one third of PMV patients who are readmitted after discharge from an ICU or hospital will die from any cause within 6 months.[13,15] Little information exists on the long-term outcomes among patients weaned and discharged from the RCW; therefore, we undertook this study to identify factors that predict mortality and readmission of these patients in the post-discharge period.

Methods

We retrospectively enrolled patients admitted to the RCW for chronic respiratory care with either an orotracheal tube or tracheostomy. Patients who were successfully weaned during this period were identified and included in the analysis. Patients who received noninvasive ventilation or required nocturnal ventilation were excluded. In order to assess the 1-year outcome status of all

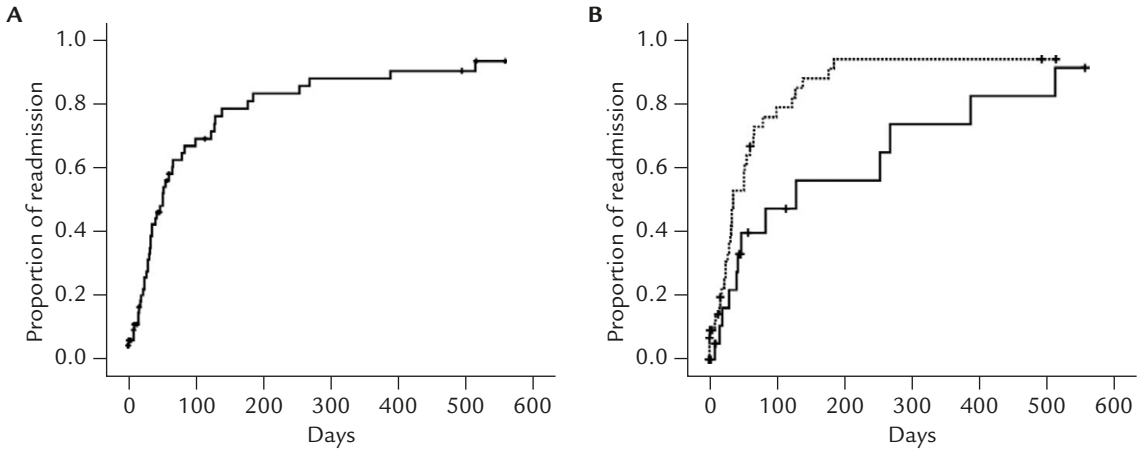

Figure 1. Kaplan-Meier curves. (A) The cumulative proportion of readmission among 67 patients. (B) Lower probability of readmission in patients with neurologic causes of ventilator dependency (solid line) than that in patients with other causes of ventilatory dependency (dotted line), $p = 0.034$ by log-rank test.

RCW patients in this series, the study cohort was restricted to patients weaned from mechanical ventilation between May 1, 2004 and October 31, 2006, with 1-year outcome status determined as of October 31, 2007. Patients were followed up until death or until the last enrolled patient had been followed up for a minimum of 12 months. This study was reviewed and approved by the Institutional Review Board of Cheng-Ching General Hospital and was conducted in accordance with its ethics policies.

In contrast to the ICU or RCC, which are dedicated to aggressive weaning attempts, the RCW was established with the purpose of basic respiratory support for ventilator-dependent patients. The level of ventilator support was tapered gradually with simultaneous intermittent mandatory ventilation mode or pressure support mode. Then either a T-piece or tracheostomy collar was used for spontaneous breathing in patients with orotracheal intubation or tracheostomy, respectively.[1] There was no universal weaning protocol in the RCW. The weaning process was individually designed and was slow. The spontaneous breathing trials gradually increased in duration if the patients could tolerate them. If the cardiorespiratory status of patients was very fragile with complete weaning from the ventilator, we avoided aggressive weaning attempts to prevent unnecessary frustration, anxiety, and discomfort. If patients could tolerate a gradual weaning process, successful liberation from mechanical ventilation was defined as freedom from ventilatory support for more than 5–7 consecutive days with subsequent discharge from hospital.

We collected clinical notes by reviewing physicians' records, nursing charts, and computer databases. When not otherwise available, additional information and long-term survival data were obtained by contacting the patients' families by phone. Age, sex, length of hospital stay before RCW admission, length of RCW stay, duration from weaned discharge to first readmission, and the cause of readmission were all recorded. The history of underlying medical conditions was used to identify comorbidities by chart review and image reports.

Underlying comorbidities associated with PMV were extracted from the patients' medical records. Neurologic illness was defined as a history of stroke, intracranial hemorrhage, traumatic brain injury (remote, with persistent neurologic deficit), dementia, hypoxic encephalopathy, hydrocephalus, or other known neuromuscular disorders. Pulmonary illness was defined as chronic obstructive pulmonary disease (COPD) with documented airflow limitation by pulmonary function tests, bronchiectasis or other symptomatic chronic respiratory disorders, and thoracic cage deformities documented by image reports or repeated episodes, with the final diagnosis of acute exacerbation of chronic bronchitis. Cardiovascular illness was defined as valvular heart disease with impaired heart performance determined by echocardiography, significant arrhythmia with long-term use of medication, or other symptomatic episodes with the final diagnosis of cardiogenic pulmonary edema. Uremic illness was defined as chronic kidney disease requiring regular hemodialysis two or three times weekly. Hepatic illness was defined as known liver cirrhosis. Malignancy was defined as known neoplasm proven by pathologic reports.

The causes of respiratory failure leading to ventilator dependency have been considered important predictors of outcome in patients with critical illness.[10,16] We categorized the causes into four groups according to the pathogenesis of disease: neurological injury, pulmonary injury, cardiac injury, and septicemia.[10,11] The post-discharge disposition was either home or to a nursing home with skilled nursing personnel. The long-term outcomes were assessed in terms of readmission and mortality.

Statistical analysis

Continuous variables were expressed as the mean ± standard deviation or median with interquartile range. Categorical data were expressed as numbers and percentage. We used survival analysis to compare the cumulative probability of readmission and survival between groups by the Kaplan-Meier method. The Cox regression model was used to analyze potential risk factors. The multiple Cox

regression model was adapted to adjust potential confounding factors by method of entry (age, underlying comorbidities, discharge disposition, and causes of respiratory failure leading to ventilator dependency). A p value of less than 0.05 was considered statistically significant. All data analyses were performed using SPSS (version 13.0; SPSS Inc., Chicago, IL USA).

Results

Two hundred and forty-three patients were admitted to the RCW during the study period. The mean (standard deviation) and median (interquartile) ages at discharge were 78.3 (9.9) and 80 (75–84) years, respectively. Most of the patients were men (61.2%). In this cohort, a total of 67 (27.6%) patients were successfully weaned from mechanical ventilation and discharged (Table 1). Only two patients who received orotracheal intubation were successfully weaned. The median length of RCW stay was 98 (43–205) days. The overall duration of mechanical ventilation ranged from 34–1329 days with a median of 166 (100–291) days.

A total of 34 (50.7%) patients were stepped down successively from the ICU and RCC, and 26 of them were weaned off the ventilator within 1 year of admission to the RCW. Fifteen patients (22.4%) were stepped down successively from the ICU and specialty ward in the medical center, 13 (19.4%) were stepped down directly from the ICU, and five (7.5%) were referred from other RCWs. The median length of ventilator use before RCW admission was 58 (26–79) days. After RCW admission, six (9.0%) and 18 patients (26.9%) were weaned within 1 and 6 months, respectively; however, 11 patients (16.4%) were weaned at a time longer than 1 year after admission to the RCW.

On average, each patient had two comorbid diseases. The four most common underlying medical comorbidities associated with PMV were neurologic diseases (70.2%), diabetes (41.8%), cardiovascular disease (40.3%), and pulmonary diseases (35.8%). One patient had decompensated liver cirrhosis, and four patients received regular hemodialysis. Of the seven patients (10.5%) who had neoplastic diseases, two had nasopharyngeal carcinoma, and the others had breast, lung, colon, ovary, and thyroid cancers.

Table 1. Characteristics of prolonged mechanical ventilation patients successfully weaned and discharged from a respiratory care ward

Characteristics	Patients ($n=67$)
Age (yr)	80 (75–84)
Sex, male	41 (61.2)
Tracheostomy	65 (97.0)
Duration of MV before RCW admission (d)	58 (26–79)
Length of RCW stay (d)	98 (43–205)
Overall duration of MV (d)	166 (100–291)
Underlying comorbidities associated with PMV	
Neurologic disease	47 (70.2)
Cardiovascular disease	27 (40.3)
Pulmonary disease	24 (35.8)
Liver cirrhosis	1 (1.5)
Uremic	4 (6.0)
Neoplastic diseases	7 (10.5)
Diabetes	28 (41.8)
Discharge disposition	
Nursing home	44 (65.7)
Home	23 (34.3)

Data presented as median (interquartile range) or n (%). RCW = Respiratory care ward; MV = mechanical ventilation; PMV = prolonged mechanical ventilation.

Causes of respiratory failure leading to ventilator dependency were classified into four groups (Table 2). The neurological injury group ($n=22$, 32.8%) comprised patients with traumatic brain injury, intracranial hemorrhage, recent cerebral infarction, C-spine injury, or hypoxic encephalopathy. The pulmonary injury group ($n=30$, 44.8%) comprised patients with COPD with acute exacerbation, severe pneumonia, far-advanced pulmonary tuberculosis, or bronchiectasis with secondary infection. The cardiac injury group ($n=6$, 8.9%) consisted of patients with previous open-heart surgery, arrhythmia, acute myocardial infarction

Table 2. Causes of respiratory failure leading to ventilator dependency in patients after weaned discharge from a respiratory care ward

Diagnostic groups	*n*
Neurological injury (*n* = 22)	
Traumatic brain injury	2
Intracranial hemorrhage	6
Cerebral infarction	8
Brain tumor	1
C-spine injury	2
Hypoxic encephalopathy	3
Pulmonary injury (*n* = 30)	
Exacerbation of COPD (without pneumonia)	4
Pneumonia	21
Lung cancer	1
Tuberculosis, far advanced	3
Bronchiectasis, 2nd infection	1
Cardiac injury (*n* = 6)	
Post open heart surgery	1
Acute myocardial infarction	1
Decompensate congestive heart failure	3
Arrhythmia	1
Septicemia (*n* = 9)	
Intra-abdominal infection other than UTI	4
UTI with septic shock	4
Gastrointestinal hemorrhage with hypovolemic shock	1

COPD = Chronic obstructive pulmonary disease; UTI = urinary tract infection.

with cardiogenic shock, or decompensated heart failure. The septicemia group (*n* = 9, 13.4%) comprised patients with intra-abdominal or genitourinary tract infection complicated with severe sepsis and multiple organ failure, or gastrointestinal hemorrhage with hypovolemic shock. Severe pneumonia (*n* = 21), recent cerebral infarction (*n* = 8), and traumatic/non-traumatic intracranial hemorrhage (*n* = 8) were the three diagnoses that caused the most respiratory failure and ventilator dependency.

In our cohort, the overall readmission rates estimated by Kaplan-Meier curve (Figure 1) at 1, 3, 6 months, and 1 year were 31.4%, 67.1%, 81.1%, and 88.2%, respectively. Among the 36 patients readmitted within 3 months, 23 (63.9%) had mechanical ventilation reinstituted at the time of the first event. The median duration between discharge and readmission was 36 (20–80) days with a range from 1–512 days. There was no difference in mortality between patients with early readmission and late readmission. The most common two reasons for readmission were airway infection (80.5%) and urinary tract infection (17.0%). As shown in Figure 1B, the probability of readmission was lower in patients with neurologic injuries (log-rank test, $p = 0.034$). By univariate analysis (Table 3), age, sex, duration of mechanical ventilation before RCW admission, length of RCW stay, and discharge disposition were not associated with readmission. Neoplastic diseases were associated with readmission [hazard ratio (HR) = 2.73, $p = 0.016$]. With reference to neurologic causes of ventilator dependency, pulmonary injury (HR = 2.15, $p = 0.027$) and septicemia (HR = 2.96, $p = 0.048$) were significantly associated with readmission. By multivariate analysis (Table 4) with adjustment of confounding factors (80 years of age or older, presence of comorbidities, discharge home, and causes of ventilator dependency), a neurologic cause of ventilator dependency was an independent predictor of the ability to avoid readmission (HR = 0.36, $p = 0.034$).

After discharge from the RCW, the overall death rates estimated by Kaplan-Meier curve (Figure 2) were 18.8% and 30.6% at 6 months and 1 year, respectively. As shown in Figure 2B, long-term survival was significantly better for patients with neurologic injury (log-rank test, $p = 0.021$). By univariate analysis (Table 3), age, sex, duration of mechanical ventilation before RCW admission, length of RCW stay, and discharge disposition were not associated with mortality. Only neoplastic diseases were associated with death (HR = 2.88, $p = 0.026$). By contrast, patients with chronic neurologic illness had a low likelihood of mortality (HR = 0.33, $p = 0.009$). With reference to neurologic causes of ventilator dependency, pulmonary (HR = 3.22, $p = 0.039$) and cardiac (HR = 5.54, $p = 0.028$) injury were significantly associated with

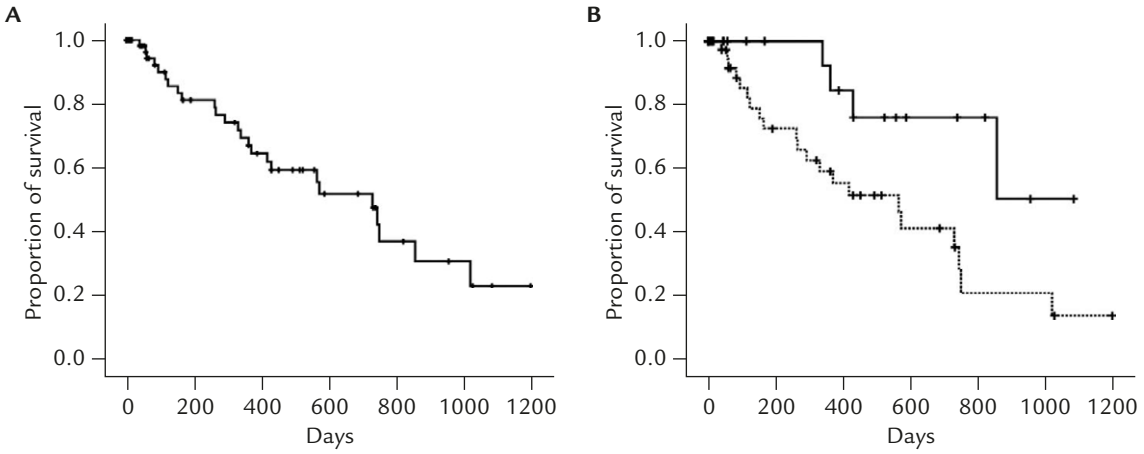

Figure 2. Kaplan-Meier curves. (A) The cumulative proportion of survival among 67 patients. (B) Better survival in patients with neurologic causes of ventilator dependency (solid line) than that in patients with other causes of ventilatory dependency (dotted line), $p = 0.021$ by log-rank test.

Table 3. Univariate analysis of variables predictive of readmission and mortality in patients after weaned discharge from a respiratory care ward

Variable	Readmission		Mortality	
	HR (95% CI)	*p*	HR (95% CI)	*p*
Age (≥ 80 yr)	0.77 (0.43–1.38)	0.385	1.14 (0.52–2.49)	0.753
Sex, male	1.65 (0.86–3.18)	0.136	0.82 (0.36–1.85)	0.630
Duration of MV before RCW admission (> 63 d)	1.28 (0.68–2.41)	0.453	1.09 (0.47–2.55)	0.844
Length of RCW stay	1.00 (0.99–1.00)	0.592	1.00 (0.99–1.00)	0.614
Overall duration of MV	1.00 (0.99–1.00)	0.482	1.00 (0.99–1.00)	0.657
Underlying comorbidities associated with PMV				
Neurologic	0.55 (0.29–1.04)	0.066	0.33 (0.14–0.76)	0.009
Cardiovascular	0.67 (0.37–1.24)	0.204	1.75 (0.79–3.85)	0.166
Pulmonary	1.12 (0.62–2.03)	0.701	0.94 (0.42–2.14)	0.886
Liver cirrhotic	6.12 (0.77–48.39)	0.086	1.21 (0.16–9.13)	0.855
Uremic	0.94 (0.23–3.92)	0.935	3.09 (0.70–13.55)	0.135
Neoplastic	2.73 (1.20–6.23)	0.016	2.88 (1.13–7.31)	0.026
Diabetic	0.95 (0.54–1.70)	0.873	0.91 (0.41–2.04)	0.824
Discharge disposition				
Nursing home	1.00		1.00	
Home	0.68 (0.36–1.26)	0.219	0.61 (0.24–1.52)	0.286
Causes of respiratory failure leading to ventilator dependency				
Neurological injury	1.00		1.00	
Pulmonary injury	2.15 (1.09–4.25)	0.027	3.22 (1.06–9.73)	0.039
Cardiac injury	1.00 (0.28–3.51)	0.995	5.54 (1.20–25.66)	0.028
Septicemia	2.96 (1.01–8.72)	0.048	2.68 (0.59–12.10)	0.201

HR = Hazard ratio; CI = confidence interval; MV = mechanical ventilation; RCW = respiratory care ward; PMV = prolonged mechanical ventilation. Hazard ratios for discharge position are referenced against the nursing home group. Hazard ratios for causes of respiratory failure are referenced against the neurological injury group.

Table 4. Multivariate analysis of variables predictive of readmission and mortality in patients after weaned discharge from a respiratory care ward

Independent variables	Adjusted HR (95% CI)	*p*
Readmission		
Neurologic causes of ventilator dependency	0.36 (0.14–0.93)	0.034
Mortality		
Neoplastic comorbidity	4.66 (1.15–18.93)	0.031

HR = Hazard ratio; CI = confidence interval.

mortality. By multivariate analysis (Table 4) with adjustment of confounding factors (80 years of age or older, presence of comorbidities, discharge home, and causes of ventilator dependency), neoplastic disease (HR = 4.66, $p = 0.031$) was the only independent predictor of mortality.

A total of 23 patients (34.3%) were discharged directly home. Others (65.7%) were discharged to a nursing home. Although there was a higher mortality in patients discharged to the nursing home (36.4%) than patients discharged home (31.5%) in 1 year, the difference was not significant (Kaplan-Meier method, $p = 0.537$ by log-rank test).

Discussion

Our study is a post-discharge outcome analysis among patients who were successfully weaned and discharged from an RCW. The study results suggest that, in addition to underlying comorbidities, the cause of respiratory failure leading to ventilator dependency can be used as an independent predictor of long-term outcome.

Some other findings in our study are worth noting. The median age of patients in our study was 80 years, and about 30% of our patients were more than 85 years of age. This occurred because our study focused on patients who failed weaning in the ICU or RCC, where younger patients tend to be weaned more easily than elderly patients,[8,10] and therefore the median age of our patients was older than that in other studies.[8,10,11,16–22] Interestingly, some of the studies including patients with a median age of 65 reported that age could be used as a predictor for death,[10,16,17,19,22] whereas other studies including patients with a median age of 75 or older reported that age was not associated with higher mortality.[8,20,21] In our study, consistent with those studies focusing on elderly patients, age was not an independent predictor associated with readmission or mortality. There are two inferences to explain this discrepancy. First, the characteristics of these patients with either prolonged critical illness or PMV were usually heterogeneous. Therefore, the short-term or long-term outcomes would be influenced by many factors other than age, such as pre-hospital health status, comorbidities, or disease severity. Thus, if most of the patients targeted in our study were primarily older, with fewer younger patients included, the impact of age on outcome would become smaller. Second, because these patients were survivors of catastrophic illnesses, they and their families might choose conservative treatment rather than aggressive procedures. Therefore, the effect of age on outcome would probably decrease.

In our study, the median length of ventilator use before RCW admission was 58 days, which was comparable to an earlier study of RCC patients, where the mean length of mechanical ventilation in patients was about 56 days.[8] However, the overall weaning rate (27.6%) in our study period (29 months) was higher than that reported by a 1-year observational study (4.9%).[8] These differences could be because in our study, of the 67 patients who were finally weaned and discharged, 28 patients (41.8%) were stepped down directly from the ICU or specialty ward without having been admitted to an RCC. In the latter study, patients stepped down successively from the ICU to the RCC and finally to the RCW and had experienced repeated weaning failures; therefore, ventilator dependency was anticipated. Furthermore, 43 patients (64.2%) had mechanical ventilation durations of fewer than 63 days before RCW admission. The

shorter duration of mechanical ventilation might have been a factor favoring successful weaning.

RCW stay in our weaned and discharged patients displayed a median of 98 (43–205) days; this is much longer than other studies [8,9,16] that focused on settings with aggressive weaning goals. According to the National Health Insurance policy of Taiwan, in contrast to the RCC, which is a unit for care of patients actively being weaned from the ventilator, the RCW is a step-down facility for patients with long-term ventilator dependence. This indicates that there was no standard weaning protocol applied to our patients, and therefore begins to explain the differences observed between this and previous studies. In addition, before being stepped down to the RCW, the patients usually had experienced repeated failures in previous weaning trials. The weaning process was then performed slowly and was conducted individually to prevent discomfort and unnecessary frustration in the patients. We also needed to reverse or improve treatable conditions that had impeded our patients' weaning process,[1] rather than declare them impossible to wean simply because they failed weaning trials within a strict timeline.[10] These observations may have some important implications; that is, patients under PMV for more than 2 months will be difficult to wean off the ventilator, and patients stepped down directly to the RCW without having undergone RCC admission should be more tolerant of the weaning process.

Readmission of patients who have previously been managed with PMV is another topic of interest as it is a significant problem for the health care system. In patients with acute illness, many studies reported that readmission to the ICU was associated with higher hospital mortality.[15,23–25] However, few studies have focused on elderly, chronic critically ill patients with multiple underlying diseases who experienced PMV. Two studies reported that readmission rates in patients with short-term mechanical ventilation in the ICU within 2 and 6 months were 39.5% and 38.2%,[18,13] respectively. In our cohort, the readmission rate was much higher, with a steep increase observed within the first 6 months (81.1%) and a slower increase thereafter. Variable baseline characteristics, even older ages, and more comorbidities resulted in a higher readmission rate among our patients. Although age,[25] longer length of ICU or hospital stay,[23] greater disease severity,[15,23,25] and multiple comorbidities[24] had been reported to be predictors associated with readmission, in our study cohort, the causes leading to PMV were the only independent predictors of readmission (Table 3).

A duration of mechanical ventilation of more than 35 days has been demonstrated to be an independent risk factor for death after discharge,[22] but such an effect was not found in our study. Present findings demonstrate that patients with underlying neoplasm had a higher risk for death, while patients with neurologic injury or chronic neurologic illness had a lower risk for long-term mortality. The Kaplan-Meier cumulative probability of 1-year survival in the neurologic injury group was 84.6% (Figure 2). Similarly, in two other studies, the 1-year survival rates among neurologic survivors were reported to be 64.6% and 81.6%, respectively.[26,27] However, in patients with COPD who survived respiratory failure, the 1-year survival rate after discharge was only 50.9%.[20] These results agree with that of one study in a regional weaning center, showing that underlying medical conditions determine the success of weaning, hospital survival, and long-term outcomes.[16] The survival rate in patients with neurologic conditions was indeed better than in those with obstructive lung disease.[10,28] The improved survival rate in this group of patients may be because patients with neurological causes of PMV might benefit from continuous medical care, and only a relatively low percentage of long-term survivors of neurologic injury had a very high degree of disability.[26] By contrast, patients who survived non-neurologic injuries, such as acute lung injury, usually experienced some extent of pulmonary function impairment in long-term follow-up[29] and, therefore, had a higher risk for death after discharge from the RCW.

Some limitations of this study should be noted. First, it was a retrospective observational study in

a single hospital-based unit. The contributing effects of chronic organ dysfunction on outcomes could not be well described without measurement of premorbid heart, lung, liver, and renal functions of every patient. Furthermore, some organ dysfunction might not have been recognized before hospitalization. Second, our study did not provide information on functional status in the post-discharge period. Poorer quality of life and impaired cognitive function of the patients might have affected long-term outcomes.[18,30,31] Third, statistical significance may not have been achieved in the analysis of some physiologic variables due to a small number of patients. However, analyzing a unit-based population in an observational study can reflect clinical practice.[10] Our study results are concise and are likely to have an impact on the way physicians practice medicine.

In conclusion, this study investigated the long-term outcomes of ventilator-dependent patients weaned and discharged from an RCW. In addition to underlying comorbidities, the causes of respiratory failure leading to ventilator dependency were closely associated with mortality and readmission. This result suggests that physicians, patients, and families can entertain cautiously optimistic expectations for patients with neurologic injury who are weaned and discharged from an RCW, as patients with neurologic causes of ventilator dependency were less likely to be readmitted.

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