Impact of whole-body rehabilitation in patients receiving chronic mechanical ventilation

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Objective: To evaluate the prevalence and magnitude of weakness in patients receiving chronic mechanical ventilation and the impact of providing aggressive whole-body rehabilitation on conventional weaning variables, muscle strength, and overall functional status.

Design: Retrospective analysis of 49 consecutive patients.

Setting: Multidisciplinary ventilatory rehabilitation unit in an academic medical center.

Patients: Forty-nine consecutive chronic ventilator-dependent patients referred to a tertiary care hospital ventilator rehabilitation unit.

Interventions: None.

Measurement and Main Results: Patients were 58 ± 7 yrs old with multiple etiologies for respiratory failure. On admission, all patients were bedridden and had severe weakness of upper and lower extremities measured by a 5-point muscle strength score and a 7-point Functional Independence Measurement. Postrehabilitation, patients had increases in upper and lower extremity strength ($p < .05$) and were able to stand and ambulate. All weaned from mechanical ventilation, but three required subsequent intermittent support. Six patients died before hospital discharge. Upper extremity strength on admission inversely correlated with time to wean from mechanical ventilation ($R = .72$, $p < .001$).

Conclusions: Patients receiving chronic ventilation are weak and deconditioned but respond to aggressive whole-body and respiratory muscle training with an improvement in strength, weaning outcome, and functional status. Whole-body rehabilitation should be considered a significant component of their therapy. (Crit Care Med 2005; 33:2259–2265)

KEY WORDS: pulmonary rehabilitation; weaning; ventilation; mechanical; chronic; deconditioning

It is generally accepted that chronic ventilator-dependent patients are weak or deconditioned; however, there are limited data showing this to be true or describing the magnitude and extent of weakness. In chronic ventilated patients, immobility and catabolism from the underlying medical/surgical illness, poor nutritional status, and exposure to pharmacologic agents (e.g., neuromuscular blocking agents and steroids) are all commonly present, all of which may adversely affect functional status and result in substantial weakness of limb, respiratory, and swallowing musculature. Although the benefit of rehabilitation in stable chronic obstructive pulmonary disease (COPD) has been well described (1, 2), there is a paucity of data regarding the effects of rehabilitation in patients receiving chronic mechanical ventilation. This is due to several factors: the high acuity of illness in ventilated patients, their frequent transfers to different institutions and levels of care, and the complexities and labor-intensiveness and need for specially trained personnel to provide rehabilitation in the ventilated patient. As a result, available studies tend to include small numbers of patients receiving a mix of invasive and noninvasive ventilation who have COPD as the primary cause of respiratory failure. Frequently, baseline characteristics are poorly characterized, and the rehabilitation treatment is not well described (3–5).

Currently there are no guidelines for rehabilitation of the chronically ventilated patient. This is important, because these patients have extremely high mortality rates (1-yr survival 30–70%) (6, 7), substantial morbidity (reduced quality of life and poor functional status), and high costs of care (≥\$9 million/day in the United States) (8). Because mechanical ventilation and its inherent constraints on mobility are superimposed on the patient's already impaired functional status by the disease necessitating ventilation, a well-trained multidisciplinary team, as well as special equipment and physical plant requirements, is usually recommended, but the actual rehabilitative needs and the efficacy of treatment are unclear.

Therefore, we sought a) to characterize the level of whole-body weakness in chronic ventilated patients admitted to an inpatient ventilator-dependent rehabilitation unit; and b) to evaluate the impact of aggressive whole-body and respiratory muscle rehabilitation on improving their respiratory and peripheral muscle strength and functional status.

MATERIALS AND METHODS

Subjects. Forty-nine consecutive patients admitted to our chronic ventilator-dependent rehabilitation unit (VRU) from surgical, medical, and cardiac intensive care units (ICUs), without previous history of underlying neuromuscular diseases, were studied. All patients met criteria for clinical stability as shown in Table 1. Patients admitted to this unit had been invasively ventilated for ≥14 consecutive days and had failed at least two attempts at weaning from mechanical ventilation. Because of the retrospective nature of the study and the use of standard therapy, the Institu-

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Table 1. Criteria for transfer of ventilator-dependent patients from intensive care unit to ventilator rehabilitation unit

Respiratory Stability	Nonrespiratory Medical Stability
Airway: Tracheostomy for invasive ventilation. Minimal aspiration	Sepsis controlled
Secretions: manageable with infrequent suctioning	No uncontrolled hemorrhage
Oxygen: adequate oxygenation with F_{IO_2} <50%, PEEP <5 cm H_2O, Sp_{O_2} >92%	No uncontrolled arrhythmias, heart failure, or unstable angina
Ventilator settings: stable, no sophisticated modes	No coma
Patient assessment: comfortable, no increased WOB or dyspnea	Secure parenteral line
Weaning technique: tracheal collar	Secure alimentation route

PEEP, positive end-expiratory pressure; Sp_{O_2}, oxygen saturation; WOB, work of breathing.

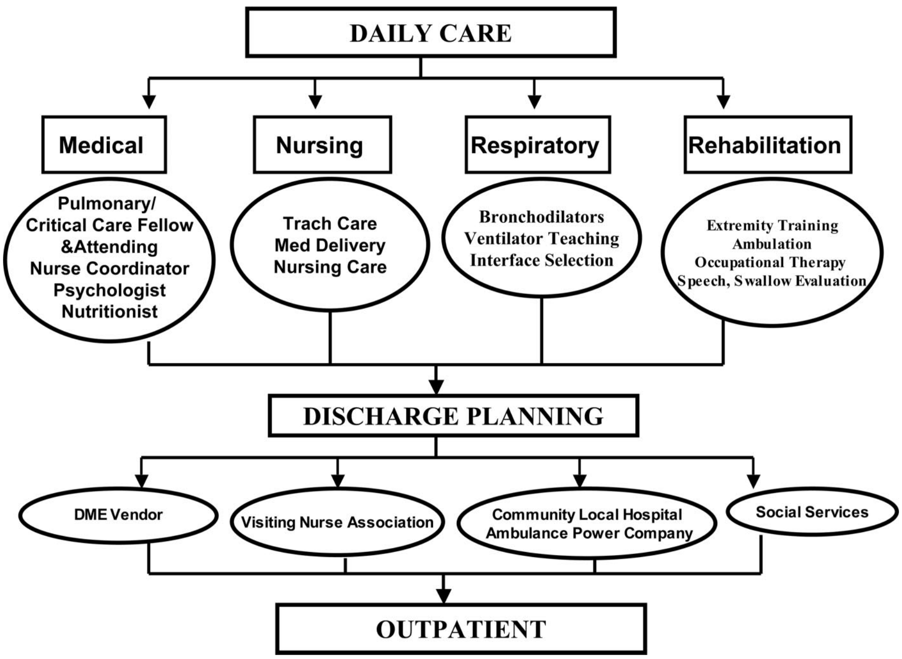

Figure 1. Outline of daily and long-term planning in the ventilatory rehabilitation unit. *DME*, durable medical equipment.

tional Review Board waived the need for written consent.

Ventilator Rehabilitation Unit (VRU). The VRU is an 18-bed respiratory care unit. It was one of the original clinical sites for the Health Care Financing Administration Chronic Ventilator Dependent Demonstration Project that examined costs and outcome in ventilated patients receiving aggressive, multidisciplinary, whole-body and respiratory rehabilitation as well as weaning attempts (9, 10). The staff, medical direction, and project objectives have remained intact since completion of the project, and the unit size and staff number have quadrupled. The unit is staffed by a multidisciplinary team, including board-certified pulmonary and critical care attendings and pulmonary/critical care fellows, a nurse coordinator, nurses with special training in respiratory patients and their management, nutritionists, psychologists, respiratory, physical, occupational and speech therapists, and a social worker. The physician staff, nurses, and therapists attend daily rounds. Weekly meetings are attended by all team members and are led by the medical director of the unit. The emphasis in this unit is placed on whole-body and respiratory rehabilitation for patients who suffer from chronic respiratory failure (9, 10). An outline of the daily and weekly treatment plan is shown in Figure 1.

Initial Assessment. On admission to the VRU, all patients underwent a detailed history and physical examination performed by the pulmonary/critical care physician attending and fellow. Causes for respiratory failure, weaning variables, ventilatory variables, and gas exchange variables were assessed on admission to the unit. A physical therapist, speech pathology specialist, and psychologist also assessed patients to establish a comprehensive rehabilitation plan. Charts were reviewed to determine whether patients had been exposed to steroids or neuromuscular blocking agents during their ICU stay. A qualitative assessment of the use of steroids or neuromuscular agents was made in each patient, but quantification of the exact amount of each of these agents was not performed. The use of other medications such as sedative agents, antibiotics, and psychotropic agents was also noted.

Weaning. All patients were weaned on tracheal collar with supplemental inspired oxygen concentrations adjusted to maintain a pulse oximetric oxygen saturation >95%. Conventional weaning variables, including the rapid shallow breathing index, were performed before and when possible at the end of the weaning period. Weaning was initiated once the patient was clinically stable and the underlying reason for respiratory failure was resolved. In clinically stable patients, a weaning trial was attempted even in the absence of adequate standardized weaning variables (such as rapid shallow breathing index and negative inspiratory force [NIF]), since these tend to be less accurate in this particular population.

Patients were initially weaned anywhere from 30 mins to 1 hr. The weaning goal was extended daily as tolerated by the patient, provided that there were no exacerbations of the underlying condition or development of a significant new disorder. A weaning trial was stopped if the patient exhibited severe agitation, a respiratory rate >35, arterial oxygen saturation <90% despite an increment in F_{IO_2} to 60%, heart rate >140, systolic blood pressure >180 mm Hg, new onset hypotension (systolic blood pressure <90 mm Hg), or marked increment in work of breathing as evidenced by additional recruitment of accessory respiratory muscles, diaphoresis, and anxiety.

Rehabilitation Program. Rehabilitation was conducted by physical therapists 5 days per week in a gym constructed onsite within the VRU. Rehabilitation was started on admission to the VRU. Because a structured rehabilitation program had not been developed for the ICU, none of these patients received rehabilitation by physical therapists during their ICU stay. Initially, therapy sessions were 30–60 mins in duration, depending on the patient's tolerance for physical activity. Physical therapy sessions were not conducted during spontaneous breathing trials until the patient could spontaneously breath for >4 hrs. Once the patient was able to do so, physical therapy did proceed simultaneously with the spontaneous breathing trials. In those who were unable to breath spontaneously, physical therapy was accomplished by using a portable ventilator. The physical therapists were instructed to increase F_{IO_2} to maintain an oxygen saturation >94% during the rehab period. In patients with airway obstruction, a nebu-

Table 2. Muscle strength score

Muscle Activity	Score
Ability to hold the test position against gravity and maximum pressure	5
Same as above, except holding against moderate to minimal pressure	4
Ability to hold the test position against gravity	3
Ability to move a body part through a partial arc of motion (with gravity lessened by a the observer)	2
Contraction of muscle, prominence of tendon without visible motion of body part	1
No contraction felt in the muscle	0

Table 3. Functional independence measurement score

Transfers (Supine to Sit, Sit to Stand)	Ambulation, feet	Stairs, steps	Score
Total assistance (two people)	<50	<4	1
Maximal assistance (two people)	50	4–12	2
Moderate assistance (two people)	150	12	3
Minimal assistance (two people)	150	12	4
Supervision	50 (indep)	12	5
Modified independence	150	12 (indep)	6
Complete independence	>150 (indep)	>12	7

Indep, independent in performance.

Table 4. Demographic data

	All Patients (n = 49)	Wean <7 Days (n = 15)	Wean >7 Days (n = 34)
Age, yrs	58.5 ± 7	52.4 ± 6	59.9 ± 5
Gender, male/female	29/20	9/6	20/14
APACHE score at admission to VRU	20	19	22
Time on mechanical ventilation, days	18.1 ± 7	18.0 ± 8	18.3 ± 7
PaO_2/FIO_2, mm Hg/%	231 ± 24	233 ± 26	231 ± 24
Albumin, g/dL	2.4 ± 0.6	2.5 ± 0.4	2.36 ± 0.7
Prealbumin, mg/dL	14.4 ± 5	15.5 ± 6	13.8 ± 9
Time to wean, days	16 ± 9		

APACHE, Acute Physiology and Chronic Health Evaluation; VRU, ventilatory rehabilitation unit.

lized albuterol treatment with was given 30 mins before the rehabilitation session. All patients were suctioned before a rehabilitation session. Respiratory therapists assisted physical therapists and made changes in ventilator rate or tidal volume as needed for comfort; in most of cases, ventilator settings were not altered during the rehab period.

As the patient tolerated the sessions, the steps of the conditioning program were advanced and the training interval was progressively lengthened. The patients progressed from one session per day to two sessions per day once they were able to consistently tolerate >45 mins in one session. Oxygen saturation, heart rate, and blood pressure were monitored during sessions.

In the initial stages, the rehabilitation process concentrated on improving trunk control and patient maintenance of body posture. Pushing against resistance and using resistance bands and/or low weights followed passive and active training of upper and lower extremities. As patients improved trunk control, upper and lower extremity ergometry (magnetically or tension adjusted pedal exerciser), standing and ambulation using parallel bars, stepping in place, and then staircase exercises were introduced.

Inspiratory muscle training using a threshold device was instituted in patients capable of breathing spontaneously for >2 hrs. Patients used the device twice daily for 15 mins set at one third of the patient's maximum NIF. NIF was measured early in the morning every day, via the tracheostomy tube, before weaning attempts or physical therapy sessions as previously described (11). Patients were considered successfully weaned from mechanical ventilation once they tolerated 48 consecutive hours of unassisted breathing on tracheal collar.

Measurements. Extremity muscle strength was assessed by a physical therapist on admission, daily during physical therapy sessions, and on discharge from the VRU using a 5-point motor score (MS) that considered strength and range of motion in all major muscle groups (Table 2) and a previously validated 7-point Functional Independence Measurement Scale (FIM) that evaluates independent functioning (Table 3) (12, 13). Upper limb motor strength score was obtained by combining the mean scores for shoulder, elbow, and wrist flexion and extension. Similarly, lower limb motor strength scores were obtained by combining the mean scores for hip, knee and plantar flexion, and extension.

Statistical Analysis. Unpaired Student's *t*-test was used to analyze pairwise comparisons in normally distributed variables. Wilcoxon's log rank test or Mann-Whitney rank sum test was used in the absence of normally distributed variables. Proportions were analyzed using a Z-test. Linear regression analysis was used to establish correlations between variables. Stepwise multiple regression analysis was used to establish correlates between weaning time and multiple intervening variables. Significance was set at $p < .05$.

RESULTS

A total of 49 patients were enrolled. Primary causes for respiratory failure were pneumonia in 15 patients (31%), heart failure in nine (18%), acute respiratory distress syndrome in eight (16%), sepsis in eight (16%), acute on chronic renal failure in three (6%), and diaphragmatic dysfunction in two (4%); the following were seen once in individual patients: cerebrovascular accident, pulmonary embolism, cardiac tamponade, drug overdose, pneumothorax, and ventricular arrhythmia. A total of nine patients had a previous history of COPD.

Demographic data are shown in (Table 4). All patients were on assist-control ventilation and had a positive end-expiratory pressure <5 cm H_2O. Patients were intubated for 18.1 ± 7.7 days (range 9–29 days) before tracheostomy. The time from tracheostomy placement to transfer to the VRU was 7 ± 6 days. At the time of admission none of the patients were able to sustain a spontaneous breathing trial for >2 hrs. The time to wean from mechanical ventilation, measured from the initial day of admission to the VRU, was 16.0 ± 9 days. Of 49 patients, 15 (30%) weaned in ≤7 days. Patients were transferred to the VRU after achieving clinical stability. No significant differences in age or male to female ratio, Acute Physiology and Chronic Health Evaluation score on admission, or time on mechanical ventilation before tracheostomy were noted between patients who weaned ≤7 days and those who took >7 days to wean. A total of 16 patients (30%) were exposed to systemic corticosteroids, whereas 16 (30%) were exposed to neuromuscular blocking agents. A total of nine patients (18%) were exposed to both agents for <5 days.

Table 5. Motor strength and functional independence measurement (FIM) score for all patients on admission and at discharge

	Admission	Discharge
Motor strength		
Upper limb score	1.9	3.6[a]
Lower limb score	1.5	2.7[a]
FIM score		
Supine to sit	1.0	3.0[a]
Sit to stand	1.0	3.0[a]

[a] $p < .001$ (Mann-Whitney rank-sum test).

Table 6. Motor strength for weaning groups upon admission and at discharge

	Short Wean (<7 Days)	Prolonged Wean (>7 Days)
Admission		
Upper limb score	3.2 ± 0.4	1.5 ± 0.6[a]
Lower limb score	2.5 ± 0.4	1.2 ± 0.5[a]
Discharge		
Upper limb score	3.9 ± 0.6	3.3 ± 0.6[b]
Lower limb score	2.4 ± 0.4	3.0 ± 0.6[c]

[a] $p < .01$; [b] $p < .08$; [c] $p = .1$.

On admission to the VRU, all patients were severely deconditioned as evidenced by low scores in motor strength and functional status scales (Tables 5).

Motor Strength. On admission, patients exhibited marked weakness of both upper and lower extremities. Proximal muscle scores were lower (e.g., weaker) than distal muscle scores for both upper and lower limbs, but they did not reach statistical significance. A significant improvement was noted in the combined motor strength score for upper and lower limbs at the time of discharge from the VRU (Table 5). Using a similar analysis, on admission, patients who weaned ≤7 days had higher upper limb motor strength scores than patients who took >7 days to wean (Table 6). Although patients who weaned quicker continued to have higher motor strength scores at the time of discharge, the difference between groups was not statistically significant (Table 6).

Functional Status and Ambulation. The ability to transfer from the supine-to-sit and sit-to-stand positions was scored according to the FIM scale and constitutes the transfer scores. A significant improvement was noted in the ability to transfer from the supine to the sitting position and from the sitting to the standing position. (Table 5). There were no significant changes in the ambulation and stair-climbing categories of the FIMS scale. All patients were able to sit and stand at the end of the rehabilitation period. All patients were bed-bound at the time of admission; ambulation went from 0 to 52 ± 18 feet for the group ($p = .005$). A total of 40 patients (81%) were able to ambulate at the time of discharge.

Weaning Variables. Several changes in respiratory variables were noted. A significant decrement in respiratory rate (f) and a concomitant increment in tidal volume (VT) resulted in lower f/VT ratio (Table 7). An improvement in respiratory muscle strength was evidenced by a significant increment in maximal NIF.

A significant correlation was found between upper limb motor strength at the time of admission and time to wean ($R = .72$, $R^2 = .54$, $p < .001$, Fig. 2). Conventional weaning variables at admission or on the day of successful weaning did not exhibit a significant correlation with weaning success. On admission, the f/VT ratio was <105 in 40% of these patients. On the day of successful weaning, only 63% of all patients had an f/VT ratio <105.

Stepwise Regression Analysis of Factors Affecting Weaning Time. Stepwise multiple regression analysis was performed to establish predictors of weaning time. Gender, age, use of neuromuscular blocking agents and systemic steroids, presence of COPD, renal failure, heart failure, stroke pneumonia, prealbumin, f, f/VT, NIF, and lower and upper limb motor strength scores on VRU admission were included in the analysis. Three variables were found to be statistically significant in terms of weaning time: upper motor strength, exposure to neuromuscular blocking, and systemic steroids (Table 8). According to the regression equation, an increment of 1 point in the upper extremity motor strength scale results in a reduction of ~7 days in weaning time. According to the same equation, the exposure to steroids and neuromuscular blocking agents independently adds ~4 days to weaning time. The percent fit (R^2) of the equation is .73. As can be seen from the standardized estimates in Table 8, the contribution of upper motor strength to weaning time appears to be twice as influential as the exposure to neuromuscular blocking agents or steroids.

Outcomes. Six (12%) patients died after having successfully weaned (three with severe sepsis, two with respiratory failure due to pneumonia, and one with worsening COPD and respiratory failure). Two patients required noninvasive mechanical ventilation at the time of discharge, and one patient eventually developed the need for nocturnal invasive ventilation via tracheostomy.

DISCUSSION

Our study shows that chronic ventilated patients, when medically stable and transferred from the ICU, are severely weak and deconditioned, with limited ability to sit and stand, and are unable to ambulate. Following several weeks of whole-body and respiratory rehabilitation, patients have significant increases in whole-body and respiratory muscle strength and are ventilator independent as well as functionally improved. Upper extremity strength significantly correlates with weaning time, even more so than conventional variables used to predict weaning outcome (e.g., f/VT). These data suggest that patients undergoing prolonged periods of mechanical ventilation following an acute, devastating medical or surgical disorder suffer from significant global skeletal muscle weakness that limits their ability to wean and perform the activities of daily living. Fortunately, favorable improvements are found in these patients in response to conventional whole-body and respiratory muscle rehabilitative techniques.

In this heterogeneous group of patients, skeletal muscle dysfunction was present in both the upper and lower limbs, a fact that contrasts with the available data in COPD patients in whom upper limb motor strength is frequently preserved (14). Our chronic ventilated patients also had significantly decreased NIF indicating respiratory muscle weakness, again in contrast to patients with COPD in whom diaphragm strength is preserved in comparison to normal individuals when assessed at isovolume conditions (15). These data suggest that weakness occurs in the chronic ventilated patient in both the peripheral and respiratory muscles and emphasize the importance of reconditioning all muscle groups in this patient population. Overall, proximal muscles appeared to be more affected than distal muscles, and larger muscle groups (hips, thighs) were more severely affected than smaller muscle groups (wrist, arm). Whether this occurs due to the greater muscle mass located in the proximal regions affording easier assessment or due to the preferential effects of neuromuscular blocking agents, systemic corticosteroids, and/or inactivity impairing these muscle groups is unclear and needs further assessment.

A significant correlation was found between upper limb motor strength on admission to the ventilatory rehabilitation unit and the time to wean from invasive mechanical ventilation, in contrast to more conventional variables, such as f/VT (16). The pectoralis muscles are of large mass, are attached to an extensive area of the ventral bony thorax, and have both inspiratory (17–20) and expiratory actions (17, 20, 21). Several studies in cystic fibrosis patients (22), elite collegiate swimmers (23), and C_4 tetraplegic patients (24) have shown that pectoralis muscle training can result in improvements in ventilatory mechanics, both inspiratory and expiratory actions. In our rehabilitative program, special training was done for the arms (e.g., weight lifting, arm cycling, and isometric exercises using an indistensible plastic band). Whether pectoralis muscle strength and thereby its potential respiratory mechanical action were responsible for the association between weaning outcome and upper extremity strength in our study is a matter of speculation and needs further investigation.

Our results suggesting that weaning outcome in chronically ventilated patients is dependent on skeletal muscle strength fit well with the present understanding of factors predicting a patient's ability to sustain unassisted breathing loads. In the initial period when the patient is at his or her weakest state, a decrease in maximum transdiaphragmatic pressure (Pdi_{max}) increases the Pdi/Pdi_{max} ratio and results in a decrease in the maximum time a breathing load can be sustained (T_{lim}) (25). As patients are reconditioned and increase skeletal muscle strength, Pdi_{max} increases, Pdi/Pdi_{max} decreases, and T_{lim} increases mirroring an increase in weaning time. That f/VT does not correlate with weaning outcome in this group of patients is also not surprising in that rapid shallow breathing likely signifies a breathing strategy adopted by the central nervous system designed to avoid the development of respiratory muscle fatigue (e.g., central fatigue), rather than signifying the presence of respiratory muscle fatigue (e.g., peripheral fatigue), itself (26).

Table 7. Breathing variables at admission and at discharge

Variables	Admission	Discharge	p
Respiratory rate	25	20	.07[a]
Tidal volume, L	0.22	0.26	.002[a]
f/VT	104	80	<.001[a]
NIF	24	35	<.001[a]

f/VT, respiratory frequency/tidal volume; NIF, negative inspiratory force.
[a]Mann-Whitney rank-sum test.

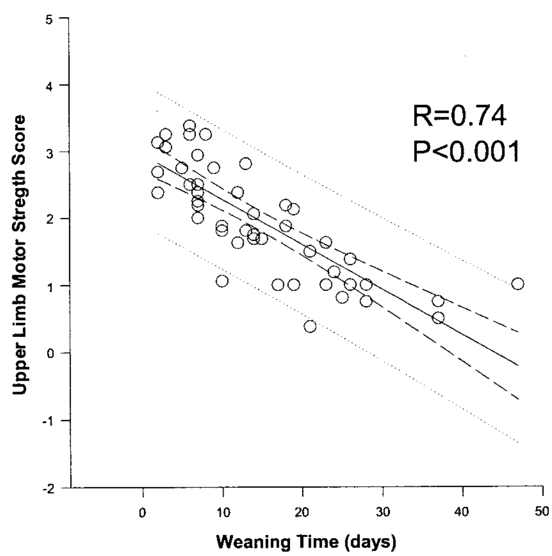

Figure 2. A significant correlation was found between upper motor strength on admission and weaning time in days (R = .72, $p < .001$).

Table 8. Variable estimates from stepwise regression analysis

Variable	*df*	Variable Estimate	SE	t Value	p	Standardized Estimate
Intercept	1	25.4	3.05	8.3	<.0001	0
NMBA	1	4.6	2.14	2.2	.03	0.21
Steroids	1	4.8	1.76	2.7	.0092	0.22
Upper motor strength score	1	−7.1	1.19	−5.9	<.0001	−0.59

df, degrees of freedom; NMBA, neuromuscular blocking agents.

In an attempt to determine whether there were any factors that may have been important in affecting weaning outcome, we divided patients into those who weaned in <7 days and those who weaned in >7 days. All patients had a significant improvement in motor strength at the time of discharge. As expected, patients who weaned in <7 days had greater upper limb motor strength scores on admission. The difference between groups persisted at the time of discharge, but it had significantly narrowed. This suggests that although certain patients may take a longer time to increase their strength, continuous whole-body rehabilitation results in similar positive outcomes for both groups. No statistically significant differences were noted in age or male to female ratio, Acute Physiology and Chronic Health Evaluation score on admission, and PaO_2/FIO_2 ratio within groups to explain the difference in weaning time.

Patients had a significant improvement in the transfer variables portion of the FIM scale; however, a significant difference was not observed in ambulation variables. We believe that this is related to the FIM scale used, where a distance improvement of 150 feet is required for statistical significance to be achieved. Nevertheless, a significant improvement was seen in the distance that patients were able to ambulate at discharge compared with admission; 81% of all patients were capable of assisted or unassisted ambulation at the time of discharge. This is similar to previous data reported by Nava

Whole-body rehabilitation conducted by a multidisciplinary team appears to improve both motor strength and functional variables and should therefore be considered an important part in the care of chronically ventilated patients.

(4), where 87% of patients had a similar outcome. It became increasingly clear to us that conventional scales adopted from regular rehabilitation programs may not be adequate to evaluate improvement and progress in this particular group of patients, and future efforts should be devoted to devising appropriate evaluation scores.

Our study has several disadvantages. It is a retrospective analysis of data collected prospectively without a control group. Our intent was not to determine whether rehabilitation should be used but to characterize the extent of weakness and need for rehabilitation in this unique patient group and evaluate the efficacy of treatment. A question that this study did not address, but that should be addressed in future work, is whether more intense or different forms of physical reconditioning would be of greater value than the results we achieved. Future studies will have to address the question of the intensity and methods of rehabilitation in patients on chronic invasive mechanical ventilation.

Although the motor strength variables were performed by the same physical therapist, strength was not objectively quantified. Unfortunately, the degree of deconditioning in these patients precludes the initial use of devices such as a dynamometer, which are ill suited in patients who are barely able to contract their muscles.

None of these patients had overt neuromuscular disease by history or physical examination, but we did not perform routine electromyograms to rule out the presence of critical illness polyneuropathy. This may be particularly important since 15% of our patients had sepsis as the precipitating factor for respiratory failure and prolonged mechanical ventilation, and critical illness polyneuropathy is highly prevalent in this group (27, 28). In this group of patients, systemic steroids and paralytic agents independently resulted in additional days to wean as evidenced by the regression model. It is therefore possible that some of these patients had less severe, albeit significant forms of critical illness myopathy, or polyneuropathy. However, if critical illness polyneuropathy was present, it temporally responded to the rehabilitative program as outlined and would not change our final results and the efficacy of whole-body rehabilitation in this patient group.

CONCLUSIONS

Chronic ventilated patients are weak and severely deconditioned following stabilization of their acute problems and deemed ready to wean from mechanical ventilation. Whole-body rehabilitation conducted by a multidisciplinary team appears to improve both motor strength and functional variables and should therefore be considered an important part in the care of chronically ventilated patients. Upper arm motor strength appears to be a simple yet significant predictor of weaning time in these patients. The benefit of rehabilitation appears to be applicable even in patients with the most severe forms of deconditioning, since all patients have comparable degrees of motor strength and functional status at the time of discharge. Randomized, controlled trials evaluating different intensities of whole body rehabilitation should be pursued.

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