Original Research

The Feasibility of Early Physical Activity in Intensive Care Unit Patients: A Prospective Observational One-Center Study

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BACKGROUND: Prolonged immobilization may harm intensive care unit (ICU) patients, and early mobilization has been proposed to counteract that process. We describe our experience in early rehabilitation of ICU patients, and its effects on physiologic outcomes. METHODS: We included all patients who stayed in our 14-bed medical ICU for ≥ 7 days and received invasive mechanical ventilation for ≥ 2 days. The rehabilitation program included chair-sitting, tilting-up (with arms supported or unsupported), and walking. We collected vital signs before and after each intervention. RESULTS: Over a 5-month period we studied 20 patients, after a median ICU stay of 5 days. A contraindication to the intervention was present on 230 days (43%). Sedation (15%), shock (11%), and renal support (9%) were the most frequent contraindications. We obtained complete data from 275 of 424 interventions, 33% of which were performed during mechanical ventilation. The chair-sitting intervention was the most frequent (56%), followed by the tilting-up-with-arms-unsupported intervention (25%), the walking intervention (11%), and the tilting-up arms-supported intervention (8%). The chair-sitting intervention was associated with a significant ($P = .03$) decline in both heart rate (mean −3.5 beats/min, 95% confidence interval [CI] −6.5 to −0.4 beats/min) and respiratory rate (−1.4 breaths/min, 95% CI −2.6 to 0.1 breaths/min), whereas blood oxygen saturation (measured via pulse oximetry [S_{pO_2}]) and mean arterial blood pressure did not change significantly. Heart rate and respiratory rate similarly increased with tilting-up: 14.6 beats/min, 95% CI 10.8 to 18.4 beats/min, and 5.5 breaths/min, 95% CI 3.6 to 7.3 breaths/min with arms unsupported, and 12.4 beats/min, 95% CI 7.0 to 17.9 beats/min and 2.6 breaths/min, 95% CI −0.4 to 5.7 breaths/min with arms supported). Heart rate and respiratory rate also increased with the walking intervention: 6.9 beats/min, 95% CI 2.6 to 11.1 beats/min, and 5.9 breaths/min, 95% CI 3.8 to 8.0 breaths/min. The walking intervention significantly decreased S_{pO_2}. An adverse event occurred in 13 (3%) of 424 interventions, but none had harmful consequences. CONCLUSIONS: Early rehabilitation is feasible and safe in patients in the ICU for longer than 1 week. The chair-sitting intervention was associated with nonsignificant oxygenation improvement. The tilting-up intervention was an effort as intense as walking. *Key words: rehabilitation; early mobilization; physical therapy; intensive care unit; mechanical ventilation; immobilization.* [Respir Care 2010;55(4):400–407. © 2010 Daedalus Enterprises]

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Introduction

During an intensive care unit (ICU) stay, any acutely ill patient is commonly exposed to injuries such as prolonged immobilization, vital organ dysfunction, sepsis, hypoxemia, acidosis, or neuromuscular drug toxicity. As a result, the cardiovascular system may be damaged and critical illness neuromuscular syndromes may occur,[1] both of which delay ventilator weaning and therefore increase ICU and hospital stay.[2] Moreover, ICU survivors frequently exhibit impaired quality of life, and only half of them can return to work.[3-5] Prolonged bed rest may be a primary factor in this process. Patients who experience more than 1 week of bed rest exhibit up to 40% loss of muscle strength in the antigravity muscles of the calf and back.[6] Early mobilization of ICU patients via the maintenance of muscle strength should increase the weaning success rate, decrease ICU and hospital stay, and improve the quality of life in the ICU and beyond.[7,8]

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The purpose of this study is to describe our experience in early rehabilitation of ICU patients undergoing mechanical ventilation. We focused on the feasibility and effects of early rehabilitation interventions on common physiologic variables. Our rehabilitation program has been underway in our ICU for many years. Because the literature has very few data to guide the intervention of early mobilization in the ICU, we decided to perform an observational pilot study and to collect data to describe its feasibility, safety, and potential benefits.

Methods

Patients

We screened all patients admitted to our 14-bed medical ICU in a tertiary-care university hospital. To be included, a patient had to receive invasive mechanical ventilation for more than 2 days and to stay in the ICU for at least 7 days. The rehabilitation program was performed daily unless the following exclusion criteria were present:

- Agitation, confusion, or impaired or no response to simple orders
- Shock, defined as systolic blood pressure < 90 mm Hg or need for ongoing vasopressors
- Persistent respiratory failure, defined as respiratory rate > 35 breaths/min and/or ratio of P_{aO_2} to fraction of inspired oxygen (F_{IO_2}) < 200 mm Hg (we chose that

value for its presumed safety), and/or P_{aCO_2} > 50 mm Hg, and/or pH < 7.30
- Ongoing renal replacement therapy
- Ongoing intravenous sedation
- Scheduled extubation
- Out of the ICU for a procedure

This report is based on routine care, so our local ethics committee waived the informed consent requirement.

Rehabilitation Protocol

In patients who are currently or have been receiving mechanical ventilation via the tracheal route, the primary aim of our ICU rehabilitation program is to provide active mobilization out of the bed and with various physical activities, including chair-sitting, tilting-up (with or without arms support), and walking. Whether a patient is eligible for and can be included in the rehabilitation program is the clinician's decision. This indication is checked every day by the physician in charge, who chooses the type of intervention in consultation with the physiotherapist. What specifically is first examined in patients to suggest to the physiotherapist that a specific intervention is reasonable to pursue that day is the absence of any contraindication listed above. The second assessment is of the motor capacity of the upper and lower limbs. If this is the case, the patient can be moved to a chair, then can walk. In patients with severe critical-illness neuropathy the tilting-up intervention is administered first. If the quadriceps muscles test is lower than 3 on a muscle-strength scale (range from 1 [worst] to 5 [best]),[9] the tilting-up-with-arms-supported intervention is preferred. This intervention can be performed daily, including Saturday and Sunday, by one of the 5 physiotherapists in our ICU team.

Chair-Sitting Intervention

Chair-sitting is offered to any included patient provided that tonus of trunk, arms, and legs muscles is strong enough to sustain this position. While keeping the same baseline mechanical ventilation, the patient is moved out of bed and into a separate chair device (SM608A, Hill Rom France, Pluvigner, France). The patient is left sitting in the chair up to 1 hour at the first attempt. The duration of further chair-sitting interventions is increased to 1–2 hours per intervention, and the number of interventions to 1 to 2 per day. The chair-sitting intervention is interrupted and the patient moved back to bed if any of the following occur:

- Tachycardia (heart rate > 130 beats/min, or ≥ 20% increase from the pre-the mobilization baseline)
- New cardiac arrhythmia

Fig. 1. Device for standing with arms supported.

- Tachypnea (respiratory rate > 35 breaths/min, or $\geq 20\%$ increase from the pre-mobilization baseline)
- Blood oxygen saturation (measured via pulse oximetry [S_{pO_2}]) $< 88\%$ for > 1 min
- Systolic arterial blood pressure < 90 mm Hg or > 180 mm Hg
- Agitation
- Anxiety
- Diaphoresis

Tilting-Up Intervention

This reconditioning intervention is performed with one of 2 devices. The first, which allows tilting the patient up with arms unsupported (Standing GT, Rupiani, Vaux-en-Velin, France) (Fig. 1), is used with patients whose trunk and legs muscles are strong enough to partly sustain the erect position but not strong enough to allow for walking. The patient's arms can be supported if necessary, and the feet are secured. The other device (flat abdominal bench, Multi-Form, La Roque D'antheron, France) (Fig. 2) allows tilting-up with the patient's arms supported; it is for pa-

Fig. 2. Tiltable table, for tilting the patient up with arms unsupported.

tients with severe diffuse neuromuscular weakness that makes the patient unable to stand erect without such support. The patient is securely fastened to the tiltable table. The tilt-up position is held for 10–30 min and managed by the physiotherapist.

During the chair-sitting and tilting-up interventions the patient continues to receive the baseline mechanical ventilation settings. Heart rate, arterial blood pressure, and S_{pO_2} are continuously monitored (Intellivue MP60, Philips France, Suresnes, France).

Walking Intervention

The patient may be given the opportunity to walk in the corridor of the ICU, with the physiotherapist's assistance. The walk distance and duration depend on the patient's tolerance. If the patient is on mechanical ventilation, the ventilation is continued during the walking intervention, with an Onyx ventilator (ResMed, Savigny-le-Temple, France) set in pressure-support mode and supplied with

supplemental oxygen if necessary. S_{pO_2} is monitored during the walk, and the physiotherapist manages the pressure-support setting and oxygen flow.

Data Collection

We prospectively gathered data on anthropometry, the presence of underlying chronic respiratory disease, Simplified Acute Physiology Score 2 (SAPS2),[10] duration of mechanical ventilation before the patient began ICU rehabilitation interventions, and physiology (respiratory rate, heart rate, mean arterial blood pressure, and S_{pO_2}) before and at the end of each intervention, and the time and number of interventions and adverse events. Adverse events we recorded were drop in muscle tone, hypoxemia (defined as $S_{pO_2} < 88\%$ for > 1 min), unscheduled extubation, and orthostatic arterial hypotension (defined as systolic arterial blood pressure < 80 mm Hg in the standing position).

Statistical Analysis

Quantitative data are presented as median and interquartile range. The absolute differences in heart rate, respiratory rate, mean arterial blood pressure, and S_{pO_2} before and after each intervention were computed and analyzed across time via linear regression with mixed effects. The time was the number of ICU days between the onset of the intervention and each measurement. The dependent variable was the absolute difference, the independent variable with fixed effects was the time in interaction with the intervention, and the patients were the grouping variable with a random effect. The values of the parameters of the regression analysis are given with their 95% confidence intervals. If the time by intervention interaction was not significant in the regression model, it was discarded from the model. The significant change in physiologic parameters for each intervention was tested from zero.

The occurrence of out-of-range values for heart rate, respiratory rate, systolic arterial blood pressure, and S_{pO_2} was computed as the ratio of the number of events to the number of interventions. The analysis of these proportions was performed by using a linear mixed model with binomial distribution and a logit link, where out-of-range was the outcome, rehabilitation intervention the covariate with fixed effect, and patient the variable with random effect. The predicted probabilities of experiencing an out-of-range value for each physiologic variable were compared between the different interventions. The statistical analysis was performed with statistics software (R version 2.6.2, R Foundation for Statistical Computing, and SPSS version 15.0, SPPS, Chicago, Illinois). A P value $< .05$ was considered statistically significant.

Results

Cohort Description

Between April and August 2006, 225 patients were admitted to our ICU, and 20 (14 men) consecutive patients (9%) were enrolled in the present study. Their age was 68 (32–85) years, body mass index was 28 (23–30) kg/m^2, SAPS2 42 (22–75) predicting a mortality rate of 28% (5–89). Fifteen patients were admitted for acute respiratory failure, 3 for septic shock, 1 for multiple organ failure, and 1 for weaning failure. Eleven patients had chronic respiratory disease (7 obstructive, 2 restrictive, and 2 combined obstructive and restrictive). Only 1 patient of those 20 died during the ICU stay (mortality rate 5%).

Rehabilitation Program

Table 1 shows the main features of the rehabilitation program. The 20 patients spent a total of 524 days in our ICU, and the median per patient was 17 (10–43) days. The median duration of mechanical ventilation was 7 (4–27) days. Thirteen patients began the rehabilitation program while they were invasively mechanically ventilated, and 7 began the program in the 24 hours following extubation. Among those, 3 patients received noninvasive ventilation. In 7 patients, extubation failed in 8 instances. In one of those, tracheotomy for prolonged mechanical ventilation was performed. The 6 remaining patients were eventually weaned successfully.

There were contraindications to starting the rehabilitation program on 230 days (43%), for the following reasons: ongoing intravenous sedation ($n = 78$ d, 15%), shock ($n = 59$ d, 11%), renal support ($n = 48$ d, 9%), out of the ICU for a procedure ($n = 17$ d, 3%), persistent respiratory failure ($n = 11$ d, 2%), scheduled extubation ($n = 9$ d, 2%), agitation, confusion, or impaired or no response to simple orders ($n = 8$ d, 1%). If a contraindication was found, the other interventions were cancelled for the day. 424 rehabilitation interventions were performed, with a median of 2 (1–3) interventions per patient and per day. However, only 275 (65%) could be analyzed, whereas 149 (35%) could not because of missing values during the collection of physiologic data. Most of the missing data pertained to the end of the intervention for that performed later in the afternoon, when understaffing limited data collection. The duration of invasive mechanical ventilation before beginning rehabilitation was 5 (2–9) days. The time from ICU admission to beginning of rehabilitation was 5 (2–8) days. In this cohort of ICU patients, 19 of 20 were extubated, and 1 of 20 required tracheostomy. The patient who required tracheostomy died at day 49 after ICU admission.

Ninety-one (33%) rehabilitation interventions were performed during invasive mechanical ventilation, and the re-

Table 1. Features of the ICU Rehabilitation Program Used in This Study

Days from ICU admission to the start of rehabilitation (median, interquartile range)	5 (1.5–9)
Contraindication to Rehabilitation Intervention (*n* and % days in ICU)	
Sedation	78 (15)
Shock	59 (11)
Renal support	48 (9)
Out of ICU for procedure	17 (3)
Acute respiratory distress	11 (2)
Scheduled extubation	9 (2)
Cognitive alteration	8 (1)
Total	230 (43)
All Rehabilitation Interventions Performed (*n*, %)	
Chair-sitting	155 (56)
Tilting-up with arms supported	22 (8)
Tilting-up with arms unsupported	68 (25)
Walking	30 (11)
Total	270 (100)
Rehabilitation Interventions While on Ventilator (*n*, %)	
Chair-sitting	55 (35)
Tilting-up with arms unsupported	18 (82)
Tilting-up with arms supported	18 (26)
Walking	0 (0)
Total	91 (33)
Duration of Each Intervention (median and interquartile range min)	
Chair-sitting	150 (90–240)
Tilting-up with arms supported	15 (10–18)
Tilting-up with arms unsupported	10 (4–15)
Distance walked (median and interquartile range m)	80 (25–100)

ICU = intensive care unit

maining 184 were while the patients were breathing spontaneously after extubation. Oxygen supplementation was received by 82% of them, at a median flow of 2 (1–3) L/min.

Chair-sitting was the most frequent intervention ($n = 155$, 56%), followed by tilting-up with arms unsupported ($n = 68$, 25%), walking ($n = 30$, 11%), and tilting-up with arms supported ($n = 22$, 8%). The median intervention durations were 150 (90–240) min, 15 (10–18) min, and 10 (4–15) min for chair-sitting, tilting-up with arms supported, and tilting-up with arms unsupported, respectively. The mean walk distance was 80 (25–100) m.

Physiologic Data

Figure 3 is a box-plot representation of the effects of the interventions, repeated over time, on physiologic variables. Table 2 compares the mean differences to zero, for each intervention. Time had no significant effect on the physiologic variables between the interventions. The change in heart rate was significantly different from zero with each

intervention (see Table 2). The increase in heart rate was clinically important with both tilting-up interventions. The significant decline in heart rate with chair-sitting might be clinically relevant. The increase in respiratory rate was statistically and clinically important after walking and tilting-up with arms unsupported. The increase in mean arterial blood pressure with standing with arms supported was statistically and clinically important. Whereas S_{pO_2} significantly decreased with walking and tilting-up with arms unsupported, only the former might be clinically relevant. The nonsignificant improvement of S_{pO_2} with chair-sitting might have clinical relevance. The probability of heart rate > 130 beats/min or increasing by $\geq 20\%$ during the intervention was 36% (16–63) with tilting-up with arms unsupported, which was significantly greater than that with walking (8% (2–23), $P < .001$), with tilting-up with arms supported 7% (2–23), $P = .001$), and with chair-sitting (5% (2–13), $P < .001$).

The probability of respiratory rate > 35 breaths/min or increasing by $\geq 20\%$ during the intervention was 63% (46–77) with walking, which was significantly greater than the 33% (16–55) with tilting-up with arms supported ($P = .03$) or the 17% (12–26) with chair-sitting ($P < .001$). The probability of this event was 49% (35–64) with tilting-up with arms unsupported, which was not significantly different from walking, but significantly greater than chair-sitting ($P < .001$).

The probability of systolic arterial pressure < 90 mm Hg or > 180 mm Hg during the intervention was 20% (0–10) with walking, which was significantly greater than the 12% (5–27) with tilting-up with arms unsupported ($P = .046$) or the 7% (3–13) with chair-sitting ($P < .001$). The difference between chair-sitting and tilting-up with arms unsupported was also significant ($P < .001$). No out-of-range value of systolic arterial blood pressure was observed with tilting-up with arms supported.

There were no S_{pO_2} values $< 88\%$ with any intervention except for tilting-up with arms supported, so the comparison between interventions could not be performed.

Adverse Events

Adverse events were observed in 13 cases (3% of the 424 interventions). Drop in muscle tone ($n = 7$) was the most frequent. This never resulted in the patient falling. Hypoxemia, defined as $S_{pO_2} < 88\%$ for > 1 min ($n = 4$), unscheduled extubation ($n = 1$), and orthostatic arterial hypotension ($n = 1$) were less frequent. None of the adverse events was associated with death, pulmonary embolism, dysrhythmia, or myocardial infarction during the observation period. Because of the low rate of adverse events, it was not possible to determine whether any of the interventions had significantly more risk than any other. The patient who self-extubated had good clinical progress and did not require re-intubation.
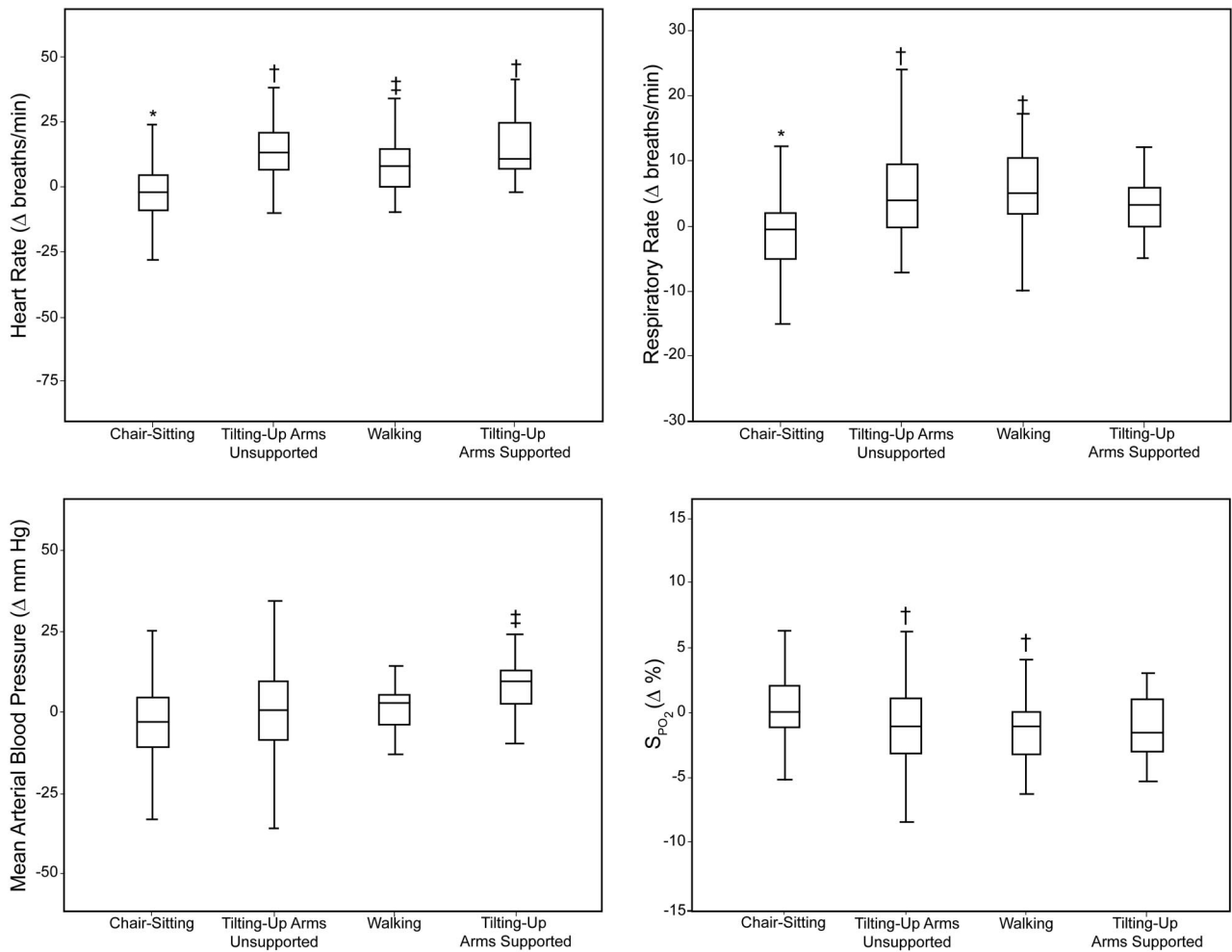
Fig. 3. Changes in physiologic variables before and after each intervention across the days in the intensive care unit. * $P = 03$. † $P = .001$. ‡ $P < .001$ versus zero for each intervention.

Discussion

The main findings of the present study are that our program of early rehabilitation of ICU patients is feasible and safe, and experienced the following contraindications: ongoing intravenous sedation, shock, renal support, out of the ICU for a procedure, persistent respiratory failure, scheduled extubation, impaired response to simple orders, agitation, or confusion. Recently summarized pulmonary rehabilitation principles[11,12] have not been widely adopted in ICUs. Mobilizing patients out of bed in the ICU can be seen as an earlier rehabilitation process to maintain muscle strength and joint motion, to improve respiratory system performance, and to prevent alteration in cardiovascular response to intervention. All of these may facilitate weaning from mechanical ventilation, shorten ICU and hospital stay, and improve quality of life after ICU stay. Although physiotherapy is a common practice in most ICUs,[13] there are few data on its current practice, feasibility, and bene-

fits.[14,15] A randomized trial that compared physiotherapy to standard care in ICU patients found longer mechanical ventilation with physiotherapy.[16]

A rehabilitation program that included COPD patients recovering from episodes of acute respiratory failure was tested in a single-center randomized study with 80 patients.[17] The protocol included 4 steps, from sitting to a complete lower-extremity rehabilitation program, and was compared to standard medical therapy. Mechanical ventilation was invasive in half of the patients and noninvasive in a quarter of them. Significant positive effects were observed on intervention capacity, respiratory muscle strength, and dyspnea score, but not on stay or weaning.

Martin et al analyzed 49 consecutive chronically ventilator-dependent patients who were admitted to a rehabilitation unit after an ICU stay.[18] All patients were clinically stable and bedridden. Limb-muscle weakness and deconditioning were serious, suggesting a high prevalence of critical-illness-associated neuromyopathy. This

Table 2. Mean Changes in Physiologic Variables After Each Intervention

Variable and Intervention	Mean Change	95% Confidence Interval	P*
Heart Rate (beats/min)			
Chair-sitting	−3.5	−6.5 to −0.4	.03
Walking	6.9	2.6 to 11.1	.002
Tilting-up with arms unsupported	14.6	10.8 to 18.4	< .001
Tilting-up with arms supported	12.4	7.0 to 17.9	< .001
Respiratory rate (breaths/min)			
Chair-sitting	−1.4	−2.6 to 0.1	.03
Walking	5.9	3.8 to 8.0	< .001
Tilting-up with arms unsupported	5.5	3.6 to 7.3	< .001
Tilting-up with arms supported	2.6	−0.4 to 5.7	.09
Mean Arterial Pressure (mm Hg)			
Chair-sitting	−2.13	−4.7 to 0.42	.10
Walking	0.9	−3.9 to 5.8	.70
Tilting-up with arms unsupported	0.3	−3.6 to 4.2	.87
Tilting-up with arms supported	8.9	1.8 to 16.0	.01
Transcutaneously Measured Oxygen Saturation (%)			
Chair-sitting	0.5	0.0 to 1.0	.07
Walking	−1.4	−2.2 to −0.5	.001
Tilting-up with arms unsupported	−0.9	−1.7 to −0.2	.001
Tilting-up with arms supported	−1	−2.2 to 0.2	.10

* Relative to zero.

uncontrolled study showed that aggressive whole-body rehabilitation can be efficient and significantly improves muscle strength and functional status. Interestingly, weaning was achieved in all patients, and there was a significant inverse correlation between weaning time and upper-limb motor strength, which suggests that weaning may depend on skeletal-muscle strength.

Although both the latter studies brought interesting information, they both described patients who were recovering from acute episodes, once clinical stabilization was obtained and the patient was out of the ICU. By contrast, our study describes an early rehabilitation practice during the ICU stay in 20 consecutive patients who were mechanically ventilated and whose ICU stay was greater than 1 week. Most of the patients were admitted for acute respiratory failure, and more than half had chronic respiratory disease. Early rehabilitation was begun once clinical stability was obtained, within the first week of ICU admission. Sedation, inotropic support therapy, and renal support therapy were the 3 most frequent contraindications to start this rehabilitation program.

Adverse events were rare; they occurred in only 3% of all the interventions. None of the adverse events, including the accidental extubation, had harmful consequences to patient outcome. No re-intubation was needed. The present results suggest the feasibility of early ICU rehabilitation (barring contraindications).

Our patients performed a median of 2 (1–3) rehabilitation interventions per day without contraindication, and half of the interventions were chair-sitting. All the patients but one were successfully weaned and survived the acute episode. The patient who failed weaning underwent tracheostomy and eventually died in the ICU.

Bailey et al[19] reported a 1-year prospective cohort study with 103 patients who required mechanical ventilation for > 4 days and were referred to a respiratory ICU. The following activities were performed: sit on edge of bed, stand at bedside, stand and transfer to chair, sit in chair, and walk. No tilt-up tables were used.[19] Most of the patients were referred from other ICUs, in which the patients had stayed for a mean ± SD 10.5 ± 9.9 days and rehabilitation had already been performed. The delay between ICU admission and sitting on the edge of the bed (which was the beginning of the rehabilitation process) was 6.6 ± 5.5 days, which is close to that in the present study. In the Bailey et al study, one third of the rehabilitation acts were sitting in a chair, and more than half were walking, as compared to 56% and 11%, respectively, in our study. One possible explanation for this discrepancy is that our program offers 4 separate interventions. In addition to chair-sitting and walking our program includes tilting-up with arms unsupported or supported, and these 2 activities allow the patient to experience the vertical position. Tilt-up-table therapy may increase ventilation, increase arousal, and facilitate lower-limb intervention[20] and thus may hasten resumption of ambulation. In our trial, tilt-up table constituted almost a third of all the interventions. However, whereas Bailey et al did not use a tiltable table, over half of their patients ambulated, compared to 33% tiltable table and 11% walking (combined 44%) in the present study. Therefore, the present data do not support that tilt-up table facilitates ambulation. Unfortunately, neither study measured muscle strength. In our study most of the rehabilitation was started after extubation (13 of 20 patients). This is unlike the Bailey et al study,[19] in which most patients were on mechanical ventilation when they started. Further, in our study 33% of the rehabilitation acts were performed during mechanical ventilation.

A recent prospective study compared 165 ICU patients who received standard care to 165 ICU patients who began a 4-step mobility program within 48 hours of intubation.[21] The steps consisted of passive and active mobilizations, sitting at the edge of the bed or in a chair, standing, and ambulation. That study showed that such a program increased the proportion of patients who may benefit from rehabilitation (80% vs 47%, P < .001). The proportion of patients who underwent standing and ambulation was not reported. A shorter hospital stay (the primary end point) was reported, but there was no difference in duration of

mechanical ventilation, and the role of early rehabilitation in ventilator weaning remains to be assessed.

Limitations

Our cohort was small because of the short study duration and the fact that we included only patients intubated at admission and in the ICU for more than 1 week, to select patients who were likely to respond to our rehabilitation intervention. Another limitation is the absence of a control group, but this study was a preliminary investigation aimed at describing our current practice, its feasibility, and some physiologic effects. At this stage we were not interested in evaluating the long-term effects of early rehabilitation on patient outcome and quality of life. Further investigations to address these issues should be done. Another potential limitation is that we did not record how many patients were not enrolled in the study due to clinician's choice.

Finally, our study is limited by the number of missing values in the physiologic variables. This underlines that even with a protocol an activity does not happen in the ICU unless there is a culture change. Successful implementation of a respiratory care process model, including early mobility, requires the ICU culture to be transformed.[22] One strength of our study was its measurement of common and relevant clinical variables. Chair-sitting nonsignificantly improved oxygenation and significantly reduced respiratory rate and heart rate, which may be the result of improved lung volumes and ventilation-perfusion matching,[23] but the differences were small and some were of limited clinical importance.

Tilting-up significantly increased heart rate and respiratory rate, which suggests that tilting-up requires substantial patient effort and therefore may be an interesting alternative in patients who cannot ambulate (eg, patients with critical-illness-associated neuromyopathy).

Another strength was that we quantified the types of contraindications to the rehabilitation acts, which may help other investigators circumvent these problems in the future and inform our colleagues at other institutions on what to expect in terms of the frequency of not being able to deliver ICU rehabilitation interventions.

Conclusions

Early ICU rehabilitation is an attractive adjunct therapy to counteract the harmful effects of immobilization and avoid ICU morbidities. In our cohort of 20 ICU patients, early rehabilitation was feasible and safe. Further investigation is necessary to assess the effects of early rehabilitation on quality of life, notably in the most disabled patients, such as those suffering from chronic respiratory failure or critical-illness-associated neuromyopathy.

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