Fizyoterapi Rehabilitasyon. 2012;23(1):3-9

Effects of mobilization on hemodynamic and respiratory responses in critically ill patients

Meriç ŞENDURAN, Arzu GENÇ, Mert AKAN, Ali GÜNERLİ

[Şenduran M, Genç A, Akan M, Günerli A. Effects of mobilization on hemodynamic and respiratory responses in critically ill patients. Fizyoter Rehabil. 2012;23(1):3-9. *Kritik hastalarda mobilizasyonun hemodinamik ve respiratuar yanıtlar üzerindeki etkileri.*]

Research Article

Purpose: The objective of this study was to investigate the effects of mobilization on hemodynamic and respiratory responses in critically ill patients. **Methods:** Data of 39 patients enrolled in one or more mobilization sessions during their intensive care unit stay were collected retrospectively from routine physiotherapy records. Heart rate, systolic/diastolic/mean arterial pressures, rate pressure product, respiratory rate and peripheral oxygen saturation were recorded before (pre-mobilization), immediately after (post-mobilization) and five minutes after (recovery) mobility tasks. **Results**: No significant differences were found in terms of parameters between three measurements ($p>0.05$). Significant differences were detected in terms of respiratory rate and rate pressure product after all three levels and post-mobilization mean arterial pressure when the patients were grouped according to their pre-treatment cardiac reserves ($p<0.05$). **Conclusion**: Our results supported the safety of early mobilization of critically ill patients in intensive care units. We recommend ongoing monitoring of hemodynamic and respiratory parameters in order to observe physiological responses during mobilization.

Key words: Early mobilization, Critical illness, Hemodynamics.

Kritik hastalarda mobilizasyonun hemodinamik ve respiratuar yanıtlar üzerindeki etkileri

Amaç: Bu çalışmanın amacı, kritik hastalarda mobilizasyonun hemodinamik ve respiratuvar yanıtlar üzerindeki etkisini incelemektir. **Yöntem:** Yoğun bakımda kalışları süresince bir veya daha fazla mobilizasyon seansına alınan 39 hastanın verileri rutin fizyoterapi kayıtlarından retrospektif olarak toplandı. Kalp hızı, sistolik/diyastolik/ortalama arteryal basınçlar, hız basınç ürünü, solunum hızı ve periferal oksijen saturasyonu mobilizasyon uygulamalarından önce (mobilizasyon öncesi), hemen sonra (mobilizasyon sonrası) ve beş dakika sonra (toparlanma) kaydedildi. **Sonuçlar:** Üç ölçüm arasında hiç bir parametre açısından anlamlı bir fark bulunmadı ($p>0.05$). Hastalar tedavi öncesi kardiyak rezervlerine göre gruplandırıldığında, üç ölçüm arasında solunum hızı ve hız basınç ürünü ve mobilizasyon öncesi ortalama arteryel kan basıncı açısından anlamlı farklar bulundu ($p<0.05$). **Tartışma:** Sonuçlarımız yoğun bakım ünitesindeki kritik hastalarda erken mobilizasyonun güvenliğini desteklemektedir. Fizyolojik yanıtları gözlemlemek amacıyla mobilizasyon sırasında hemodinamik ve respiratuvar parametrelerin sürekli monitorizasyonunu önermekteyiz.

Anahtar kelimeler: Erken mobilizasyon, Kritik hastalık, Hemodinami.

M Şenduran,
School of Physical Therapy and Rehabilitation, Dokuz Eylül University, Izmir, Turkey
PT, MSc

A Genç,
School of Physical Therapy and Rehabilitation, Dokuz Eylül University, Izmir, Turkey
PT, PhD, Assoc Prof

M Akan
Faculty of Medicine, Department of Anesthesiology, Dokuz Eylül University, Izmir, Turkey
MD, Assist Prof

A Günerli,
Faculty of Medicine, Department of Anesthesiology, Dokuz Eylül University, Izmir, Turkey
MD, Prof

Address correspondence to:
Meriç Şenduran, MSc, PT
School of Physical Therapy and Rehabilitation,
Dokuz Eylül University, İnciraltı, İzmir, Turkey
E-mail: meric.senduran@deu.edu.tr

Critical illness has been defined as a life-threatening medical condition that impairs one or more vital function and may last from hours to months depending on the underlying pathology and response to treatment.[1,2] It is important to protect critically ill patients from further deterioration or delays in recovery.[3] Physiotherapy programs in intensive care units (ICUs) are required in order to enhance patients' functional capacity, to restore respiratory and physical independency and to aid the patients' recovery.[4]

Bed rest is a common prescription for nearly all ICU patients.[5,6] However, complications of prolonged immobility such as pressure ulcers, deep vein thrombosis, joint contractures, muscle waste and pulmonary insufficiency may further affect the health status and lengthen ICU stays.[1,3] Early activity is suggested to be an important part of physiotherapy programs for critically ill patients to improve respiratory function, to reduce adverse effects of immobilization, to increase functional independency and level of consciousness.[7,8] Recent literature has focused on the feasibility and safety of early activity in ICUs.[8-13]

It is clinically relevant that early mobilization should not cause hemodynamic and/or respiratory instability as critically ill patients may have marked limitations in their cardiovascular and/or respiratory reserve.[7,9] However, the evidence related to the field is limited in the literature although physiotherapy interventions are common in practice in ICUs. Therefore; our study was designed to retrospectively investigate the effects of early mobilization on hemodynamic and respiratory parameters in ICU patients.

METHODS

This retrospective study was conducted in general ICU of a university hospital to which one physiotherapist dedicated routinely. The study was approved by the institutional Ethics and Human Research Committee (protocol number:192).

Inclusion criteria for participation in mobilization sessions included hemodynamic stability, Glasgow Coma Scale >13, core temperature <38°C, absence of orthopedic problems limiting mobilization, anemia, severe metabolic problem, and agitation. Patients with ongoing vasopressors, renal replacement therapy and intravenous sedation were not implemented mobilization as a part of their daily routine physiotherapy sessions.

Mobilization Procedure

At the 1st mobility task, the patient had been seated in the bed at 45° head up position. At the 2nd task, the patient had been seated on the edge of the bed with support. In order to prepare the patient to mobilization, the surgical area was bandaged in case of any post-surgical condition, drains, urine and nasogastric catheters were fixed to the body of the patient with a plaster, oxygen tube and catheters were lengthened. After the preparation to ambulation, the patient was moved to standing position with the aid of the physiotherapist. At the 3rd task, the patient was moved to a supported chair near the bed. Sitting time out of bed was determined according to patient's tolerance. Figure 1 shows the gradual mobilization program implemented in ICU. Hemodynamic and respiratory parameters were recorded before and during the interventions. Progression to next step depended on not having any following signs of intolerance: ≥20 mmHg increase or decrease in systolic and diastolic arterial pressure, ≥20 beats per minute increase or decrease in heart rate (HR), peripheral oxygen saturation (SpO_2) <90%, shortness of breath, severe chest pain, dizziness, excessive fatigue, perspiration, and faintness.

Patients

We retrospectively investigated the data of 39 patients who met the inclusion criterion. Twenty-eight of the patients had undergone a major surgery (71.8%) while 11 of them (28.2%) were followed in the ICU due to different medical diagnoses. Fourteen patients had undergone upper abdominal surgery 6 of which had liver transplantation whereas 7 patients had undergone lower abdominal surgery. Two patients had both upper and lower abdominal surgery. Four patients had operations due to different orthopedic conditions. One patient had a eusophagectomy surgery. Medical diagnoses that led to ICU admission were serebral infarctus, pneumonia, respiratory insufficiency, gastrointestinal hemorrhage, and cardiac arrest.

Twenty-one of 39 patients had no comorbidites accompanying their primary medical diagnoses while 8 had hypertension, 2 had chronic obstructive pulmonary disease, 4 had Type 2 Diabetes Mellitus, 5 had cardiac disease and 2 had neurological disease. Twenty-seven of our patients were not intubated and were able to maintain spontaneous ventilation during the mobilization procedures while 11 of them had a T-tube and were also able to maintain spontaneous ventilation. Only 1 patient was intubated on an assistive ventilation mode.

Many of the patients included in the study had limited cardiac reserve at rest, as indicated by pre-mobilization HR being more than 50 per cent of the age predicted maximum on 56 of the 67 occasions (83.5%) of mobilization. Marginal respiratory reserve at rest was also evident for some patients, in that pre-mobilization PaO_2/FiO_2 ratio was less than 300 on 43 of 67 occasions (64.1%) in patients with available arterial blood gas analyses. Twelve of 14 patients had limited cardiac reserve with 100-200 PaO_2/FiO_2 whereas 23 of 29 patients had limited cardiac reserve with 201-300 PaO_2/FiO_2.

Data Collection

Data were collected retrospectively from the routine physiotherapy records of the patients who were enrolled in one or more mobilization sessions during their ICU stay. The HR, systolic and diastolic and mean arterial pressures (MAP) as hemodynamic parameters, respiratory rate (RR) and SpO_2 as respiratory parameters were recorded from intensive care patient tracing monitor (Draeger Medical Systems Inc, USA) before (pre-mobilization), immediately after (post-mobilization) and five minutes after (recovery) mobility tasks. Additionally, rate pressure product (RPP) was calculated by multiplying systolic arterial pressure and HR.

Statistical analysis:

The Statistical Package for the Social Sciences (SPSS, Version 11.0, Chicago, Ill, USA) was used for data entry and statistical analyses. An alpha level of 0.05 was chosen as the level of statistical significance for all analyses. Descriptive statistics (mean, standard deviation, frequency and percentage) were used to summarize demographic data. Repeated measures of ANOVA followed by post-hoc Bonferroni t tests were used to determine the differences between pre-mobilization, post-mobilization and recovery measurements. In the second section of the analysis patients were grouped according to their cardiac and respiratory reserve and to their gender, and then compared with Kruskal Wallis and Mann-Whitney U test.

RESULTS

A total of 39 patients were enrolled in the study during the period. These patients received totally 67 sessions of mobilization as a part of their physiotherapy treatment. Table 2 shows the descriptive information and baseline data for 39 patients enrolled in the study.

In total, 64 of the 67 mobilization sessions (95.5%) were performed with patients who had marginal cardiac and/or respiratory reserve at rest (i.e., pre-mobilization HR more than 50% age predicted maximum and/or PaO_2/FiO_2 less than 300) (Table 1).

Figure 1. Mobility tasks.

Step 1	Sitting upright in bed 45º head up position **(1st mobility task)**
	↓
Step 2	Sitting over the edge of bed **(2nd mobility task)**
	↓
Step 3	Standing near the bed
	↓
Step 4	Sitting out of bed **(3rd mobility task)**

Table 1. Baseline data for patients.

	Mean±SD
Age (years)	56.6±18.0
Body weight (kg)	68.8±12.9
Length of ICU stay (days)	30.6±41.4
Pre-mobilization PaO_2/FiO_2	291.1±111.7
Pre-mobilization HR (bpm)	97.9±16.9
	n (%)
Gender	
Male	22 (56.4)
Female	17 (43.6)
Primary diagnosis	
Medical	11 (28.2)
Surgical	28 (71.8)
Surgical type	
Upper abdominal	14 (35.8)
Lower abdominal	7 (17.9)
Upper and lower abdominal	2 (5.1)
Comorbidities	
None	21 (53.8)
Hypertension	8 (20.5)
COPD	2 (5.1)
Diabetes mellitus	4 (10.2)
Cardiac disease	5 (12.8)
Neurological disease	2 (5.1)
Intubation and ventilation status	
Not intubated, spont. vent.	27 (69.2)
Tracheostomy, spont. vent.	11 (28.2)
Tracheostomy, assisted vent.	1 (2.6)
Pre-mobilization PaO_2/FiO_2	
100-200	14 (21.8)
201-300	29 (43.2)
>300	24 (35.8)
Pre-mobilization HR	
<50% age predicted max.	11 (16.4)
50–70% age predicted max.	41 (61.2)
>70% age predicted max.	15 (22.4)

ICU: Intensive care unit, HR: heart rate. spont.: spontaneously. vent.: ventilating. COPD: Chronic obstructive pulmonary disease.

The 67 mobilization sessions implemented to 39 patients involved:

- Sitting on the edge of the bed in 57 occasions.
- Sitting outside of the bed on a chair in 10 occasions.

Data were recorded through three levels. First measurements were recorded when the patient was lying supine before starting the mobilization stages. Second measurements were recorded just after the mobility tasks as sitting on the edge of bed or sitting outside the bed. The last measurements included the values of 5 minutes after the task when the patient was taken to pre-mobilization lying position.

When the pre-mobilization, post-mobilization and recovery measurements including all the mobilization occasions were compared no significant difference was found in terms of all hemodynamic and respiratory parameters ($p>0.05$) (Table 2). However, significant differences were detected in terms of RR and RPP recorded after all three levels and post- mobilization MAP when the patients were grouped according to their pre-treatment cardiac reserve (Table 3).

The patients were also grouped according to their respiratory reserve and a significant difference was found only in terms of pre-mobilization RR ($p<0.05$). This difference existed between two subgroups of patients with marginal respiratory reserve ($PaO_2/FiO_2<300$).

Besides, the patients were compared according to their gender. There was a significant difference in pre-mobilization RR ($p<0.05$). No significant difference was found in terms of the responses to the mobilization sessions between male and female patients.

DISCUSSION

In our study, in which we investigated the effects of early mobilization in critically ill patients we found no significant difference in any of the parameters recorded for three times during the mobilization process. However, significant differences were detected in terms of RR recorded

Table 2. Comparisons of pre-mobilization, post-mobilization and recovery measurements.

	Pre-mobilization	Post-mobilization	Recovery	p
HR (beats/minute)	97.9±16.9	101.8±17.8	97.1±17.5	0.671
SAP (mmHg)	129.3±16.8	129.4±19.1	128.5±18.1	0.089
DAP (mmHg)	68.4±12.1	67.9±13.6	67.4±12.3	0.977
MAP (mmHg)	90.7±14.5	89.0±16.0	89.0±16.0	0.458
RPP	12676.3±2780.1	13165.3±2949.4	12535.2±3054.1	0.900
RR (breaths/minute)	26.3±5.8	28.3±6.8	26.1±6.8	0.209
SpO_2 (%)	97.7±2.4	97.3±5.5	97.9±2.2	0.657

HR: heart rate, SAP: systolic arterial pressure, DAP: diastolic arterial pressure, MAP: mean arterial pressure, RPP: rate pressure product, RR: respiratory rate, SpO_2: peripheral oxygen saturation.

Table 3. Comparisons of patients according to cardiac reserve.

	Group 1 <50%	Group 2 50%-70%	Group 3 >70%	1-2 p	1-3 p	2-3 p
Pre-mob. RR	22.5±3.8	26.5±5.5	29.0±6.8	0.030*	0.015*	0.249
Post-mob. MAP	96.5±13.2	90.0±17.3	81.0±11.1	0.164	0.003*	0.067
Pre-mob. RPP	10755.5±2230.3	12353.0±2360.7	14969.0±2850.3	0.030*	0.001*	0.002*
Post-mob. RR	21.8±5.7	28.2±5.8	32.8±7.4	0.030*	0.006*	0.032*
Post-mob. RPP	10725.8±2023.4	12889.2±2755.6	13735.3±2377.7	0.020*	0.008*	0.385
Recovery RR	20.0±5.2	25.4±5.8	30.9±7.6	0.045*	0.006*	0.009*
Recovery RPP	9966.7±1380.4	11932.5±2904.7	13817.6±2153.3	0.032*	<0.001	0.023*

* p<0.05. RR: respiratory rate, MAP: mean arterial pressure, RPP: rate pressure product, mob.: Mobilization.

before, after and five minutes after mobilization and post-mobilization MAP between the patients with different cardiac reserves.

Safety and feasibility of early activity are the latest focus of the literature related to physiotherapeutic interventions in ICUs.[7-12] Recent literature has been include different patient populations. However, no standardized mobilization program has been established yet. Moreover, the criterion to enroll the patients to a mobilization program has not been clearly defined. Researchers mostly focus on vital parameters and hemodynamic stability both before and during mobilization sessions. [8-11]

Bourdin et al[10] investigated the feasibility of early physical activity in ICU patients via measuring physiological parameters before and after each intervention including chair-sitting, tilting-up, and walking. The authors followed HR, RR, MAP and SpO_2 similar to our follow-up parameters and reported significant increases in HR and RR after tilting-up indicating the patient effort with this activity whereas the parameters reduced after chair-sitting which might be the result of improved oxygenation. Although the authors did not mention the recovery effect, the decrease in these parameters might be dependent on the time of chair-sitting which was 90-240 minutes in their study.

Senduran et al[11] investigated the hemodynamic effects of physiotherapy program including gradual mobilization in ICU in liver transplant recipients and revealed significant increases in HR after all mobilization tasks.

However, after a five-minute recovery HR returned to pre-treatment values indicating the safety of mobilization in this patient group during the early post-operative period in ICU.

In a similar study including sitting on the edge of bed, standing, walking to chair and sitting in the chair in critically ill obese patients, mobilization resulted in significant increases in RR and PaO_2/FiO_2 ratio. Similar to our findings, the authors reported no significant change in hemodynamic and respiratory parameters after a-5-minute period compared to initial values.[13]

Zafiropoulos et al[14] implemented a similar mobilization protocol to the patients undergone upper abdominal surgery who were closely similar to our patient population, and indicated significant increases in HR and MAP after sitting and standing compared to supine position. Sitting on the edge of the bed caused a significant increase in systolic, diastolic and MBP. HR and MBP decreased significantly to baseline values when the subjects sat out of bed for 20 minutes.[14] Parallel to the results we also detected a non-significant increase in HR after mobilization. Unfortunately, we could not compare our results for standing as none of our patients were able to walk. Having a major surgery under general anesthesia and the abdominal incisions causing post-operative pain exacerbated by activity might limit the ambulation of our patient population as 71.8% of them had upper and lower abdominal surgery. The study of Senduran et al supports the idea of pain increase accompanying to standing and walking in ICU after upper abdominal surgery.[11]

Early mobilization was suggested to be started as soon as the physiologic stability was achieved.[6] Physiologic stability has been defined as the whole state of neurologic, respiratory and cardiovascular stability in many different studies.[15,16] In most studies investigating the safety and feasibility of early activity in ICU hemodynamic and respiratory parameters are followed in order to observe the physiological changes. We measured the similar parameters before and after the mobility tasks and found no significant difference in any of the measurement levels.

We also grouped the patients according to their resting cardiac reserve which was suggested to be an important criterion and compared their hemodynamic and respiratory responses to the mobility tasks.[7,17] Most of our patients had limited cardiac reserve as indicated by pre-mobilization HR being more than 50 per cent of the age predicted maximum on 56 of the 67 mobilization sessions. Although our interventions were safe for our entire patient group including those, significant differences were found in terms of RR recorded after all three levels and post-mobilization MAP between the patients grouped according to their resting HR. The RR response increased significantly parallel to the decrease in cardiac reserve. We assumed that the patients responded to the effort of physical activity by increasing their RR as their cardiac capacity failed to compensate for this effort. Not interestingly, post-mobilization MAP was lower as the cardiac reserve got worse. This failure in increasing the blood pressure indicated the inability of the patient's cardiovascular system to meet the increased demands due to the mobility tasks. We also detected a trend of increase in RPP after all tasks as the cardiac reserve got worse. Although RPP is an important indicator of myocardial oxygen uptake and coronary blood flow monitoring of this parameter has not been established yet for critically ill patients. As no significant difference was found in terms of systolic arterial pressure between the patients with different cardiac reserves, the increase in RPP occurred due to HR response.

In a study of Fowler et al[18] sex and age-related differences were found in the outcomes of critical illness. When we compared the mobilization responses between male and female patients we did not find any significant differences. The only difference was found in pre-mobilization RR.

The retrospective design of the current study was one of the most important limitations leading to the absence of some vital data such as the day of the sessions implemented in ICU and the pre-mobilization laboratory findings as levels of hemoglobin, blood glucose, and platelet. The sample size was also small in order to generalize the results for a standardized mobilization algorithm that can be used in ICUs. There was no patient who was able to walk outside the bed in our study; therefore it was impossible to discuss the results of ambulation.

The results of this current study supported the other relevant articles that revealed the safety and feasibility of early mobilization in ICUs. Hemodynamic and respiratory responses should be followed during the mobilization sessions in order to evaluate the tolerance of the critically ill patients to the intervention. Our findings can support the further studies which will be designed to plan standardized mobilization algorithms in ICUs.

REFERENCES

1. Thomas DC, Kreizman IJ, Melchiorre P, et al. Rehabilitation of the patient with chronic critical illness. Crit Care Clin. 2002;18:695-715.
2. Gosselink R, Bott J, Johnson M, et al. Physiotherapy for adult with critical illness: recommendations of the European Respiratory Society and European Society of intensive care Medicine Task Force on physiotherapy for critically ill patients. Intensive Care Med. 2008;34:1188-1199.
3. Timmermann RA. A mobility protocol for critically ill adults. Dimens Crit Care Nurs. 2007;26:175-179.
4. Clini E, Ambrosino N. Early physiotherapy in the respiratory intensive care unit. Respir Med. 2005;99:1096-1104.
5. Winkelman C, Higgins PA, Chen YJ. Activity in the chronically critically ill. Dimens Crit Care Nurs. 2005;24:281-290.
6. Truong AD, Fan E, Brower RG, et al. Bench-to-bedside review: mobilizing patients in the intensive care unit-from pathophysiology to clinical trials. Crit Care. 2009;13:216-223.
7. Stiller K. Safety issues that should be considered when mobilizing critically ill patients. Crit Care Clin. 2007;23:35-53.
8. Stiller K, Philips AC, Lambert P. The safety of mobilisation and its effect on haemodynamic and respiratory status of intensive care patients. Physiother Theory Pract. 2004;20:175-185.
9. Zeppos L, Patman S, Berney S, et al. Physiotherapy intervention in intensive care unit is safe: an observational study. Aust J Physiother. 2007;53:279-283.
10. Bourdin G, Barbier J, Burle JF, et al. The feasibility of early physical activity in intensive care unit patients: A prospective observational one–center study. Respir Care. 2010;55:400-407.
11. Senduran M, Yurdalan SU, Karadibak D, et al. Haemodynamic effects of physiotherapy programme in intensive care unit after liver transplantation. Disabil Rehabil. 2010;32:1461–1466.
12. Kress JP. Clinical trials of early mobilization of critically ill patients. Crit Care Med. 2009;37:S442-447.
13. Genc A, Ozyurek S, Koca U, et al. Respiratory and hemodynamic responses to mobilization of the critically ill obese patients. Intensive Care Med. 2010;36:390.
14. Zafiropoulos B, Alison JA, McCarren B. Physiological responses to the early mobilisation of the intubated, ventilated abdominal surgery patients. Aust J Physiother. 2004;50:95–100.
15. Bailey P, Thomsen GE, Spuhler VJ. Early activity is feasible and safe in respiratory failure patients. Crit Care Med. 2007;35:139-145.
16. Morris PE, Goad A, Thompson C, et al. Early intensive care unit mobility therapy in the treatment of acute respiratory failure. Crit Care Med. 2008;36:2238-2243.
17. Genc A, Ozyurek S, Koca U, et al. Cardiac reserve is a determinant of the responses to early mobilization in critically ill patients. Intensive Care Med. 2010;36:390.
18. Fowler RA, Sabur N, Li P, et al. Sex- and age-based differences in the delivery and outcomes of critical care. CMAJ. 2007;177:1513-1519.