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Early mobilization is associated with decreased mechanical ventilation and ICU length of stay following cardiac surgery

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RESEARCH ARTICLE

EARLY MOBILIZATION IS ASSOCIATED WITH DECREASED MECHANICAL VENTILATION AND ICU LENGTH OF STAY FOLLOWING CARDIAC SURGERY

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Abstract

Background: Early mobilization of the Intensive Care Unit (ICU) patients improves muscle strength and functional capacity. It has been demonstrated that prevents Intensive Care Unit Acquired Weakness (ICUAW) and accelerates ICU discharge. However, data on mobilization early after cardiac surgery are inadequate. This study aimed to record early mobilization and investigates the association with ICU findings in cardiac surgery patients.

Material and Methods: In this observational study, 165 patients after cardiac surgery were enrolled. Of these, 159 were assessed for early mobilization and mobilization status during ICU stay. Mobilization practices were recorded from 1st post ICU admission and every 48 h until 7th day. The duration of mechanical ventilation (MV) support, ICU length of stay and clinical outcome were recorded from medical records registration.

Results: Early mobilization consisted of active and passive limb mobilization, sitting in bed and transferring from bed to chair. The proportion of patients mobilized, was 18% ($n = 29/159$) on day 1, 53% ($n = 46/87$) on day 3, 54% ($n = 22/41$) on day 5 and 62% ($n = 15/24$) on day 7. ICU length of stay was reduced for mobilized patients ($n = 29$) on day 1 compared to non-mobilized ones (24 ± 10 vs 47 ± 73 h respectively, $P = 0.001$). The duration of MV was shorter in mobilized patients on day 3 ($n = 46$) compared to bedridden, (18 ± 9 vs 23 ± 30 h respectively, $P = 0.01$).

Conclusions: Early mobilization after cardiac surgery was found to be low with a significant trend to increase over ICU stay. It is also associated with a reduced duration of MV and ICU length of stay.

Keywords: Early mobilization, cardiac surgery, intensive care unit, Intensive Care Unit Acquired Weakness, physiotherapy.

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INTRODUCTION

Patients during ICU stay, often experience muscle wasting and remain ventilated for a prolonged time due to sedation and immobilization.¹ Especially for those undergoing cardiac surgery has been reported major morbidity,² high incidence of ICUAW,³ physical dysfunction and in-hospital and 1-year mortality.^{4,5} Postoperative muscle weakness causes a variety of disorders including long term disability and low quality of life after hospital discharge.⁶

Early mobilization of ICU patients has been proposed to prevent postoperative complications. It is beneficial for reducing ventilation time, improving peripheral and respiratory muscle strength as well as functional capacity.^{7,8} It is also associated with low ICUAW incidence and acceleration of ICU and hospital discharge.^{9,10,11} For safety concerns, it has been reported that is safe with an overall cumulative incidence of potential safety events of 2.6% and rare (0.6%) medical consequences.¹²

Although there is a growing number of studies about physiotherapy intervention to ICU patients^{13,14,7} and in particular after cardiac surgery,^{15,16,17} the rates of early mobilization are controversial. There is a variety of physiotherapeutic techniques and time for launching early mobilization.¹⁵ Furthermore, data on physiotherapy practice for cardiac surgery ICU patients in Greece are missing.

Our hypothesis in the present study is that early mobilization is implemented in cardiac surgery patients and is associated with reduced duration of mechanical ventilation support and ICU length of stay.

This study aims to describe physiotherapy intervention practices in form of early mobilization of patients undergoing cardiac surgery and investigate its association with duration of mechanical ventilation support and ICU length of stay.

METHODOLOGY

Study design

This observational study was conducted at the Cardiac Surgery ICU of Onassis Cardiac Surgery Center. All patients included in

the study were recruited from February to May 2018. The research had the approval of the Ethics Committee of the Onassis Cardiac Surgery Center (No. 607/17.11.17) with obtained patients' informed consent and carried out under the ethical standards set by the Declaration of Helsinki.

Patients over 18 years old following their admission in the Cardiac Surgery ICU within 24 h of cardiac surgery and receiving mechanical ventilation, included consecutively in the study. Patients with severe obesity [body mass index (BMI) > 35kg/m²], open sternum, lobectomy, supported by Central Extracorporeal Membrane Oxygenation, with extensive peripheral thigh oedema and preexisting neuromuscular disease, were excluded from the study. Moreover, patients who were re-admitted to the ICU were also excluded from the study.

Data collection

The study was a prospective observational single-centre study conducted in the Cardiac Surgery ICU at Onassis Cardiac Surgery Center. Physiotherapy intervention was recorded on the 1st, 3rd, 5th and 7th day of ICU admission and every 48 h until ICU discharge. Demographic data and baseline clinical characteristics of all participants according to mobilization status on the 1st-day post ICU admission were collected and are presented in Table 1. The duration of MV, ICU stay and the ICU outcome of enrolled patients were also recorded.

Early mobilization activities were defined as active and passive limb mobilization, sitting in bed and transferring from bed to chair. The physiotherapy team in collaboration with the medical team conducted physiotherapy sessions according to the patients' clinical status. Data for each physiotherapy session were collected by the research team according to the documentation of the physiotherapist for each patient.

Statistical analysis

Baseline data were presented with descriptive statistics analysis. All data were assessed for normality with the Kolmogorov-Smirnov test. Normally distributed continuous variables were reported as mean ± SD and non-normally distributed variables were expressed as median with interquartile range. Categorical variables were reported as absolute numbers and as proportions

with percentages and compared with the chi-square test. Mann Whitney test was used for continuous variables between patient groups with non-normal distribution and t-test for those with a normal distribution. The level of significance was set at a P value less than 0.05. SPSS Statistics version 25 software was used for data analysis.

RESULTS

Clinical characteristics

In this prospective observational study, a total of 165 patients (107 men and 58 women), median age 71 (64-77) years, were eligible to participate. Six were excluded from the study; four patients due to high BMI ($> 35 \text{ kg/m}^2$) and two patients due to open chest-sternotomy or lobectomy. Finally, 159 patients included in the study. Baseline clinical characteristics of the 159 patients are summarized in Table 1.

Most patients underwent Coronary Artery Bypass Grafting (CABG) 80 (51%) and/or heart valve replacement surgery 79 (49%). The duration of ICU stay was 42 (24-87) h, of sedation until awakening was 11 (9-15) h and MV was 15 (12-21) h. Descriptive peri-operative clinical characteristics of the study population according to mobilization status within 24 hours post ICU admission are presented in Table 2.

Mobilization status

Patients received physiotherapy sessions according to their clinical status. Early mobilization included techniques such as active and passive limb mobilization, sitting in bed and transferring from bed to chair. Within 24 h post ICU admission, 18% ($n = 29/159$) of patients had been mobilized. On day 3 mobilization rate increased to 53% ($n = 46/87$) following 54% ($n = 22/41$) on day 5 and 62% ($n = 15/24$) on day 7, (Figure 1).

In terms of ICU stay patients that were mobilized within 24 h post ICU admission, discharged from ICU earlier than non-mobilized (24 ± 10 vs 47 ± 73 hours respectively, $P = 0.001$), (Figure 2).

Patients who were mobilized on day 3 ($n = 46$) remained less time to MV compared to bedridden, (18 ± 9 vs 23 ± 30 hours respectively, $P = 0.01$), (Figure 3). Moreover, ICU mortality was

observed only to non-mobilized ($n = 41$) compared to mobilized patients ($n = 46$), (9.7% vs 0% respectively, $P = 0.051$).

However, there was no statistically significant difference in terms of mobilization on days 3 and 5 and ICU length of stay ($P = 0.32$ and $P = 0.36$ respectively). Patients who remained for 7 days in ICU and received physiotherapy intervention, required less time of MV than bedridden (30 ± 20 vs 453 ± 356 h respectively, $P = 0.012$), (Figure 4).

DISCUSSION

By this study, we have shown that early mobilization is implemented at a low rate in patients after cardiac surgery with an increasing mobilization rate during ICU stay. The results of this observational study have also demonstrated that early mobilization after cardiac surgery is associated with reduced duration of mechanical ventilation and decreased ICU length of stay.

The first physiotherapy sessions within 24 h post ICU admission occurred at a low rate. According to a previous study on physiotherapy practice in Greek ICUs although 50% of ICU physiotherapists are aware of the mobilization guidelines, only 19% practice musculoskeletal physiotherapy.¹³ Low mobilization rates are also mentioned in other studies in Australia and New Zealand⁷ and Australia and Scotland.¹⁴

Nevertheless, more patients were mobilized at 48 h post-admission and afterwards with the most commonly used techniques the active limb mobilization and transfer from bed to the chair which are consistent with other protocols.^{18,17} Mobilization seemed to be beneficial for improving the outcomes of mechanically ventilated patients as also reported by Ding et al.,¹⁹ indicating the initiation of mobilization within 48–72 h of mechanical ventilation. However, there is little evidence on certified protocols and on how best to implement physiotherapy intervention.^{20,11}

The duration of mechanical ventilation was found to be decreased in those cardiac surgery patients who were mobilized similarly to previously reported studies included patients undergoing coronary artery bypass graft surgery^[21] and critically ill patients.^{10,8} The length of ICU stay was also found to be shortened

for participants performing an early activity. Systematic reviews have shown that early mobilization of patients is associated with early discharge from the hospital in both cardiac surgery¹⁵ and critically ill patients.⁹ However, a previous randomized controlled trial concluded that the mode of exercise after coronary artery bypass graft surgery did not affect the postoperative length of hospital stay.²² In another recent study, we have shown that skeletal quadriceps muscle mass presented with a trend to a decrease in patients after cardiac surgery post-ICU admission and was associated with prolonged duration of MV and ICU length of stay.²³ Neuromuscular electrical stimulation (NMES) as an alternative form of exercise seems beneficial for preserving muscle mass and strength,^{24,25} local and systemic microcirculation^{26,27} in critically ill patients and also might reduce the duration of mechanical ventilation and ICU stay.^{25,28} NMES has the advantage that can be applied even in sedated patients, an action that might enhance early mobilization, particularly in critically ill patients. Further studies are required to demonstrate their value in cardiac surgery patients.

Strengths and limitations

This observational study is one of the first prospective studies investigating mobilization interventions early after cardiac surgery and consists of the first study from a cardiac surgery ICU in Greece. However, the present study has several limitations. The sample size was estimated based mainly on feasibility for a pre-defined certain period. The number of patients eligible to enrol on the study was large; however, the sample size for the observed effect size was small because most participants exited ICU shortly post-admission. Mobilization activities were recorded according to the documented patient's physiotherapeutic session which limited real-time observation of physiotherapy practice. Moreover, sedation, hemodynamic instability and patient safety concerns were constraining early mobilization. The study although its prospective and observational design was not randomized, not designed to determine the effects of early mobilization in cardiac surgery patients.

More studies are needed to record ICU physical therapy practice focusing on early mobilization techniques across different ICUs

and countries to collect data information with regards to the barriers and perceptions of medical and allied professional team members. The creation of specific protocols and guidelines at a local, national and international level would help optimizing healthcare service for cardiac surgery ICU patients improving quality of care.

CONCLUSIONS

In conclusion, early mobilization is implemented at a low rate in patients post-cardiac surgery, while an increased mobilization rate was observed during ICU stay. Early mobilization is associated with the duration of mechanical ventilation support and ICU length of stay.

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ANNEX

TABLE 1: Baseline characteristics of patients enrolled in the study in all patients and according to mobilization status assessed within 24 hours of ICU admission

| Baseline data | <i>All (n=159)</i> | <i>Mobilized (n=29)</i> | <i>Bedridden(n=130)</i> | P-value |
|---------------------------------|--------------------|-------------------------|-------------------------|---------|
| Gender (males) | 103 (65) | 18 (62) | 85 (65) | 0.735 |
| Age (years) | 71 (64-77) | 69 ± 8 | 71 (64-78) | 0.977 |
| Weight (kg) | 77.2 ± 11.69 | 76 ± 11 | 77 ± 12 | 0.702 |
| Height (m) | 1.67 ± 0.091 | 1.65 ± 0.1 | 1.67 ± 0.1 | 0.203 |
| BMI (kg/m ²) | 27.58 ± 3.7 | 27.9 ± 3.6 | 27.5 ± 3. | 0.556 |
| Clinical characteristics | | | | |
| Hypertension | 123 (77) | 22 (76) | 101 (78) | 0.831 |
| Diabetes | 55 (35) | 8 (27) | 47 (36) | 0.380 |
| Dyslipidemia | 95 (60) | 17 (59) | 78 (60) | 0.891 |
| Smoker | 33(21) | 4 (14) | 29 (22) | 0.44 |
| Former smoker | 38 (24) | 6 (20) | 32 (25) | 0.44 |
| Coronary artery disease | 84 (53) | 15 (52) | 69 (53) | 0.895 |
| Chronic Heart Failure | 10 (6) | 2 (7) | 8 (6) | 0.882 |
| COPD | 21 (13) | 4 (14) | 17 (13) | 0.918 |
| Chronic Kidney Failure | 13 (8) | 0 (0) | 13 (10) | 0.076 |
| Thoracic Aortic Aneurysm | 11 (7) | 3 (10) | 8 (6) | 0.421 |
| Valve disease | 99 (62) | 17 (59) | 82 (63) | 0.654 |
| Other diseases | 63(40) | 8 (27) | 55 (42) | 0.16 |
| Apache II Score | 10 (8-12) | 9 ± 2 | 10 (8-12) | 0.277 |
| Sofa Score | 5 (3-6) | 4 ± 2 | 5 (3-6) | 0,127 |

Categorical variables are described as n (%) and continuous as mean ± SD or median (Q1 - Q3)

TABLE 2: Peri-operative study characteristics of patients enrolled in the study in all patients and according to mobilization status assessed within 24 hours of ICU admission

| Type of surgery | <i>All (n=159)</i> | <i>Mobilized (n=29)</i> | <i>Bedridden(n=130)</i> | P-value |
|--|--------------------|-------------------------|-------------------------|---------|
| Coronary Artery Bypass Grafting (CABG) | 80 (51) | 15 (52) | 66 (51) | 0.926 |
| Heart Valve Repair or Replacement Surgery | 79 (49) | 14 (48) | 64 (49) | 0.563 |
| Medication | | | | |
| Propofol (n %) | 105 (66) | 15 (52) | 90 (69) | 0.072 |
| Dobutamine (n %) | 100 (63) | 18 (62) | 82 (63) | 0.919 |
| Nor adrenaline (n %) | 38(24) | 7 (24) | 31 (24) | 0.973 |
| Morphine (n %) | 13 (8) | 2 (6) | 11 (8) | 0.781 |
| Adrenaline (n %) | 10 (6) | 0 (0) | 10 (8) | 0.123 |
| Other characteristics | | | | |
| Duration of extracorporeal circulation (minutes) | 103 (81-135) | 110 ± 56 | 104 (82-139) | 0.756 |
| Duration of aortic cross-clamp (minutes) | 75 (56-99) | 85 ± 48 | 80 ± 37 | 0.577 |
| Duration of mechanical ventilation (hours) | 15 (12-21) | 15 ± 4 | 15 (12-22) | 0.175 |
| Duration of sedation (hours) | 11 (9-15) | 10 (9-12) | 11 (9-16) | 0.09 |
| Duration of ICU stay (hours) | 42.5 (24-87) | 24 (22-32) | 47 (25-98) | 0.001 |

Categorical variables are described as n (%) and continuous as mean ± SD or median (Q1 - Q3)

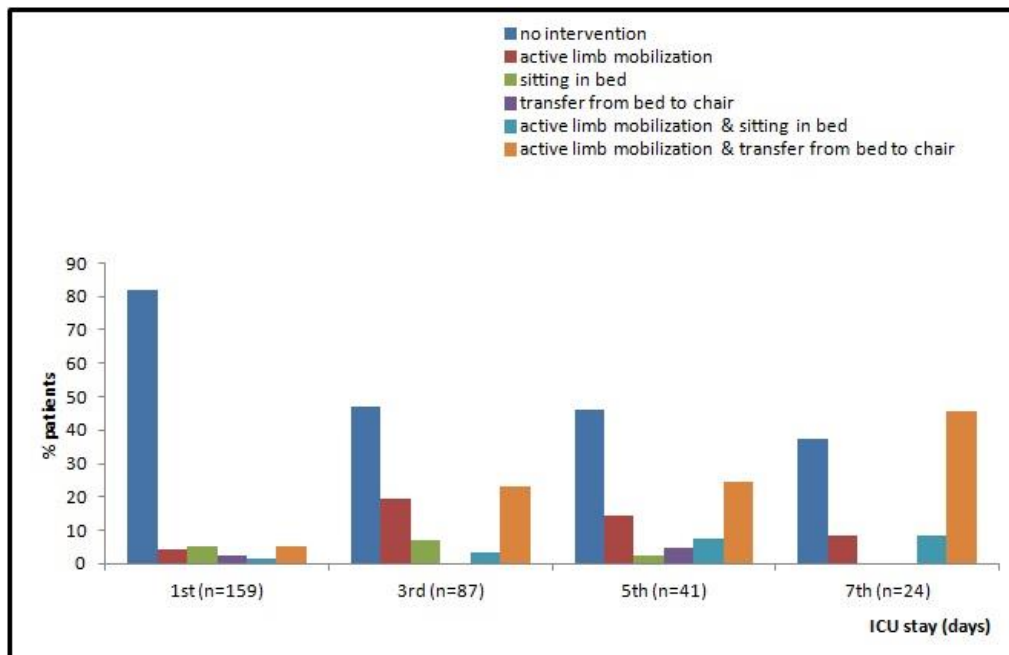
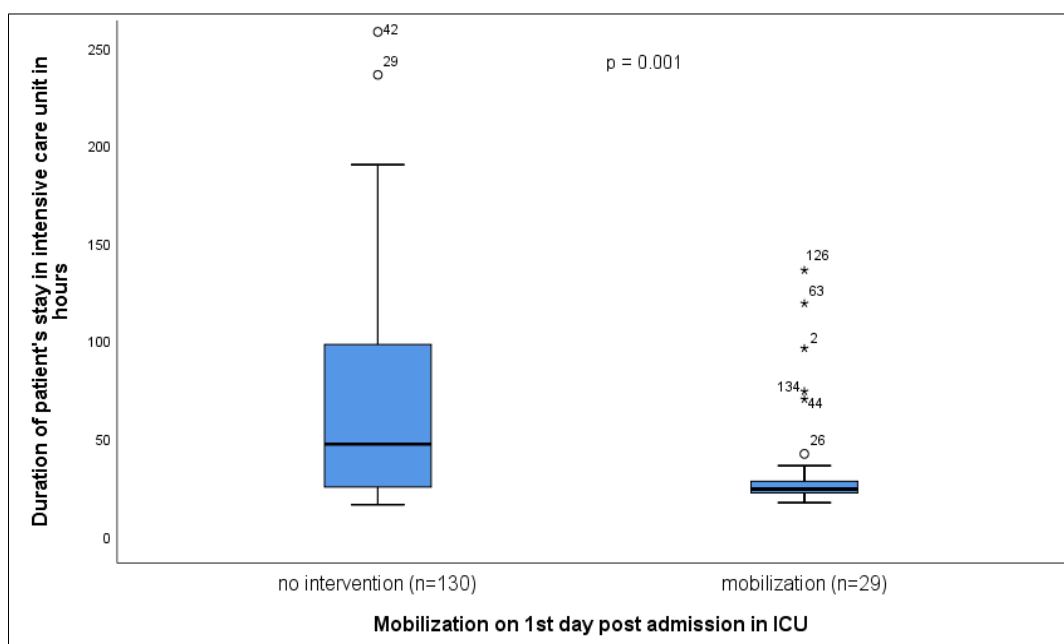
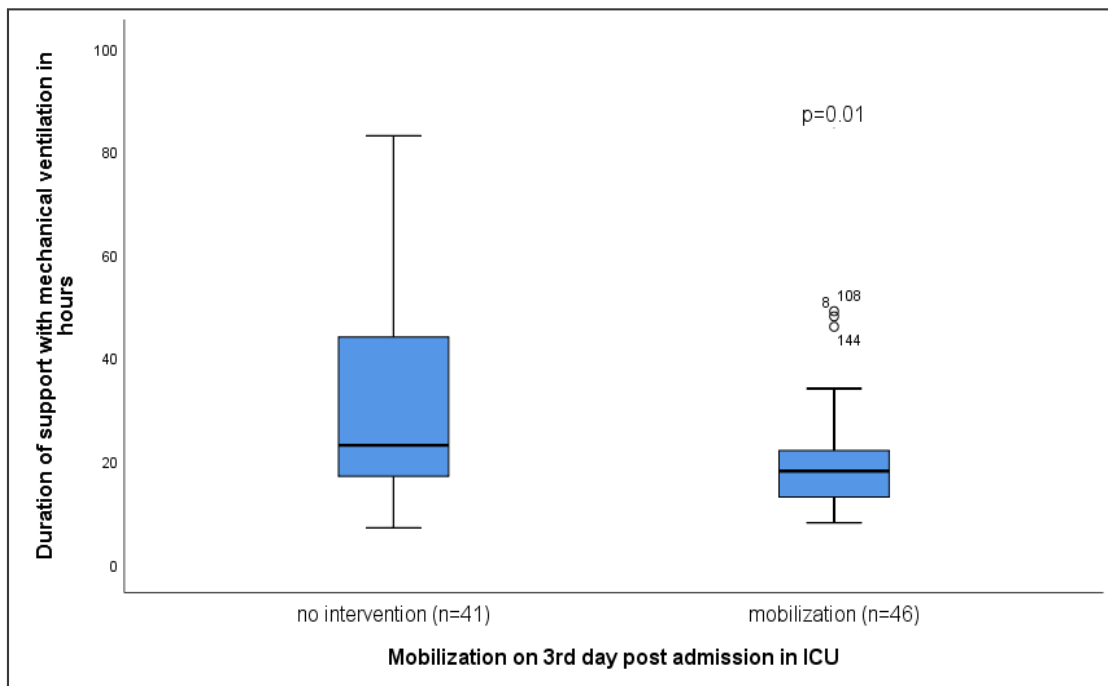
FIGURE 1. Physiotherapy mobilization of patients included in the study from 1st to 7th-day post ICU admission**FIGURE 2.** ICU length of stay in bedridden and mobilized patients (n=29) on day 1 post ICU admission

FIGURE 3. Duration of mechanical ventilation in bedridden and mobilized patients (n=87) on day 3 post ICU admission**FIGURE 4.** Duration of mechanical ventilation in bedridden and mobilized patients (n=24) remained 7 days in ICU