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The impact of progressive early mobilization on oxygen saturation and heart rate in STEMI patients in ICU: A randomized controlled trial

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ABSTRACT

INTRODUCTION: ST-segment Elevation Myocardial Infarction (STEMI) is a serious condition requiring immediate medical intervention. Although reperfusion therapy is effective, long-term complications such as impaired cardiac function remain a challenge. Progressive early mobilization offers a rehabilitation approach to accelerate recovery, but its implementation remains limited. This study aims to evaluate the effect of progressive early mobilization on oxygen saturation and heart rate in STEMI patients treated in the ICU.

METHODS: This study utilized a Randomized Controlled Trial (RCT) design with 68 STEMI patients divided into two groups: the intervention group receiving progressive early mobilization (n=34) and the control group receiving standard therapy (n=34). Data were collected over three days, with measurements of oxygen saturation and heart rate taken before and after the intervention.

RESULTS: The intervention group showed a significant increase in oxygen saturation (mean +1.3%; p<0.001) and a significant decrease in heart rate (mean -6 bpm; p<0.001) compared to the control group, which showed no significant changes. Repeated measures ANOVA indicated a significant difference between groups on the third day (p<0.001).

CONCLUSION: Progressive early mobilization significantly improves oxygen saturation and stabilizes heart rate in STEMI patients. This intervention could be a crucial component in cardiac rehabilitation programs to expedite recovery and prevent long-term complications.

Keywords: STEMI, early mobilization, oxygen saturation, heart rate, cardiac rehabilitation

INTRODUCTION

Acute myocardial infarction with ST-segment elevation (STEMI) is a serious condition requiring immediate medical intervention to reduce myocardial tissue damage and improve patient prognosis [1]. While reperfusion therapy such as Primary Percutaneous Coronary Intervention (PPCI) has proven effective in restoring blood flow to ischemic myocardial tissue, STEMI patients

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often experience long-term complications such as heart failure, arrhythmias, and decreased cardiac function, which can affect their quality of life and survival [2,3].

One intriguing approach in the management of STEMI patients is progressive early mobilization [4,5]. Progressive early mobilization is a rehabilitation strategy that combines physical exercise and gradual daily activities to accelerate patient recovery after a heart attack [6]. This practice has received strong support from various studies demonstrating its benefits in improving cardiopulmonary function, muscle strength, and quality of life in patients following acute events such as STEMI [7,8].

Despite promising evidence regarding the effectiveness of progressive early mobilization in improving clinical outcomes in STEMI patients, its implementation remains limited in many cardiac care units [9,10]. Several factors may influence the adoption of this practice, including insufficient understanding of its benefits, concerns about patient safety, and logistical challenges in implementing progressive early mobilization programs [11].

Several studies have consistently supported the practice of progressive early mobilization in STEMI patients [12]. Patients undergoing progressive early mobilization after PPCI have better cardiopulmonary fitness levels and shorter recovery times compared to those who experience excessive rest. Patients engaged in early and progressive cardiac rehabilitation programs have a lower risk of recurrent cardiovascular events [13,14].

Previous studies have demonstrated that progressive early mobilization provides benefits for STEMI patients, such as improved cardiopulmonary function and accelerated muscle recovery [10,15]. However, most research has focused on long-term outcomes, such as quality of life and risk of recurrence, without specifically evaluating its impact on certain physiological indicators, such as oxygen saturation and heart rate, in real-time during intensive care [16]. Existing studies tend to be observational or use non-randomized designs, which are limited in exploring how early mobilization may influence the stability of vital parameters, particularly in acute settings and ICU environments, where there are challenges to implementing early rehabilitation optimally [17].

Other observational studies have shown that progressive early mobilization can accelerate the recovery of muscle function and quality of life in STEMI patients, by reducing muscle weakness and improving independence in daily activities [18]. However, despite this evidence indicating clear benefits of progressive early mobilization, there is a need for further research to understand the underlying mechanisms of its effects on heart rate control in STEMI patients specifically.

Based on the background and identified needs, this study aims to evaluate the impact of progressive early mobilization on oxygen saturation and heart rate control in STEMI patients, focusing on the physiological changes occurring during the recovery process. Thus, it is hoped that the results of this study will significantly contribute to our understanding of STEMI patient management and strengthen the evidence base for the implementation of progressive early mobilization in clinical practice.

METHODS

Study Population

The population of this study consisted of STEMI patients who experienced chest pain, both men and women, who were undergoing treatment at the Regional General Hospital, Central Java, Indonesia. The inclusion criteria for this study are as follows; responsive STEMI patients, patients with good general condition, conscious, and stable vital signs allow for progressive level 1 early passive mobilization, patients aged between 26 and 65 years, not pregnant, and with a minimum length of stay of 3 days. The sample size for this research was 68 people. Data were taken from February to September 2024.

Study Design

This research is a quantitative study with a randomized control trial design, consisting of an intervention group (n=34) and a control group (n=34). Random Allocation Software (RAS) for the Windows operating system was used as a random number generator. The researchers created a unique sequence of random numbers between 0 and 1. All random numbers were the same for all participants, in both the intervention and control groups. Random numbers are assigned to participants, and each participant has a unique random number from the generated list.

Study Protocol

Before the therapy initiation, all patients underwent a selection process based on the criteria. Patients were initially measured to obtain vital sign data such as respiratory rate, body temperature, heart rate, and Mean Arterial Pressure (MAP), as well as pain scale assessment. Pain scale measurement is conducted using the Numeric Rating Scale (range from 1 to 10). Patient activity was also assessed using the Barthel index. The same procedure is applied to the control group.

The therapy was administered for three days for intervention group patients who receive progressive early mobilization. The intervention involves a 10-minute session accompanied by expert supervision. Meanwhile, the control group received standard medical therapy practiced at the hospital. Upon completion, patients' vital signs, including respiratory rate, body temperature, heart rate, MAP, and pain scale, were reassessed. Evaluation and monitoring are conducted over the course of three days.

Study Intervention

Our research method is based on a structured and systematic procedure to evaluate the effect of progressive early mobilization on STEMI patients in intervention group. Here's a description of the research procedure we conducted: (1) Patient Assessment: A medical history check of the patients was performed to determine cardiovascular and respiratory disorders before starting the intervention. This involves examining the patient's medical history to gather information about cardiovascular and respiratory conditions that may affect their response to mobilization, (2) Physiological Examination: The patients' physiological parameters, including body temperature, respiratory rate (RR), heart rate (HR), mean arterial pressure (MAP), systolic blood pressure, and oxygen saturation. These parameters provide an overview of the patient's clinical condition before and during the mobilization

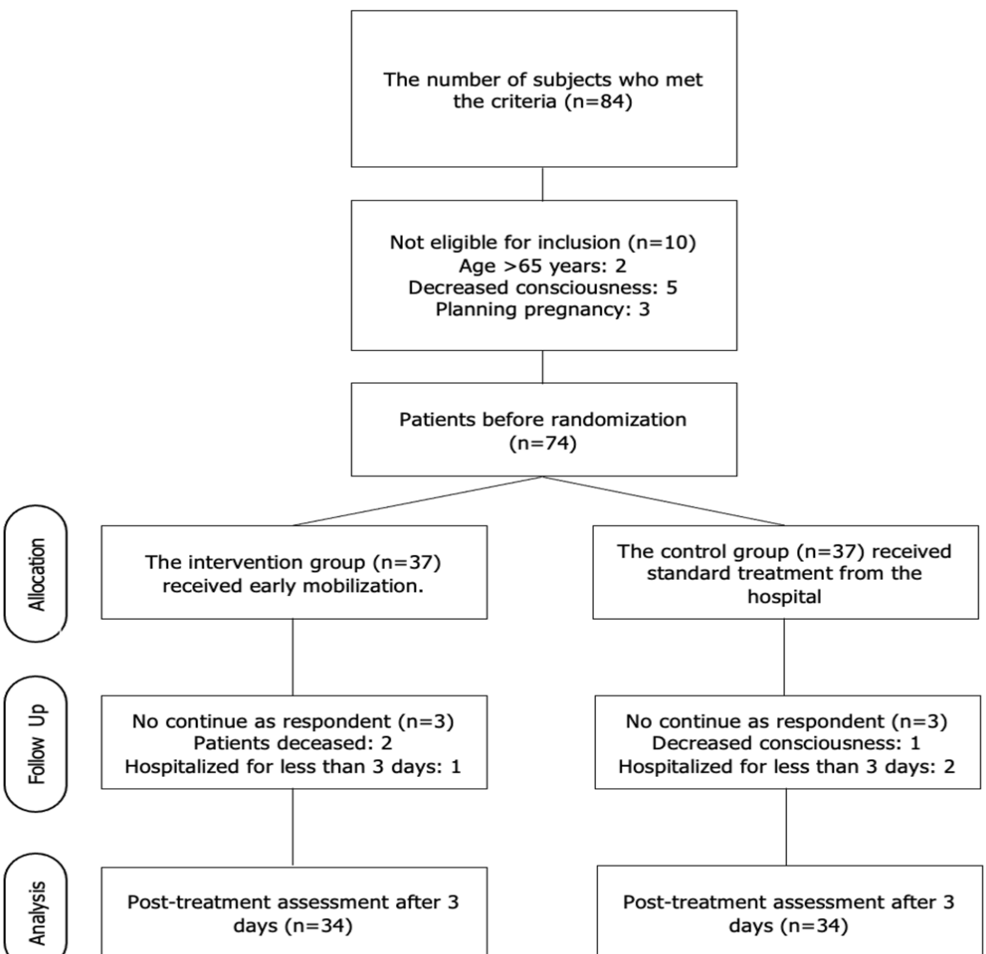

Figure 1: Flow diagram in this study

process, (3) Consciousness Assessment: The patient's level of consciousness was assessed using the Richmond Agitation-Sedation Scale (RASS) to ensure that the patient achieved an adequate level of consciousness before starting mobilization. Good consciousness levels allow patients to participate more effectively in the mobilization process, (4) Level I Mobilization: Mobilization begins by elevating the patient's position more than 30 degrees from the supine position and providing passive Range of Motion (ROM) exercises twice a day. This aims to initiate physical stimulation in patients and reduce the risk of complications associated with prolonged bed rest, and (5) Progressive Mobilization with CLRT: Progressive mobilization continues using Continuous Lateral Rotation Therapy (CLRT), where exercises are performed every two hours. Patients are placed in right and left lateral positions alternately according to their ability. The goal is to improve mobility and increase blood flow to ischemic tissues, as well as reduce the risk of blood clot formation. In the control group, patients received standard management or basic therapy according to the hospital's guidelines.

Statistical analysis

The collected data were entered, sorted, and cleaned using Microsoft Excel (Windows 10), and then transferred to IBM SPSS Statistics for Windows, version 26.0 IBM Corp for analysis. Measures of central tendency and frequency distribution were reported using means and percentages. Paired t-tests were conducted to analyse the changes before and after the study within both the intervention and control groups. An independent t-test was used to compare the results between the intervention and control groups. To determine the significant changes in the intervention group that received the treatment over three days, a repeated measures ANOVA test was conducted.

This study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki and adhered to relevant national and institutional guidelines for biomedical research involving human subjects. Prior to the commencement of the study, ethical approval was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Gombong under protocol number 006.5/II.3.AU/P/KEPK/I/2024. The committee reviewed the study design, ensuring that it met the criteria of beneficence, respect for autonomy, and justice. All participants provided written informed consent, and their privacy and confidentiality were strictly maintained throughout the research. The potential risks and benefits of early mobilization were clearly communicated to participants, and measures were taken to minimize discomfort or harm.

RESULTS

Table 1 shows that the intervention and control groups were broadly comparable across demographic and clinical characteristics. The mean ages were similar (44.2 vs. 45.3 years), with a slightly higher proportion of males in both groups. Most participants were married, and education levels were relatively balanced, though the control group had slightly more individuals with high school education. Employment patterns were comparable, with most participants employed or self-employed. Smoking prevalence was somewhat higher in the control group. Clinical parameters, including BMI, oxygen saturation, and heart rate, were nearly identical, indicating good baseline equivalence between groups for subsequent analysis.

In Table 2, paired t-test results demonstrate significant within-group improvements in the intervention arm. Oxygen saturation increased from 94.8 ± 2.5 to 96.1 ± 2.4 (mean difference: 1.3, $p < 0.001$), while heart rate decreased from 78.5 ± 10.2 to 72.5 ± 8.7 (mean difference: −6.0, $p < 0.001$). In contrast, the control group showed smaller, non-significant changes in oxygen saturation ($p = 0.067$) and heart rate ($p = 0.052$).

Table 3 further supports these findings through between-group comparisons. Post-intervention oxygen saturation was significantly higher in the intervention group compared to the control group (96.1 ± 2.4 vs. 95.8 ± 2.6; $p < 0.001$), while heart rate was significantly lower (72.5 ± 8.7 vs. 74.1 ± 9.2; $p < 0.001$). These differences indicate a measurable beneficial effect of the intervention relative to standard care.

Table 4, using repeated measures ANOVA, illustrates temporal trends over three days. The intervention group exhibited a consistent and statistically significant improvement in oxygen saturation and reduction in heart rate over time

Table 1. Baseline Demographic and Clinical Characteristics of Participants by Study Group

Variable	Intervention Group		Control Group	
	n (%)	Mean ± SD	n (%)	Mean ± SD
Age		44.2 ± 10.5		45.3 ± 9.8
Gender				
Male	20 (58.8)		18 (52.9)	
Female	14 (41.2)		16 (47.1)	
Marital Status				
Married	24 (70.6)		22 (64.7)	
Single	8 (23.5)		9 (26.5)	
Widowed	2 (5.9)		3 (8.8)	
Education Level				
Primary School	5 (14.7)		6 (17.6)	
Secondary School	10 (29.4)		8 (23.5)	
High School	12 (35.3)		14 (41.2)	
College/University	7 (20.6)		6 (17.6)	
Occupation				
Employed	18 (52.9)		16 (47.1)	
Self-employed	10 (29.4)		12 (35.3)	
Retired	4 (11.8)		4 (11.8)	
Unemployed	2 (5.9)		2 (5.9)	
Smoking History				
Current Smoker	12 (35.3)		14 (41.2)	
Former Smoker	6 (17.6)		7 (20.6)	
Non Smoker	16 (47.1)		13 (38.2)	
Body Mass Index		25.1 ± 3.1		25.3 ± 3.3
Oxygen Saturation		96.1 ± 2.4		95.8 ± 2.6
Heart Rate		72.5 ± 8.7		74.1 ± 9.2

($p < 0.001$ for both outcomes). Conversely, the control group showed modest changes that were not statistically significant (oxygen saturation $p = 0.072$; heart rate $p = 0.061$).

DISCUSSION

Research findings indicate that men are more likely to experience STEMI than women. This is influenced by various biological, behavioural, and lifestyle factors that are more commonly found in men [19]. The incidence of STEMI is higher in men than in women, especially in younger age groups [20,21]. One primary reason cited is that men tend to have more prominent cardiovascular risk factors, such as smoking, hypertension, and dyslipidaemia [22,23]. Additionally, men generally have higher levels of testosterone, which may contribute to the development of atherosclerosis plaque build up in the arterial walls that can lead to heart attacks. The prevalence of STEMI in men is approximately three times higher than in women [24]. Studies suggest that men are more susceptible to STEMI due to frequent exposure to lifestyle-related risk factors, such as diets high in saturated fats, lack of physical activity, and excessive alcohol consumption

Table 2: Within-Group Changes in Oxygen Saturation and Heart Rate Following Intervention: Paired t-Test Analysis

Variable	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference (95% CI)	p-value
Oxygen Saturation				
Intervention	94.8 ± 2.5	96.1 ± 2.4	1.3	<0.001
Control	94.9 ± 2.7	95.8 ± 2.6	0.9	0.067
Heart Rate				
Intervention	78.5 ± 10.2	72.5 ± 8.7	- 6.0	<0.001
Control	79.1 ± 9.6	74.1 ± 9.2	- 5.0	0.052

Table 3. Between-Group Comparison of Post-Intervention Oxygen Saturation and Heart Rate: Independent t-Test Results

Variable	Post-Intervention Mean ± SD	Mean Difference (95% CI)	p-value
Oxygen Saturation			
Intervention	96.1 ± 2.4	0.9	<0.001
Control	95.8 ± 2.6		
Heart Rate			
Intervention	72.5 ± 8.7	- 2.5	<0.001
Control	74.1 ± 9.2		

[25,26]. Furthermore, men often experience stress related to work or social life, which contributes to an increased incidence of heart disease.

Smoking is a major risk factor that significantly contributes to the occurrence of STEMI. Patients who smoke have a higher risk of experiencing STEMI compared to non-smokers, with smoking nearly doubling the risk [27,28]. This is due to the effects of smoking on the cardiovascular system, including damage to the endothelial lining of blood vessels, an increase in carbon monoxide levels in the blood, and activation of blood clotting processes that can trigger thrombus formation in the coronary arteries [29]. This thrombosis is the primary cause of coronary artery occlusion, leading to STEMI. Smokers are also more likely to experience STEMI

Table 4. Temporal Trends in Oxygen Saturation and Heart Rate Over Three Days: Repeated Measures ANOVA Analysis

Variable	Day 1 Mean ± SD	Day 2 Mean ± SD	Day 3 Mean ± SD	p-value
Oxygen Saturation				
Intervention	94.5 ± 2.5	95.5 ± 2.4	96.1 ± 2.4	<0.001
Control	94.6 ± 2.7	95.0 ± 2.6	95.8 ± 2.6	0.072
Heart Rate				
Intervention	78.8 ± 9.5	75.5 ± 9.1	72.5 ± 8.7	<0.001
Control	79.0 ± 9.8	77.0 ± 9.6	74.1 ± 9.2	0.061

at a younger age compared to non-smokers. Nicotine in cigarettes increases blood pressure and heart rate, while reducing blood oxygen levels, which worsens overall cardiovascular health [30]. Additionally, smoking is associated with elevated levels of LDL cholesterol and triglycerides, as well as decreased HDL cholesterol, accelerating the formation of atherosclerotic plaque in the arterial walls [31].

Patients with a BMI in the overweight category (BMI 25-29.9 kg/m²) have a higher risk of experiencing STEMI compared to those with a normal BMI. Excess weight can lead to increased blood pressure, dyslipidaemia, and insulin resistance, all of which contribute to the formation of atherosclerotic plaque in the coronary arteries, thereby increasing the risk of myocardial infarction [32,33]. Moreover, individuals in the overweight BMI category tend to have a poor metabolic profile, including higher LDL cholesterol levels, lower HDL cholesterol, and elevated triglycerides. This profile can accelerate the process of atherosclerosis, the build up of plaque in the arterial walls, which is the underlying mechanism for STEMI [34]. Overweight individuals also often experience chronic systemic inflammation, further compromising cardiovascular health. Increased BMI is associated with a rise in visceral fat mass, which is more metabolically active and contributes to inflammation and endothelial dysfunction. This dysfunction can lead to plaque instability in the coronary vessels, thereby elevating the risk of STEMI in overweight individuals [35].

Early mobilization in STEMI patients has proven to provide significant benefits, including improved oxygen saturation. Early mobilization interventions can help enhance cardiovascular and pulmonary function, thereby positively impacting patients' oxygen saturation [1,36]. This mobilization improves blood circulation and tissue oxygenation by enhancing left ventricular function, which is often impaired in STEMI patients [8,13]. With this improvement in circulation, oxygen distribution throughout the body becomes more optimal.

Early mobilization also helps reduce pulmonary complications, such as atelectasis or fluid accumulation, which are common in patients who remain immobile for extended periods. Improved lung condition contributes to increased oxygen saturation. Additionally, light physical activity initiated soon after patient stabilization helps prevent deoxygenation or a drop in blood oxygen levels, which frequently occurs in patients with prolonged immobility [6,16].

Furthermore, early mobilization in STEMI patients can stimulate better ventilation and reduce the likelihood of hypoxia. Mobilization activates respiratory muscles, increases tidal volume, and improves gas exchange in the lungs, thereby enhancing patients' oxygen saturation. This is particularly important in preventing hypoxia, which can worsen the prognosis for cardiac patients [7,28].

Early mobilization interventions can help improve heart rate regulation, reduce excessive heart rate, and support cardiac function recovery. STEMI patients who undergo early mobilization show significant improvements in pulse control. Early mobilization enhances blood flow and heart function, which in turn supports more stable heart rate regulation. Light physical activity conducted under supervision can reduce the load on the heart, lower rapid heart rate, and increase the heart's efficiency in pumping blood [13,16].

The effects of early mobilization on STEMI patients during the first few days after a heart attack include a significant reduction in tachycardia, or rapid heart rate. This is because early mobilization stimulates the autonomic nervous system to work more effectively in regulating heart function, reducing excessive stress responses on the heart [37]. It can also help improve the body's parasympathetic function, which plays a role in lowering heart rate. Activities such as light walking or breathing exercises improve the balance between the sympathetic and parasympathetic nervous systems, thereby reducing elevated heart rates in STEMI patients. This intervention also accelerates cardiac function recovery by reducing the load on the heart, optimizing blood flow to vital organs, and allowing the heart to better adapt to the body's metabolic demands [38]. More stable heart rate regulation can reduce the risk of arrhythmias and other cardiovascular complications common in STEMI patients.

Conclusion and recommendation

Progressive early mobilization has a positive impact on the condition of STEMI patients. Early mobilization significantly improves oxygen saturation and stabilizes heart rate in patients receiving ICU care. Patients who receive early mobilization interventions show greater improvements in oxygen saturation and heart rate compared to the control group who do not undergo early mobilization. This indicates that early mobilization is an effective intervention in supporting the recovery of STEMI patients by enhancing tissue oxygenation and optimizing cardiovascular function. Patients who have recently experienced STEMI are encouraged to actively participate in cardiac rehabilitation and early mobilization programs to prevent long-term complications and expedite recovery. This study only measures changes in oxygen saturation and heart rate over a short period (three days). Further research could extend the follow-up period to assess the long-term effects of early mobilization on patients' quality of life, cardiovascular condition, and the incidence of post-STEMI complications.

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