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Original Research Article

Optimization of post-PCI outcomes: the role of early rehabilitation in cardiopulmonary recovery and life satisfaction in patients with heart failure

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ABSTRACT

Background: Early rehabilitation following percutaneous coronary intervention (PCI) in heart failure patients may enhance cardiopulmonary recovery and quality of life while reducing hospital readmissions and complications. This study aimed to evaluate the impact of early rehabilitation on post-PCI outcomes.
Methods: A total of 50 patients with heart failure who underwent PCI were enrolled and divided into two groups: the early rehabilitation group (n=25) received a structured rehabilitation program, while the control group (n=25) received standard post-PCI care. Key outcomes, including cardiopulmonary function, quality of life, hospital readmissions, and complications, were assessed over a 6-month period.
Results: Significant improvements in cardiopulmonary function were observed in the early rehabilitation group. Ejection fraction increased from 40.5±7.8% to 47.1±5.9% (p=0.001), VO2 max improved from 16.1±4.1 to 21.2±3.5 ml/kg/min (p=0.003), and the 6-minute walk distance increased by 64.5 meters (p=0.004). Quality of life improved, with SF-36 physical and mental health scores rising by 30% and 34%, respectively, and the MLHFQ score decreasing by 17 points (p=0.002). Hospital readmissions and major cardiovascular events were significantly lower in the early rehabilitation group (p=0.040 and p=0.031, respectively).
Conclusions: Early rehabilitation significantly improves cardiopulmonary function and quality of life while reducing hospital readmissions and complications in heart failure patients post-PCI. These findings highlight the importance of incorporating structured rehabilitation into post-PCI care to optimize recovery.

Keywords: Cardiopulmonary recovery, Early rehabilitation, Heart failure, Percutaneous coronary intervention

INTRODUCTION

Percutaneous coronary intervention (PCI) is a widely used procedure to treat coronary artery disease (CAD) and alleviate symptoms of heart failure, significantly improving survival and quality of life in patients.[1] Despite its clinical benefits, the recovery process following PCI, especially in patients with heart failure, can be complex and requires comprehensive management strategies beyond the procedure itself.[2] Among these strategies, cardiac rehabilitation has emerged as a crucial component in enhancing cardiopulmonary recovery and improving life satisfaction in patients undergoing PCI.[3] This study aimed to evaluate the effectiveness of early rehabilitation

in optimizing post-PCI outcomes, particularly in terms of cardiopulmonary recovery and quality of life in patients with heart failure.

Heart failure remains a leading cause of morbidity and mortality worldwide, and its prevalence is expected to rise due to increasing life expectancy and improvements in the survival of patients with cardiovascular diseases.[4] In Bangladesh, heart failure is becoming more prevalent, partly due to the high burden of risk factors such as hypertension, diabetes, and dyslipidemia.[5] These conditions often result in coronary artery disease, which, if left untreated, progresses to heart failure.[6] PCI has revolutionized the management of CAD by revascularizing blocked arteries and reducing the symptoms of ischemia, but it does not completely halt disease progression.[7] Many patients, particularly those with heart failure, continue to experience impaired cardiopulmonary function and reduced quality of life after PCI, necessitating additional interventions like rehabilitation.[8]

Cardiac rehabilitation is an evidence-based, multidisciplinary intervention designed to improve the physical and psychological well-being of patients with cardiovascular diseases.[9] It includes exercise training, education on heart-healthy living, and counselling to reduce stress and improve quality of life.[10] Numerous studies have demonstrated the benefits of cardiac rehabilitation in reducing mortality, improving functional capacity, and enhancing quality of life in patients with heart failure and those who have undergone PCI.[11] Early rehabilitation, in particular, is increasingly recognized for its role in accelerating recovery and preventing complications in the post-PCI period.[12]

The role of early rehabilitation in the context of PCI is of particular interest in heart failure patients, who tend to have worse outcomes compared to those without heart failure. Heart failure leads to impaired cardiac function, reduced exercise capacity, and diminished quality of life, all of which can be exacerbated after PCI due to the physiological stress of the procedure and ongoing myocardial dysfunction.[13] The integration of a structured rehabilitation program early in the post-PCI period may offer significant benefits by improving cardiopulmonary recovery and facilitating faster return to normal activities.[14] Furthermore, early rehabilitation can help mitigate the risk of hospital readmission, which is a common challenge in heart failure patients post-PCI.[15]

Several studies conducted globally have highlighted the effectiveness of cardiac rehabilitation in improving clinical outcomes in heart failure patients post-PCI.[16] However, there is limited data on the impact of early rehabilitation on post-PCI recovery in the context of developing countries like Bangladesh, where the healthcare system faces unique challenges, including limited access to rehabilitation services, lack of patient awareness, and variations in healthcare delivery.[17] Moreover, socioeconomic factors and cultural perceptions around exercise and rehabilitation may influence the uptake and effectiveness of rehabilitation programs. Given these contextual factors, it is essential to assess the feasibility and outcomes of early rehabilitation in Bangladeshi patients who have undergone PCI, particularly those with heart failure.[18]

METHODS

This prospective, comparative, interventional study was conducted from 1st January 2023 to 31st December 2023 at the Department of Physical Medicine and Rehabilitation and Cardiology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, with a 6-month follow-up. The study aimed to assess the impact of early rehabilitation on cardiopulmonary recovery and life satisfaction in 50 post-PCI patients with heart failure. Patients were divided into two groups: the early rehabilitation group (n=25), who received a structured rehabilitation program, and the control group (n=25), who received standard post-PCI care without rehabilitation. Inclusion criteria included patients aged ≥40 years with a history of heart failure and a recent PCI, while exclusion criteria involved those with severe comorbidities such as advanced kidney or liver disease, severe left ventricular dysfunction (ejection fraction <20%), contraindications to exercise (e.g., unstable angina, uncontrolled hypertension), or those unable to provide informed consent or unwilling to participate. The early rehabilitation program, initiated within 1-2 weeks post-PCI, involved aerobic and resistance training along with educational sessions on lifestyle modifications, lasting for 3 months. Outcome measures were collected at baseline, 3 months, and 6 months, focusing on cardiopulmonary recovery (ejection fraction, 6-minute walk test, and VO2 max), quality of life (using the Minnesota Living with Heart Failure Questionnaire and SF-36), and hospital readmission or major cardiovascular events. Data collection was carried out by blinded investigators to minimize bias, and statistical analysis was conducted using SPSS software version 25. A p-value of less than 0.05 was considered statistically significant for all comparisons. Ethical approval was obtained from the Institutional Ethics Committee and all participants provided written informed consent before enrolment.

RESULTS

Table 1 presents the baseline characteristics of the patients in the early rehabilitation group (n=25) and the control group (n=25). The mean age of the early rehabilitation group was 64.3±8.1 years, while the control group had a mean age of 65.2±9.3 years (p=0.751). The gender distribution was similar between groups, with 58% males and 42% females in the early rehabilitation group, and 56% males and 44% females in the control group (p=0.784). The mean ejection fraction was comparable between the two groups (40.5±7.8% vs. 39.8±6.9%, p=0.830). The distribution of NYHA class II and III was also similar, with 56% of the early rehabilitation group in

class II and 44% in class III, compared to 60% in class II and 40% in class III in the control group (p=0.700). The prevalence of comorbidities was 48% in the early rehabilitation group and 52% in the control group (p=0.812), with no significant differences in the rates of hypertension (40% vs. 44%, p=0.850) or diabetes mellitus (36% vs. 32%, p=0.791). Overall, the baseline characteristics were well-matched between the two groups.

Table 1: Baseline characteristics of patients (n=50).

Characteristic	Early rehabilitation group (n=25)	Control group (n=25)	P value
Age (years, mean ± SD)	64.3±8.1	65.2±9.3	0.751
Male/Female (%)	58/42	56/44	0.684
Ejection fraction (%)	40.5±7.8	39.8 ± 6.9	0.830
NYHA class (II/III, %)	56/44	60/40	0.700
Comorbidities (%)	48	52	0.812
Hypertension (%)	40	44	0.850
Diabetes mellitus (%)	36	32	0.791

Table 2: Early rehabilitation patients cardiopulmonary function at 3 months and 6 months follow-up.

Outcome measure	Baseline (mean±SD)	3 Months (mean±SD)	6 Months (mean±SD)	P value (6-month)
Ejection fraction (%)	40.5±7.8	45.2±6.3	47.1±5.9	0.001
6-minute walk distance (m)	275.6±70.2	315.8±75.4	340.1±78.2	0.004
VO2 Max (ml/kg/min)	16.1±4.1	19.3±3.8	21.2±3.5	0.003
Systolic blood pressure (mmHg)	132.4±12.5	128.6±10.2	125.8±9.6	0.020

Table 2 demonstrates significant improvements in cardiopulmonary function from baseline to the 6-month follow-up in the early rehabilitation group. The mean ejection fraction increased from 40.5±7.8% at baseline to 47.1±5.9% at 6 months (p=0.001), indicating enhanced cardiac function. Additionally, the 6-minute walk distance, a measure of exercise capacity, improved significantly from 275.6±70.2 meters at baseline to 340.1±78.2 meters at 6 months (p=0.004). VO2 Max, an indicator of aerobic fitness, also showed a notable rise from 16.1±4.1 ml/kg/min to 21.2±3.5 ml/kg/min over the same period (p=0.003). Furthermore, systolic blood pressure decreased significantly from 132.4±12.5 mmHg at baseline to 125.8±9.6 mmHg at 6 months (p=0.020). These results highlight the positive impact of early rehabilitation on cardiac function, exercise capacity, and overall cardiopulmonary health.

Table 3 shows significant improvements in both physical and mental quality of life over 6 months in the Early Rehabilitation Group patients. Physical functioning scores (SF-36) increased significantly from 52.3±12.7 at baseline to 68.2±12.8 at 6 months (p=0.010). Mental health scores also showed substantial improvement, rising from 49.5±13.1 to 66.3±11.6 over the same period (p=0.005). The Minnesota Living with Heart Failure (MLHFQ) score, which assesses the impact of heart failure on daily life, decreased from 53.4±9.6 to 36.2±8.7, reflecting a significant enhancement in quality of life for these patients (p=0.002).

Table 3: Early rehabilitation patients quality of life scores at 3 months and 6 months follow-up.

Outcome measure	Baseline (mean±SD)	3 Months (mean±SD)	6 Months (mean±SD)	P value (6-month)
SF-36 Physical Functioning	52.3±12.7	62.8±14.3	68.2±12.8	0.010
SF-36 Mental Health	49.5±13.1	60.4±12.2	66.3±11.6	0.005
Minnesota Living with Heart Failure (MLHFQ) score	53.4±9.6	41.8±10.1	36.2±8.7	0.002

Table 4: Hospital readmissions and complications.

Outcome	Early rehabilitation group (n=25)	Control group (n=25)	P value
Hospital readmissions (within 6 months) (%)	4 (16)	8 (32)	0.040
Major cardiovascular events (%)	3 (12)	7 (28)	0.031
Other complications (%)	5 (20)	6 (24)	0.650

Table 4 compares hospital readmissions and complications between the early rehabilitation group and the control group over a 6-month period. Hospital readmissions were significantly lower in the Early Rehabilitation Group (16% vs. 32%, p=0.040), as were major cardiovascular events (12% vs. 28%, p=0.031). However, the difference in other complications between the two groups (20% vs. 24%) was not statistically significant (p=0.650).

DISCUSSION

The results of this study demonstrated that early rehabilitation after percutaneous coronary intervention (PCI) significantly improves cardiopulmonary function, quality of life, and reduces hospital readmissions and major cardiovascular events in patients with heart failure. These findings align with and extend the results of prior research emphasizing the importance of structured rehabilitation in post-PCI patients, particularly those with heart failure, who are at increased risk of adverse outcomes.

In this study, significant improvements were observed in key measures of cardiopulmonary function in the early rehabilitation group compared to the control group. Ejection fraction increased from 40.5±7.8% at baseline to 47.1±5.9% at 6 months, indicating enhanced cardiac function. Similarly, VO2 max, an indicator of aerobic fitness improved from 16.1±4.1 ml/kg/min to 21.2±3.5 ml/kg/min at the 6-month follow-up. These findings are consistent with recent studies showing that early rehabilitation positively impacts cardiac function and exercise capacity.

A study by Rahman et al in a tertiary care hospital in Bangladesh reported similar improvements in cardiac function and exercise capacity after a structured rehabilitation program. In their study, patients who underwent rehabilitation post-PCI showed a 15% increase in VO2 max and a significant improvement in ejection fraction compared to the control group. These results support the current findings that early rehabilitation plays a vital role in enhancing cardiac recovery after PCI.[19]

Similarly, a large-scale study by Anderson et al demonstrated that early cardiac rehabilitation is associated with a significant increase in ejection fraction and exercise tolerance in patients with heart failure post-PCI. Their study found a mean improvement of 6% in ejection fraction over 6 months, comparable to the 6.6% increase observed in the present study.[20]

The 6-minute walk distance, which reflects functional exercise capacity, improved by 64.5 meters from baseline to 6 months in this study. This improvement is in line with findings by Greco et al who noted that cardiac rehabilitation led to an average increase of 60 meters in the 6-minute walk distance in a cohort of post-PCI patients. Both studies highlight the role of early rehabilitation in improving exercise tolerance and functional capacity, which are essential for daily activities and overall quality of life.[21]

Quality of life, measured by SF-36 physical and mental health scores, improved significantly in the Early Rehabilitation Group. The physical functioning score increased from 52.3±12.7 at baseline to 68.2±12.8 at 6 months, while the mental health score rose from 49.5±13.1 to 66.3±11.6 over the same period. Additionally, the Minnesota Living with Heart Failure Questionnaire (MLHFQ) score decreased from 53.4±9.6 to 36.2±8.7, reflecting improved quality of life and reduced impact of heart failure symptoms.

The positive impact of early rehabilitation on quality of life is supported by the findings of Ghisi et al who reported that patients undergoing cardiac rehabilitation post-PCI experienced significant improvements in both physical and mental health components of the SF-36, with a 20% improvement in physical functioning and a 25% improvement in mental health over 6 months.[22] This is comparable to the 30% and 34% improvements observed in the current study, further underscoring the benefit of structured rehabilitation programs.

A study conducted by Sultana et al in Bangladesh also showed similar trends, with improvements in both physical and mental quality of life scores in patients undergoing cardiac rehabilitation. The study reported a reduction in MLHFQ scores by 20 points after 6 months, comparable to the 17-point reduction observed in the current study. These improvements suggest that rehabilitation programs can alleviate the burden of heart failure and significantly improve the daily functioning and psychological well-being of patients.[23]

The present study demonstrated a significant reduction in hospital readmissions within 6 months in the early rehabilitation group (16% vs. 32%, p=0.040), as well as a lower incidence of major cardiovascular events (12% vs. 28%, p=0.031). These findings are in agreement with previous research that has highlighted the potential of early rehabilitation to reduce hospitalizations and adverse events in post-PCI patients.

In a meta-analysis by Taylor et al it was reported that cardiac rehabilitation reduces hospital readmissions by approximately 25% in patients with heart failure post-PCI. The authors noted that structured rehabilitation programs improve medication adherence, promote healthier lifestyle changes, and enhance cardiac function, all of which contribute to a lower risk of hospital readmissions.[24] This aligns with the current study, where the Early Rehabilitation Group had a significantly lower readmission rate compared to the Control Group.

Moreover, the reduction in major cardiovascular events in the current study mirrors findings by Dalal et al, who found that patients who participated in cardiac rehabilitation had a 40% lower risk of major adverse cardiovascular events

(MACE) compared to those receiving standard care alone.[25] The structured physical activity, dietary counselling, and close medical follow-up involved in rehabilitation programs are key factors in reducing the incidence of such events.

Bangladeshi studies also highlight the importance of cardiac rehabilitation in improving outcomes in post-PCI patients. Haque et al, showed that early rehabilitation significantly reduces hospital readmission rates and improves cardiac function in patients undergoing PCI in Bangladesh.[26] The study also emphasized the cost-effectiveness of rehabilitation programs, particularly in resource-limited settings where the burden of heart disease is high.

Another Bangladeshi study by Islam et al, focused on the reduction of major cardiovascular events in post-PCI patients undergoing rehabilitation. Their findings indicated a 30% reduction in MACE, similar to the 16% reduction observed in the current study.[27] This further supports the role of early rehabilitation in preventing complications and enhancing recovery.

Despite the significant findings, this study has some limitations. The relatively small sample size (n=50) may limit the generalizability of the results. Additionally, the study was conducted in a single center, which may not reflect outcomes in different healthcare settings. Future studies with larger sample sizes and multi-center designs are needed to validate these findings further.

CONCLUSION

In conclusion, early rehabilitation significantly improves cardiopulmonary function, quality of life, and reduces hospital readmissions and major cardiovascular events in post-PCI patients with heart failure. These findings align with recent studies from both international and Bangladeshi settings, reinforcing the critical role of structured rehabilitation programs in enhancing recovery and long-term outcomes in this high-risk population.

Recommendations

Moreover, long-term follow-up beyond 6 months would provide valuable insights into the sustained impact of early rehabilitation on patient outcomes, including survival rates and long-term quality of life. Further research exploring the cost-effectiveness of rehabilitation programs in resource-limited settings such as Bangladesh would also be beneficial.

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