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Effect of Phase I Cardiac Rehabilitation on Cardiac Delirium after Aortic Valve Replacement

Paula Gamal Kadous Ibrahim[*1], Nesreen Ghareeb Mohamed El-Nahas[1], Bassem Zarif Foad Badr [2], Donia Mohamed El-Masry[1]

[1]Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt

[2]National Health Insurance, Cairo University, Cairo, Egypt

***Corresponding author:** Paula Gamal Kadous Ibrahim, **Mobile:** (+20)01271183870, **E-Mail:** bolagemovic@gmail.com

ABSTRACT

Background: Patients underwent aortic valve replacement (AVR), particularly the elderly, are at increased risk of developing delirium during hospitalization. Delirium following surgical and transcatheter AVR (SAVR and TAVR) has been associated with poorer functional outcomes, increased hospitalization days and reduced long-term survival.

Objective: This study aimed to identify the effect of phase-I cardiac rehabilitation (CR) on the incidence and severity of delirium following AVR.

Patients and methods: Sixty patients with AVR of both sexes with age ranged from 60 to 70 years old were selected from the Intensive Care Unit (ICU) and Cardiac Care Unit (CCU) of the National Heart Institute and Kasr El Ainy Hospital and were randomly assigned into two equal groups (n=30 each). Group (A) received phase-I CR for 20 minutes daily. Group (B) received breathing and circulatory exercises for 20 minutes, three times per day, in addition to optimal medical therapy, until discharge.

Results: Age, sex distribution, weight, height, body mass index (BMI), HbA1c, platelet-to-white blood cell ratio (PWR), and cardiac index were not significantly different between the two groups at baseline ($P > 0.05$). The mean duration of hospitalization was significantly shorter for group A (5.83 ± 1.05 days) compared to group B (11.57 ± 1.91 days), with a mean difference of -5.73 days (95% CI: -6.53 to -4.94; $p < 0.001$; ES=-3.72). The pre-operative and pre-treatment CAM scores did not exhibit a significant difference between the groups ($P = 1.000$ and $P = 0.587$, respectively). Nevertheless, the CAM scores in group A were markedly lower than those in group B after treatment (0.00 vs. 1.00; $P < 0.001$; effect size [ES] = -0.78). In the same vein, Group A's post-treatment RASS scores were substantially higher (0.00 vs. -1.00; $P = 0.030$; ES = -0.28), suggesting that arousal and responsiveness increased.

Conclusion: It could be concluded that phase-I CR significantly reduced the severity of delirium and improved sedation-agitation levels in patients following AVR compared to standard breathing and circulatory exercises.

Keywords: Aortic valve replacement, Cardiac rehabilitation, Postoperative delirium, Phase 1 rehabilitation.

INTRODUCTION

Patients who require AVR due to aortic stenosis are generally elderly and may be susceptible to delirium during hospitalization. Delirium has been associated with a decline in long-term survival and a worsening of functional status following both surgical and transcatheter AVR (SAVR and TAVR respectively). Delirium care in the elderly not only imposes psychological burden on patients and families but also demands considerable resources and may extend hospital or ICU stays [(1)].

Postoperative delirium (POD) is the most common cognitive consequence following heart surgery, with a frequency reported between 25% and 50%. Clinically, it presents as an abrupt and variable alteration in cognition, characterized by inattention, disordered thought processes, and altered states of consciousness. POD has been consistently linked to increased mortality, protracted hospital stays, increased expenses, and supplementary complications, including infection and stroke [(2)].

In order to ensure precision, the diagnosis of delirium should be based on clinical observation and validated bedside psychometric diagnostic methods, such as the CAM-ICU (Cognitive Assessment Method for ICU) or ICDSC (Intensive Care Delirium Screening Checklist) [(3)].

Early mobilization correlates with a reduced duration of delirium in elderly inpatients experiencing delirium. POD frequently manifests on the initial postoperative day. It is also linked to falls, and minimizing the duration of delirium may be beneficial in decreasing its incidence [(4)].

Cardiac rehabilitation (CR) is a structured program of physical and respiratory exercises that is administered by a multidisciplinary team with the primary objective of enhancing cardiovascular function and physical capability in the aftermath of an acute cardiac event or intervention. CR treatments have been demonstrated to enhance quality of life and reduce morbidity in these individuals [(5)].

Numerous mechanisms exist through which CR may reduce hospitalizations of post-cardiovascular surgery patients, including enhanced monitoring by CR personnel who may notify the patient's clinician in cases of deterioration, promotion of medication compliance, and enhancement of functional status [(6)].

The objective of this study was to assess the impact of phase-I CR on cardiac delirium following AVR.

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PATIENTS AND METHODS

Sixty patients of both sexes (40 male and 20 female), aged between 60 and 70 years, underwent AVR. They were randomly chosen from the ICU and CCU of the National Heart Institute and Kasr El Ainy Hospital.

Subsequently, they were divided into two equal groups. The participants undergoing AVR had provided informed consent and were free from study exclusion criteria, which included risks associated with SAVR, any physiological or hemodynamic instability post-surgery, comorbidities and frailty from non-cardiovascular origins, unstable conditions, cognitive impairments prior to SAVR, unrelated comorbidities resulting in delirium, and sensory or movement disorders.

Figure 1 showed the flow chart of participants.

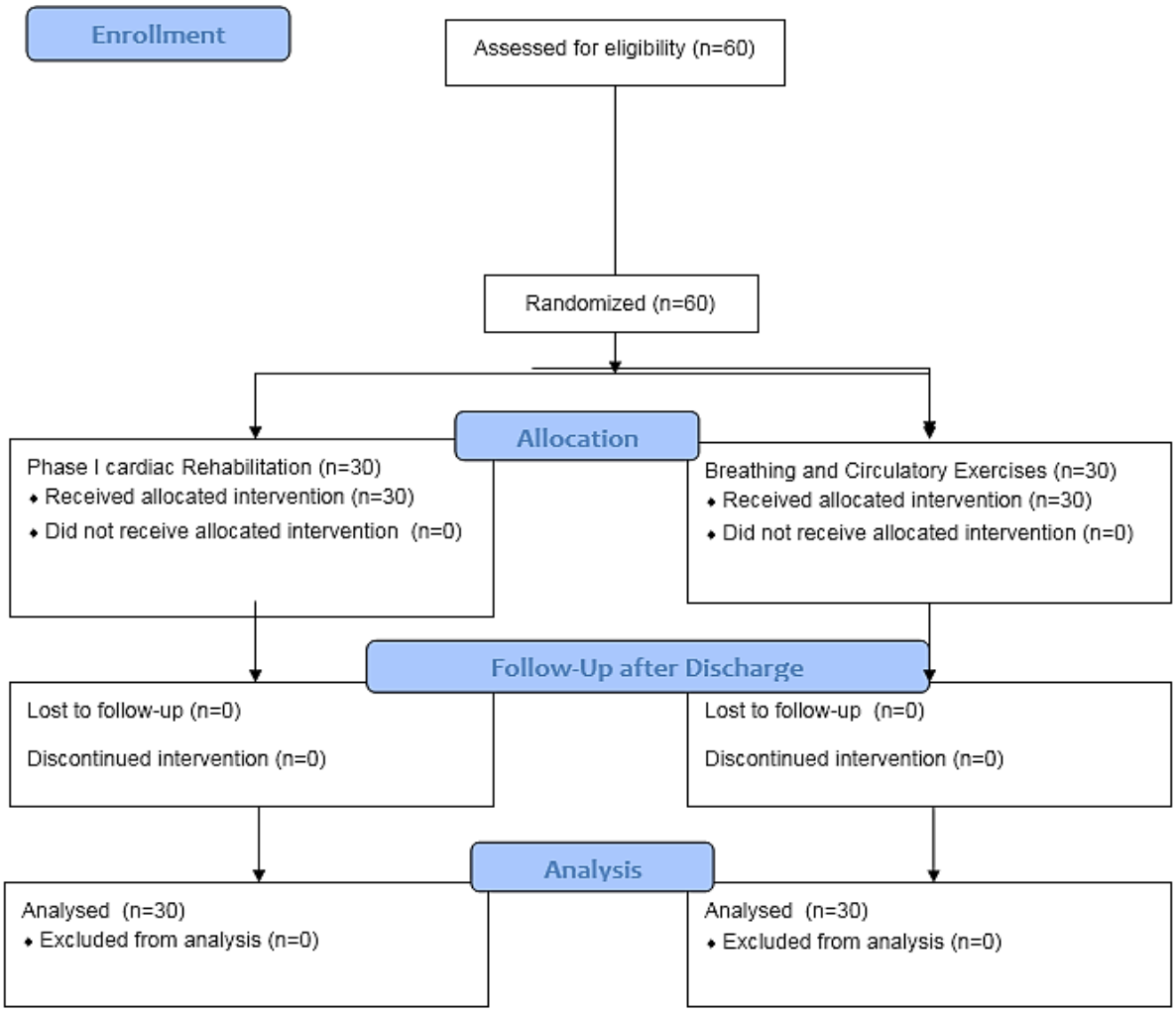

Figure (1): Flow chart of participants.

OUTCOME MEASURES

Cardiac delirium index (CARDEL index): Since the CARDEL index is based on age, glycated hemoglobin level (HbA1c), and PWR, it was examined to see whether there are any connections between these three factors in order to determine the risk of delirium. The CARDEL index is inexpensive, easy to understand, and straightforward to compute using common, readily available methods.

CARDEL Index is calculated by adding age, 0.341 times HBA1c, and finally, 0.049 times PWR.) [(7)].

Confusion assessment method (CAM): The CAM assesses four aspects of cognition: (1) Sudden start and fluctuating course; (2) Lack of focus; (3) Fragmented thought processes; and (4) Altered state of consciousness. A patient is considered to be in delirium if they exhibited not only components 1 and 2, but also elements 3 or 4 [(8)].

The Richmond Agitation-Sedation Scale (RASS): One of the most used tools for measuring psychomotor agitation and sedation levels in research and clinical practice is the RASS. A calm and alert condition is denoted by one level (0), four degrees of anxiety or agitation range from +1 to +4, and five levels of drowsiness range from -1 to -5 on the 10-point scale. A score of +4 indicates that the patient is very aggressive or violent and poses a direct threat to the personnel. The patient becomes unresponsive to vocal stimulation at a score of -4 and eventually enters an unarousable condition with a score of -5 [(9)].

Management procedure: 60 patients were randomly assigned into two equal groups (n=30 each). Group (A) received Phase I cardiac rehabilitation for 20 minutes daily. Group (B) received breathing and circulatory exercises for 20 minutes, three times per day, in addition to optimal medical therapy, until discharge.

Group A: 30 patients with AVR who received phase-I CR for 20 minutes, three times per day in addition to their optimal medical treatment until discharge as a total period of treatment.

Relaxation exercises, chest expansion, breathing exercises, cough and wheeze techniques, postural drainage therapy, ambulation, and stair ascending were the primary components of the physiotherapy treatment that was administered during the hospital stay. A component of acute physiotherapy management was the progressive ambulation and education of patients in preparation for their return home [(10)].

- **Day 1:** Phase-I CR primarily emphasized respiratory exercises, relaxation techniques, incentive spirometry, cough and huff maneuvers, and range of motion (ROM) activities for both upper and lower limbs.
- **Day 2:** Seated with legs suspended at the bed's edge.
- **Day 3:** Initiation of movement from bed to chair, implementation of sit-to-stand exercises, and room ambulation will commence with the therapy modalities from Days 1 and 2.
- Staircase climbing will commence on Day 4 and Day 5.
- Presentation of the ACSM guidelines for exercise prescription in phase I of CR:
- **Intensity:** Resting heart rate (RHR) + 30 bpm.
- **Duration:** Intermittent sessions of 3 to 5 minutes, interspersed with rest periods of 1 to 2 minutes, totaling 20 minutes in duration.
- **Frequency:** Initial mobilization: Three to four times daily (Days one to three). Subsequent mobilization: Twice daily (From day four onward).
- **Progression:** Initially augment the duration of exercise by 10 to 15 minutes, followed by an increase in intensity [(11)].

Group B: 30 patients with AVR who received breathing and circulatory exercises, three times per day in addition to their optimal medical treatment until discharge as a total period of treatment.

In planned deep breathing exercises, patients were in sitting or semi-setting positions and took deep and slow breathes through their noses while their hands were put on their chests and pushed to lower the pain and breathe easier. After inhaling, patients held their breath for a count of 3 and exhale while lips and stomach muscles were compressed. This exercise was repeated for 10 circuits every 2 hours when the patient awakened. Patients in the group B also received traditional circulatory exercises [(12)].

Ethical consent: The Ethical Committee of the Faculty of Physical Therapy, Cairo University granted sanction for a single-blinded randomized controlled clinical trial. Quality control and approval from the Research Ethics Committee were obtained (P.T.REC/012/005085). Each participant was provided with a detailed explanation of the current investigation prior to the acquisition of their informed written consent. Consistently, the trial coordinator implemented quality control measures for data administration, filtering, and protocol assurance. Throughout its implementation, the study complied with the Helsinki Declaration.

Statistical analysis:

SPSS version 25.0 for Windows was used. The demographics of the subject groups were compared using descriptive statistics and an unpaired t-test. The gender distribution among categories was compared using Chi-squared analysis. The normality of data distribution for all variables was assessed using the Shapiro-Wilk test. The homogeneity of variances was assessed using Levene's test. The mean values of the CARDEL Index, CAM, and RASS were compared among the research groups using an unpaired t-test. The pre- and post-treatment results of each cohort were compared using a paired t-test. The significance level was established at $p \leq 0.05$.

RESULTS

At baseline, there were no significant differences between the two groups in terms of age, sex distribution, weight, height, BMI, HbA1c levels, PWR, and cardiac index (P > 0.05 for all) (Table 1).

Table (1) showed that baseline characteristics between the two studied groups

Variables	Total (n=60)	Group (A) (n=30)	Group(B) (n=30)	Testof significance	*P*-value
Age (Years)	67.20±2.29	67.23±2.21	67.17±2.42	t= 0.111	0.912
Sex, N(%) **Male** **Female**	 40 (66.7%) 20 (33.3%)	 20 (66.7%) 10 (33.3%)	 20 (66.7%) 10 (33.3%)	$\chi 2 = 0.000$	1.000
Weight (Kg)	86.72±9.52	88.43±9.25	85.00±9.62	t= 1.409	0.164
Height (cm)	171.85±7.14	172.47±7.47	171.23±6.87	t= 0.666	0.508
BMI (Kg/m^2)	29.31±2.34	29.73±2.74	28.89±1.82	t= 1.414	0.163
HbA1c (%)	7.06±0.20	7.06±0.21	7.05±0.20	t= 0.252	0.802
PWR	29.35±0.82	29.46±0.88	29.24±0.75	t= 1.053	0.297
Cardiac index	8.22±0.25	8.22±0.24	8.22±0.26	t= 0.061	0.952

Test of significance: t: Independent Samples Test. χ^2= Chi-square test.
*: Statistically significant at *P*-value<0.05.

Table (2) showed that the mean duration of hospitalization was significantly shorter for group A (5.83 ± 1.05 days) compared to group B (11.57 ± 1.91 days), with a mean difference of -5.73 days (95% CI: -6.53 to -4.94; p < 0.001; ES=-3.72).

Table (2): Comparison of hospitalization duration between the two studied groups

Variables	Group (A) (n=30)	Group (B) (n=30)	MD (95%CI)	Test of significance	*P*-value	*ES* *(Cohen's d)*
Hospitalization duration (days)	5.83±1.05	11.57±1.91	-5.73 (-6.53, -4.94)	t= -14.420	<0.001**	-3.72

Data are presented as Mean ±SD and range.
Test of significance: t: Independent Samples Test.
MD: Mean difference; CI: Confidence interval; ES: effect size.
Cohen's d classified effect sizes as follows (small = 0.2, moderate = 0.5, and large ≥ 0.8).
*: Statistically significant at P <0.05.
**: Statistically significant at P <0.01.

Effect of treatment on CAM:

Within-group comparison: There were statistically significant changes in both of group A and group B across different times, according to the Friedman test (*P* <0.001). In group A, there was a statistically significant increase in median CAM score from pre-operative (0.00) to pre-treatment (4.00), followed by a significant decrease to post-treatment (0.00) (*P* <0.001). However, there was no significant difference between pre-operative and post-treatment scores (*P* = 0.157). In group B, there were a statistically significant increase from pre-operative (0.00) to pre-treatment (4.00), and then a significant decrease to post-treatment (1.00) (P<0.001).

Between-groups comparison: There were no statistically significant differences in CAM scores at pre-operative and pre-treatment between the two groups (*P* = 1.000 and 0.587). However, group A showed a statistically significant lower CAM score post-treatment compared to group B (0.00 vs. 1.00; *P* <0.001; ES=-0.78) (Table 3).

Table (3): Comparison of CAM scores at pre-operative, pre-treatment, and post-treatment between the two studied groups

CAM scores	Pre-operative	Pre-treatment	Post-treatment	MD1 (95%CI)	MD2 (95%CI)	MD3 (95%CI)	Test of significance	*P*-value within time	$P_{\text{Post-hoc (WSR)}}$
Group (A) (n=30)	0.00 (0.00-0.00)	4.00 (3.00-4.00)	0.00 (0.00-1.00)	4.00 (3.45,3.82)	0.00 (-0.03, 0.16)	-4.00 (-3.75, -3.38)	$\chi^2_{(Friedman)}$ =58.783	**<0.001****	**P1<0.001**** P2=0.157 **P3<0.001****
Group (B) (n=30)	0.00 (0.00-0.00	4.00 (3.00-4.00)	1.00 (0.00-2.00)	4.00 (3.53, 3.87)	1.00 (1.01, 1.52)	-3 (-2.62, -2.25)	$\chi^2_{(Friedman)}$ =58.207	**<0.001****	**P1<0.001**** **P2<0.001**** **P3<0.001****
Test of significance	Z_{MWU} =0.000	Z_{MWU} =-0.543	Z_{MWU} =-6.068						
P-value between groups	1.000	0.587	**<0.001***						
ES_r	0.00	-0.07	**-0.78**						

Data are presented as Median and range.
MD1: Median difference between Pre-treatment and Pre-operative; MD2: Median difference between Pre-treatment and Post-treatment; MD3: Median difference between Pre-treatment and Post-treatment; CI: confidence interval; ES: effect size.
Test of significance: Z_{MWU}: Mann-Whitney U; χ^2 Friedman: Friedman Test; WSR: Wilcoxon Signed Ranks Test.
Effect size conventions for r effect size are as follows: small = 0.1, moderate = 0.3, and large ≥ 0.5.
*: Statistically significant at P <0.05. **: Statistically significant at P <0.01.
P1: comparison between Pre-operative and Pre-treatment. P2: comparison between Pre-operative and post-treatment. P3: comparison between Pre-treatment and Post-treatment.

Effect of treatment on RASS:

Within-group comparison: There were statistically significant changes in RASS scores in both of group A and group B at various time points, according to the Friedman test (P <0.001). In group A, the RASS score significantly decreased from the pre-operative score of 0.00 to a pre-treatment score of -2.00 and then significantly increased to 0.00 post-treatment (P < 0.001). There was no significant difference between the pre-operative and post-treatment scores (P = 0.157). In group B, the RASS score also significantly decreased from the pre-operative score of 0.00 to -2.00 pre-treatment (P < 0.001) and then increased to -1.00 post-treatment (P = 0.019). There was a statistically significant difference between the pre-operative and post-treatment scores in this group (P < 0.001).

Between-groups comparison: No statistically significant differences were found between the two groups at the pre-operative and pre-treatment (P=1.000 and 0.452). However, in post-treatment, group A had a statistically significantly higher RASS score compared to group B (0.00 vs. -1.00; P=0.030; ES=-0.28) (Table 4).

Table (4): Comparison of RASS scores at pre-operative, pre-treatment, and post-treatment between the two studied groups.

RASS scores	Pre-operative	Pre-treatment	Post-treatment	MD1 (95%CI)	MD2 (95%CI)	MD3 (95%CI)	Test of significance	*P*-value within time	$P_{\text{Post-hoc (WSR)}}$
Group (A) (n=30)	0.00 (0.00 -0.00)	-2.00 (-4.00-3.00)	0.00 (-1.00-0.00)	-2.00 (2.38,1.16)	0.00 (-0.16, -0.03)	2.00 (1.11,2.29)	$\chi^2_{(Friedman)}$ = 37.652	<0.001**	P1<0.001** P2=0.157 P3<0.001**
Group (B) (n=30)	0.00 (0.00-0.00	-2.00 (-4.00-3.00)	-1.00 (-2.00-1.00)	-2.00 (2.64,-1.36)	-1.00 (0.84,--0.09)	1 (1.01, 2.06)	$\chi^2_{(Friedman)}$ =31.274	<0.001**	P1<0.001** P2=0.019* P3<0.001**
Test of significance	Z_{MWU} =0.000	Z_{MWU} =-0.752	Z_{MWU} = -2.164						
P-value between groups	1.000	0.452	0.030*						
$ES_{(r)}$	0.00	−0.10	–0.28						

Data are presented as Median and range.
MD1: Median difference between Pre-treatment and Pre-operative; MD2: Median difference between Pre-treatment and Post-treatment; MD3: Median difference between Pre-treatment and Post-treatment; CI: confidence interval; ES: effect size. Test of significance: Z_{MWU}: Mann-Whitney U; χ^2 Friedman: Friedman Test; WSR: Wilcoxon Signed Ranks Test.
Effect size conventions for r effect size are as follows: small = 0.1, moderate = 0.3, and large ≥ 0.5.
*: Statistically significant at P <0.05. **: Statistically significant at P <0.01.P1: comparison between Pre-operative and Pre-treatment. P2: comparison between Pre-operative and post-treatment. P3: comparison between Pre-treatment and Post-treatment.

DISCUSSION

Patients with aortic stenosis who require AVR are usually older and may be prone to delirium during hospitalization. Delirium following AVR has been associated to worse functional status and shorter long-term survival after both surgical and transcatheter AVR (SAVR and TAVR, respectively) [(1)]. The purpose of our clinical investigation was to assess the impact of phase-I CR on the occurrence and intensity of delirium subsequent surgery AVR.

A multidisciplinary team administers the CR program, which includes physical and respiratory exercises. Its major goal is to restore cardiovascular function and physical capability following an acute cardiac incident or intervention. CR programs have been demonstrated to improve the quality of life and reduce morbidity in these people [(5)].

Our clinical trial results recorded that at baseline, there were no significant differences between the two groups in terms of age, sex distribution, weight, height, BMI, HbA1c, PWR, and cardiac index ($P > 0.05$). Pre-operative and pre-treatment CAM scores did not significantly differ between groups ($P = 1.000$ and $P = 0.587$, respectively). However, post-treatment CAM scores were significantly lower in group A compared to group B (0.00 vs. 1.00; $P < 0.001$; effect size [ES] = -0.78). Similarly, post-treatment RASS scores were significantly higher in group A (0.00 vs. -1.00; $P = 0.030$; ES = -0.28), indicating improved arousal and responsiveness. **Maniar *et al.*** [(13)] found that POD occurred in 32% of patients undergoing surgical or transcatheter AVR. Transfemoral TAVR had the lowest POD incidence (18%). POD was linked to longer ICU/hospital stays, higher readmission rates, and increased mortality at 30 days and 1 year. Even after adjusting for other factors, POD independently predicted 1-year mortality, underscoring the need for prevention strategies to improve patient outcomes.

Despite the significant impact of phase-I CR on cardiac delirium after AVR, there were insufficient research studies regarding its outcomes.

Parnan *et al.* [(14)] conducted a randomized trial showing that Phase-I CR significantly reduces delirium severity in post-CABG patients. Using the Neecham Confusion Scale, the study found that patients receiving early CR had notably lower delirium scores from postoperative days 1 to 4 compared to those receiving routine care. The results support Phase-I CR as a cost-effective intervention to prevent and manage POD in cardiac surgery patients.

Cupka *et al.* [(15)] reviewed 27 recent studies on non-pharmacologic strategies for managing ICU delirium. They found that while individual interventions like family visitation were effective, mobility alone was less. Multi-component bundled protocols were more effective overall, with most studies showing reductions in both delirium incidence and duration. The authors concluded that bundled approaches outperform single interventions but called for more research to identify the most impactful components. Improved delirium management can enhance outcomes and reduce healthcare resource use.

Previous study by **Shirvani *et al.*** [(16)] conducted a double-blind randomized trial to evaluate early mobilization's effect on POD in CABG patients. Those who received structured mobilization during the first two postoperative days showed significantly better cognitive function and a higher return to normal mental status compared to the control group. Key factors influencing confusion scores included age, ejection fraction, myocardial infarction, and blood pressure. The study concluded that early mobilization effectively reduces delirium after CABG surgery. Furthermore, **Adel *et al.*** [(17)] conducted a quasi-experimental study showing that early mobilization after cardiac surgery significantly improved physiological parameters, reduced complications, enhanced sleep quality, and shortened hospital stays. The findings support early mobilization as a feasible and effective strategy to promote recovery, with recommendations for further research across broader patient populations.

Katano *et al.* [(18)] analyzed data from nearly 20,000 older patients undergoing transcatheter aortic valve implantation and found that inpatient CR significantly reduced the risk of hospital-associated disability (HAD). Patients receiving CR had a lower HAD incidence (8.8% vs. 14.2%), and CR was independently associated with reduced HAD risk. However, its effectiveness was diminished in patients with low BMI or poor baseline function. The study supports inpatient CR as a key strategy in preventing functional decline post-TAVI, with limitations in certain vulnerable subgroups.

Regarding quality of life outcomes, the evidence similarly supported beneficial effects of CR. In CHD patients, seven out of ten randomized controlled trials reported significant improvements in quality of life using validated instruments, although data heterogeneity precluded meta-analysis [(19)]. Among patients with heart failure, exercise-based CR generated a clinically substantial improvement in quality of life as judged by the Minnesota Living with Heart Failure questionnaire, with a mean difference of 5.8 points (95% confidence interval 2.4 to 9.2, $P = 0.0007$) across 13 studies [(20)]. **Borzou *et al.*** [(21)] conducted a randomized trial showing that early Phase-I CR significantly improves self-efficacy in post-CABG patients. Those who received CR education within 72 hours after surgery had higher self-efficacy scores at discharge and one month later compared to controls. The study concluded that early CR enhances patients' confidence in managing daily activities and may reduce the need for more intensive rehabilitation later. **Wang *et al.*** [(22)] studied the effect of Phase-I CR on cardiac function and hemodynamics in individuals with coronary heart disease (CHD) and acute heart failure. Patients receiving CR alongside standard treatment showed significant improvements in NT-proBNP

levels, cardiac output, and other hemodynamic parameters. Although, between-group differences post-treatment were not statistically significant. The findings suggest that Phase-I CR enhances cardiac function and may benefit stable patients when used alongside pharmacotherapy.

Cochrane reviews have assessed the effects of exercise-based CR on outcomes in CHD and heart failure. In 2015 review on CHD, **Dibben *et al.*** [(19)] found that while CR did not significantly lower the risk of myocardial infarction or the need for revascularization, it resulted in a modest but significant reduction in hospital admissions (from 30.7% to 26.1%; NNT = 22), indicating a beneficial role in reducing healthcare utilization. A Cochrane review by **Sagar *et al.*** [(20)] analyzing 33 randomized trials with 4,740 heart failure patients, found that exercise-based CR significantly reduced all-cause hospitalizations (RR 0.75; NNT = 15) and hospitalizations due to heart failure specifically (RR 0.61; NNT = 18). This highlights the effectiveness of CR in lowering hospitalization rates among heart failure patients.

This clinical study was restricted to the physical and psychological status of participants that could influence trial evaluation and treatment measure values. The study was constrained by a small sample size, a restricted age range of patients, and unmeasured confounding variables, including baseline cognition and medication usage, which may have affected delirium results.

CONCLUSION

It could be concluded that phase-I CR significantly reduced the severity of delirium and improved sedation-agitation levels in patients following AVR compared to standard breathing and circulatory exercises.

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