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ORIGINAL ARTICLE

Impact of Delayed Postoperative Rehabilitation on Patients with Valvular Heart Disease: A Retrospective Cohort Study

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Objectives: Delayed initiation of postoperative rehabilitation may be detrimental for improving everyday activities in postoperative patients with valvular heart disease. Rehabilitation is essential for postoperative valvular heart disease; however, the effective starting time of rehabilitation is unknown. This study aimed to investigate whether a delay in postoperative rehabilitation affects outcomes in patients after waiting for surgery for valvular heart disease. **Methods:** Data from the JMDC database were extracted for 4330 patients diagnosed with valvular heart disease and who underwent surgery within 5 days of admission. Patient characteristics were compared between the usual rehabilitation group (started rehabilitation within 2 days postoperatively) and the delayed rehabilitation group (started rehabilitation at 3–5 days postoperatively). The primary outcome was hospitalization-associated disability (HAD); that is, the proportion of patients who showed a decline in the Barthel Index during hospitalization. Barthel Index at discharge, pulmonary complications following hospitalization, and postoperative complications were the secondary outcomes. Outcomes were compared in the usual and delayed rehabilitation groups after propensity score matching. **Results:** Of the 4330 patients, 3845 patients were assigned to the usual rehabilitation group, and 485 patients were assigned to the delayed rehabilitation group. After propensity score matching, statistical analysis was performed on the usual and delayed rehabilitation groups, which each contained 418 patients. The delayed rehabilitation group had significantly higher rates of HAD (10.5% vs 8.1%) and respiratory complications (14.8% vs 11.2%) than the usual rehabilitation group. **Conclusions:** Delayed postoperative rehabilitation may be associated with poor prognosis in patients with valvular heart disease.

Key Words: early rehabilitation; hospitalization-associated disability; postoperative complication; retrospective cohort study; valvular heart disease

INTRODUCTION

Valvular heart disease is a major cardiovascular disease worldwide, and the burden of disease associated with valvular heart disease is expected to increase over the next several decades.[1)] Rheumatic valvular disease in young adults and aortic stenosis, mitral regurgitation, and aortic regurgitation in the older adults are common valvular diseases worldwide.[2)] In developed countries, aortic stenosis and mitral regurgitation are showing increased prevalence as populations age, and chronic hypertension, atherosclerosis, and other cardiovascular diseases are becoming more common.[1)] In developing countries, the prevalence of rheumatic valvular disease is increasing, likely caused by decreased premature mortality that has resulted from improved availability of antibiotics and echocardiography.[1)] Aortic valve disease is associated with aging and chronic cardiovascular disease, accounting for 61% of deaths caused by valvular heart disease.[1)] Surgical valve replacement for aortic valve disease has been reported to reduce symptoms and improve survival.[3–5)] In Japan, the

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need for treatment of valvular heart disease is increasing; among cardiac surgery cases, the number of valve surgery cases is the highest.[6]

More than 50% of patients hospitalized for valvular heart disease developed hospitalization-associated disability (HAD), 90% of whom underwent surgery.[7] Fifty percent of patients who begin walking more than 6 days after surgery develop HAD, suggesting that early rehabilitation is significant for HAD prevention.[8] In cases of acute heart failure, early rehabilitation is associated with maintenance of the Barthel Index (BI).[9] Starting rehabilitation within 3 days following coronary artery bypass graft (CABG) surgery has been reported to improve activities of daily living (ADL) at discharge.[10] However, the effectiveness of early rehabilitation has not been reported in the postoperative period for valvular heart disease. In general, early and aggressive rehabilitation is performed in the intensive care unit (ICU).[11,12] Early rehabilitation in the ICU is safe and effective in maintaining ADL.[13] In patients undergoing CABG surgery, early postoperative rehabilitation was effective in improving ADL at discharge.[10] Although early postoperative rehabilitation for valvular heart disease is widespread,[14] the disadvantages of delayed rehabilitation are unknown. This study aimed to determine whether delayed rehabilitation affects patient outcomes after waiting for surgery for valvular heart disease.

MATERIALS AND METHODS

Study Design and Data Source

This retrospective cohort study used a hospital-based database developed by JMDC. As of June 2023, the JMDC database contained Diagnosis Procedure Combination (DPC) survey data of approximately 16 million cases from 830 participating hospitals.[15] Data including administrative claims and some clinical details were collected for all inpatients discharged from the participating hospitals. The following patient data are included in the database: age, sex, diagnosis, and comorbidities recorded in the International Statistical Classification of Diseases, 10th Revision (ICD-10) codes. The attending physicians recorded all diagnoses and comorbidities. In previous studies using the DPC database, the specificity of medical record data for diagnosis exceeded 96%, with 50%–80% sensitivity.[16] The overall diagnostic validity was high, suggesting that it can be a relatively accurate surrogate for clinical data.

Participants

Patients admitted to the participating hospitals between April 2017 and December 2022 and had a valvular heart disease diagnosis (ICD-10 codes K554 and K555) were selected. Patients who underwent surgery for valvuloplasty and valve replacement within 5 days of admission were included. The following exclusion criteria were used: admitted to the emergency department; did not start rehabilitation within 5 days postoperatively; underwent transcatheter valve therapy; missing BI score; underwent surgery after 5 days of admission; underwent coronary artery bypass grafting or multiple heart surgery, including coronary artery bypass grafting. Patient characteristics were compared between the group that started rehabilitation within 2 days postoperatively (usual rehabilitation group) and the group that started rehabilitation at 3–5 days postoperatively (delayed rehabilitation group). For each group, rehabilitation was initiated and supervised by a physical or occupational therapist. The database used in this study is an administrative claims database. In Japan, costs for rehabilitation services lasting more than 20 min are reimbursed by national health insurance. Therefore, we only used data on the number and date of provision of rehabilitation services. The Ethics Committee of Mie University determined that no ethical review was required for studies using the JMDC database, because this database is generally available and widely used in research. Because the JMDC provided deidentified and unlinked data, informed consent was not required.

Outcomes

To evaluate independence at admission and discharge, ADL status was measured using the BI, which is a 10-item scale that measures the ability to eat, groom, bathe, toilet, dress, walk, transfer, and climb stairs as well as the status of fecal and urinary incontinence. The BI is calculated by adding 5, 10, or 15 points for each variable (final score=0–100 points). In this study, the primary outcome was HAD; that is, the proportion of patients who showed a decline in BI during hospitalization.[17] Secondary outcomes were BI at discharge, pulmonary complications following hospitalization, and postoperative complications including pneumonia, pressure ulcers, and deep vein thrombosis.

Statistical Analysis

Continuous data were presented as mean ± standard deviation, and differences were analyzed using Student's *t*-test. Categorical data were presented as percentages, and differences were analyzed using the χ^2 test. One-to-one propensity score (PS) matching was performed between the usual and delayed rehabilitation groups, and the PS was calculated us-

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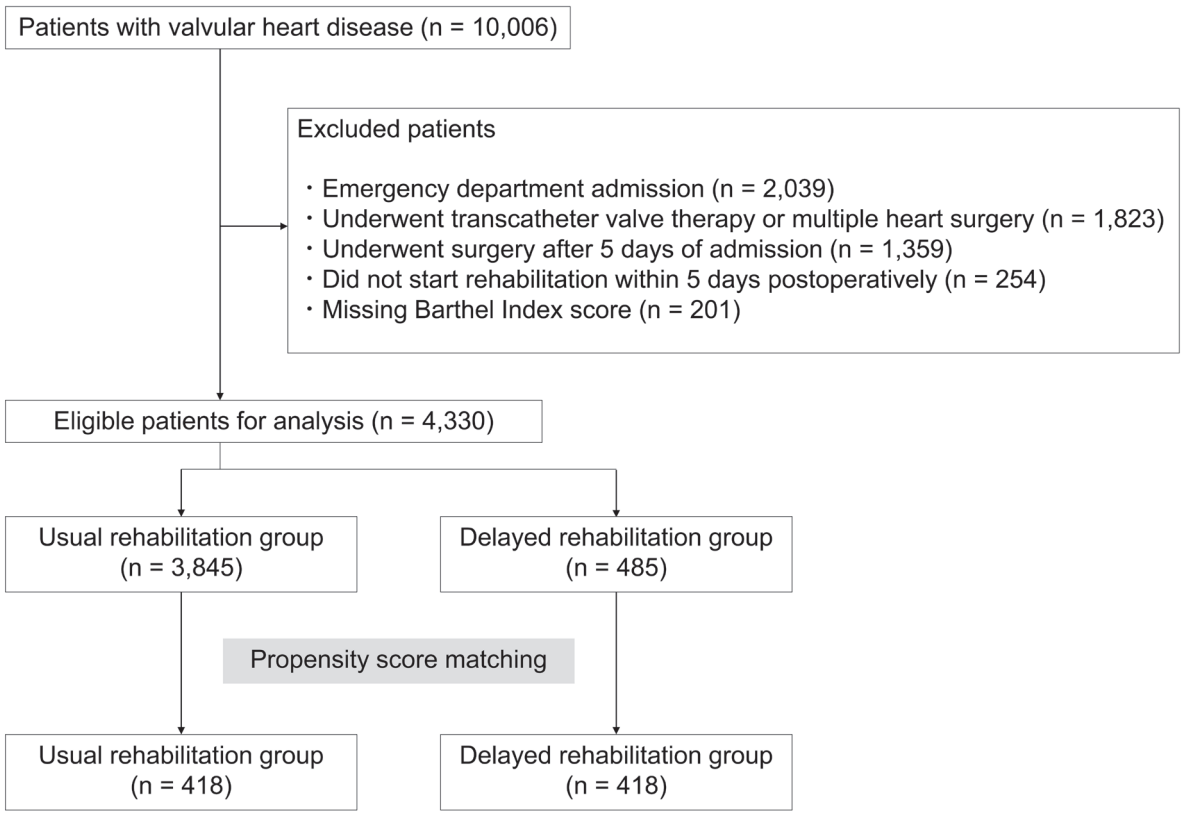

Fig. 1. Flowchart of patient selection.

ing a multivariate logistic regression model with the following independent variables: sex, age, BI on admission, ICU length of stay, days on ventilator, Hospital Frailty Risk Score (HFRS), body mass index, year of admission, number of beds, atrial fibrillation as comorbidity at admission (ICD10: I480–I489), chronic kidney disease (ICD10: N181–N189), and heart failure (ICD10: I110, I500, I501, and I509). In addition to one-to-one PS matching, nearest neighbor matching was performed using a caliper of 0.2 standard deviations from the pooled PS.

HFRS is a scale for frailty risk assessment using a weighted score based on the ICD-10. A high HFRS indicates a high frailty risk.[18] The HFRS is highly consistent with scores on common frailty rating scales and can predict adverse events, including in-hospital death and readmission, in patients with heart failure, pneumonia, hip fracture, vertebral compression fracture, and COVID-19, which are common in the older adult population.[19–22]

The threshold for statistical significance was $P<0.05$. Statistical analyses were performed using Statistical Package for the Social Sciences version 30 (IBM, Armonk, NY, USA).

RESULTS

During the study period, 10,006 patients hospitalized for valvular heart disease were identified from the JMDC database. After applying the exclusion criteria, 4330 patients with valvular heart disease were eligible for this study (**Fig. 1**).

The patient characteristics are summarized in **Table 1**. Before PS matching, 3845 patients were included in the usual rehabilitation group and 485 patients were included in the delayed rehabilitation group. Patients in the delayed rehabilitation group had significantly higher HFRS and longer ICU stay than those in the usual rehabilitation group. After PS matching, the usual rehabilitation group and the delayed rehabilitation group each contained 418 patients. The baseline patient characteristics were well balanced between the groups.

The outcomes are summarized in **Table 2**. Before PS matching, patients in the delayed rehabilitation group had significantly lower BI at discharge, more pulmonary complications (14.6% vs 8.2%), more postoperative complications, and higher HAD incidence (10.9% vs 5.9%) than those in the

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Table 1. Patient characteristics

Characteristic	Unmatched groups		P value	Propensity score-matched groups		P value
	Usual rehabilitation (n=3845)	Delayed rehabilitation (n=485)		Usual rehabilitation (n=418)	Delayed rehabilitation (n=418)	
Male sex	2180 (56.7)	273 (56.3)	0.864	227 (54.3)	235 (56.2)	0.578
Age, years	69.5 ± 11.8	68.3 ± 13.2	0.05	69.6 ± 11.9	68.8 ± 12.6	0.173
BMI, kg/m^2	22.6 ± 3.2	22.9 ± 3.4	0.081	22.8 ± 3.1	22.9 ± 3.4	0.323
BI at admission	98.5 ± 8.7	97.7 ± 10.8	0.104	97.8 ± 10.8	97.7 ± 10.7	0.439
HFRS	1.3 ± 2.0	1.6 ± 1.8	0.001	1.5 ± 2.3	1.6 ± 1.8	0.251
Alb, g/dL	3.5 ± 0.9	3.4 ± 1.0	0.697	3.5 ± 0.8	3.4 ± 0.9	0.358
Hb, g/dL	12.0 ± 2.3	11.6 ± 2.0	0.174	11.8 ± 2.3	11.5 ± 2.1	0.229
ICU LOS, days	3.4 ± 2.6	3.7 ± 2.3	0.029	3.4 ± 3.1	3.6 ± 2.3	0.095
Time on ventilator, days	1.6 ± 3.3	1.7 ± 3.6	0.403	1.5 ± 2.4	1.6 ± 3.7	0.218
Year of admission						
2017	233 (6.1)	14 (2.9)	0.016	15 (3.6)	14 (3.3)	0.872
2018	615 (16.0)	64 (13.2)		58 (13.8)	52 (12.4)	
2019	810 (21.1)	101 (20.8)		90 (21.5)	85 (20.3)	
2020	798 (20.8)	111 (22.9)		91 (21.8)	95 (22.7)	
2021	785 (20.4)	102 (21.0)		94 (22.5)	89 (21.3)	
2022	604 (15.7)	93 (19.2)		70 (16.7)	83 (19.9)	
Number of beds						
20–99	176 (4.6)	11 (2.3)	<0.001	27 (6.5)	9 (2.2)	0.037
100–199	200 (5.2)	84 (17.3)		63 (15.1)	69 (16.5)	
200–299	335 (8.7)	2 (0.4)		2 (0.5)	2 (0.5)	
300–499	1283 (33.4)	156 (32.2)		136 (32.5)	130 (31.1)	
500–	1851 (48.1)	232 (47.8)		190 (45.5)	208 (49.8)	
Hospital LOS, days	21.0 ± 10.6	21.7 ± 11.3	0.202	21.0 ± 10.9	21.6 ± 11.6	0.211
Atrial fibrillation	835 (21.7)	126 (26.0)	0.033	94 (22.5)	106 (25.4)	0.331
CKD	110 (2.9)	8 (1.6)	0.123	8 (1.9)	6 (1.4)	0.59
Heart failure	895 (23.3)	128 (26.4)	0.128	98 (23.4)	112 (26.8)	0.264

Data given as number (percentage) or mean ± standard deviation.
BMI, body mass index; BI, Barthel index; HFRS, Hospital Frailty Risk Score; Alb, albumin; Hb, hemoglobin; ICU, intensive care unit; LOS, length of stay; CKD, chronic kidney disease.

usual rehabilitation group. After PS matching, patients in the delayed rehabilitation group had more pulmonary complications (14.8% vs 11.2%) and higher HAD incidence (10.5% vs 8.1%) than those in the usual rehabilitation group.

DISCUSSION

We used data from a nationwide database to investigate the association between delayed postoperative rehabilitation and outcomes in patients that were hospitalized and had surgery for valvular heart disease. In postoperative patients with valvular heart disease, delayed early rehabilitation was associated with higher incidence of pulmonary complications and HAD when compared with usual rehabilitation.

In post-CABG and post-aortic surgery, early rehabilitation within 3 days postoperatively was associated with improved ADL at discharge, shorter ICU stay, and shorter hospital stay.[10,23] In this study, the delayed rehabilitation group had a higher incidence of HAD, which was consistent with the results of previous studies that showed early rehabilitation leads to better outcomes. However, in our study, the timing of rehabilitation was not associated with the length of hospital stay. Ventilator use time is associated with the ICU length of stay and hospital length of stay.[24] Herein, the difference in ICU stay was only 0.2 days, and no difference in ventilator use time was observed between the delayed and usual rehabilitation groups. Therefore, both groups were considered stable, and the timing of the initiation of rehabilitation had

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Table 2. Comparison of outcomes

Outcome	Unmatched groups		P value	Propensity score-matched groups		P value
	Usual rehabilitation (n=3845)	Delayed rehabilitation (n=485)		Usual rehabilitation (n=418)	Delayed rehabilitation (n=418)	
BI at discharge	97.7 ± 11.2	95.6 ± 14.8	0.003	96.8 ± 14.2	96.0 ± 13.9	0.209
Pulmonary complications	284 (7.4)	71 (14.6)	<0.001	32 (7.7)	62 (14.8)	0.001
Postoperative complications	3.1 ± 2.3	3.7 ± 2.0	<0.001	3.4 ± 2.4	3.8 ± 2.0	0.019
HAD	201 (5.2)	53 (10.9)	<0.001	24 (5.7)	44 (10.5)	0.011

Data given as number (percentage) or mean ± standard deviation.
BI, Barthel index; HAD, Hospitalization-associated disability.

little impact on the length of hospital stay.

Pulmonary complications frequently occur following cardiac surgery.[25] Postoperative complications occur in 58% of postoperative cardiac surgery patients, which delay hospital discharge and functional recovery.[26] Postoperative pulmonary complications would reduce BI at discharge. In the present study, the delayed rehabilitation group had more pulmonary complications and higher HAD incidence, suggesting that delayed rehabilitation can lead to pulmonary complications and HAD.

Because no difference was observed between the usual and delayed rehabilitation groups for the length of ICU stay or the number of days on a ventilator, disease severity was not the main reason for delayed rehabilitation. Facility and doctor preferences, surgery on weekends, and other factors may be the primary causes of delayed rehabilitation.

In the study of Sezai et al.,[14] early rehabilitation of postoperative patients with valvular heart disease was reported to increase BI at discharge and reduce the length of hospital stay, suggesting the effectiveness of early rehabilitation. Their study included emergency admissions and those who underwent multiple surgeries. We limited our study to patients waiting for surgery and excluded those who underwent multiple surgeries. Previous studies probably included more severely ill patients than ours. A previous study included patients who had surgery within 2 weeks of admission and those who started rehabilitation within 2 weeks after surgery. In contrast, our study included patients who had surgery within 5 days of admission and those who started rehabilitation within 5 days after surgery. We unified the severity of illness in patients and set a short postoperative rehabilitation initiation period to investigate the negative effects of even a slight delay in rehabilitation.

Following cardiac surgery, patients with impaired physical function not only develop HAD but also have high readmission rates.[27] Among patients with HAD, less than 50% of older adults recover to their premorbid ADL within 1 year of hospital discharge, with high nursing home placement and death rates.[28,29] HAD is a poor prognostic factor, and HAD prevention is significant. Delayed postoperative rehabilitation may increase HAD and decrease life expectancy. Therefore, preventing delayed rehabilitation is a feasible alternative for improving the quality of care in acute care.

The findings of this study suggest that delayed postoperative rehabilitation is detrimental. However, owing to various barriers, some hospitals are unable to implement early rehabilitation.[30] These barriers may include structural barriers, such as limited staff and equipment, and cultural barriers, such as a lack of mobilization culture and early rehabilitation not being a priority. Given that surgery is frequently performed on Thursdays or Fridays, weekend rehabilitation may be necessary for providing early rehabilitation. In addition, we consider that there is further need for risk assessment of ADL decline, rehabilitation for selected high-risk patients, training of therapists, and interprofessional education.

This study has some limitations. First, we could not adjust for variables not included in the database. Therefore, the effects of unmeasured confounders, including intraoperative findings and cardiac function, may be present. Cardiac function at baseline could influence postoperative management and outcomes, which could be a confounding factor in this study. We adjusted for preoperative heart failure, so the impact of heart function may have been reduced somewhat, although the lack of data is a limitation of this study. Second, given that data were not available after discharge, we were unable to analyze long-term outcomes after discharge. Furthermore, we did not have detailed information on the rehabilitation programs or demographics of the therapists who provided the rehabilitation. Despite these limitations, this study showed that delayed rehabilitation was associated

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with an increased incidence of pulmonary complications and HAD among postoperative patients with valvular heart disease.

CONCLUSION

To widely disseminate early rehabilitation to postoperative patients with valvular heart disease, we believe that further training of therapists should be considered. Furthermore, to determine the appropriate number of therapists to be employed, research on the cost-effectiveness of early rehabilitation with outcomes such as preventing readmission is needed. To confirm the effect of early rehabilitation on postoperative patients with valvular heart disease, further studies including randomized controlled trials are warranted. Delayed postoperative rehabilitation may be detrimental to the prognosis of patients with valvular heart disease.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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