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Original Article

Changes in the amount of physical activity in minimally invasive cardiac surgery

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Abstract. [Purpose] This study aimed to compare the amount of physical activity in a minimally invasive cardiac surgery (MICS) group with that in a conventional surgery (median sternotomy) group. [Subjects and Methods] Between November 2010 and December 2011, 39 consecutive patients who underwent elective surgery for valvular disease were prospectively enrolled. The amount of physical activity before and after surgery was measured in 22 cases. The daily in-hospital physical activity level was measured continuously using a triaxial accelerometer. The results were compared in terms of change in the amount of physical activity pre- and postoperatively. [Results] There was no significant difference between the two groups in the amount of physical activity before surgery. However, the amount of physical activity after surgery was significantly higher in the MICS group compared with the conventional surgery group. The number of steps after surgery was significantly increased in the MICS group, and the rate of change in the amount of physical activity was significantly higher in the MICS group than that in the conventional surgery group. [Conclusion] The MICS approach is associated with improvement in postoperative physical activity over median sternotomy.

Key words: Minimally invasive cardiac surgery, Physical activity, Postoperative rehabilitation

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INTRODUCTION

There have been many reports relating to the amount of physical activity and cardiac disease, and it has become apparent that an increase in the amount of physical activity reduces the incidence of cardiovascular disease and the mortality rate[1, 2)]. In the study by Takahashi et al. on the amount of physical activity after cardiac surgery[3)], and in our previous survey on the amount of physical activity after bypass surgery in patients with peripheral artery disease[4)], the amount of physical activity during postoperative hospitalization was related to the incidence of cardiovascular events after discharge, and the rate of readmission. Hence, the amount of physical activity during postoperative hospitalization may be related to prognosis after cardiac surgery, and evaluation of postoperative physical activity can be an important indicator of the appropriate amount of physical activity.

With recent advances in medical technology and improvements in perioperative management, minimally invasive cardiac

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surgery (MICS) is increasingly popular. MICS is characterized by a smaller intercostal mini-thoracotomy compared to the conventional median sternotomy, and it confers the following benefits during the postoperative process: decreased duration of mechanical ventilation, shortened intensive care unit (ICU) and hospital stays, decreased blood loss and blood transfusion rates, and shortened postoperative recovery time[5–7]. As MICS is less invasive, the quicker postoperative recovery potentially allows patients who underwent MICS to maintain higher levels of physical activity compared to those who underwent conventional median sternotomy. However, there have been no reports on the amount of physical activity during postoperative hospitalization following MICS. Establishing the amount of physical activity during hospitalization is important for determining the appropriate amount of physical activity following MICS. The aim of this study was to compare the amount of physical activity in patients who underwent MICS with those who underwent conventional median sternotomy surgery.

SUBJECTS AND METHODS

Between November 2010 and December 2011, 39 consecutive patients who underwent elective surgery for valvular disease were prospectively enrolled in the study. Seventeen patients were excluded from this study because they were not independent in activities of daily living (ADL) before surgery, their physical activity was restricted before surgery, or they recorded 1,000 or fewer steps before surgery. In the remaining 22 patients (16 males and 6 females, age 64.5 ± 10.0 years, height 163.9 ± 8.3 cm, weight 63.7 ± 12.2 kg, BMI 23.5 ± 3.0), the amount of physical activity was measured before and after surgery. The patients were then categorized into two groups based on the surgical procedure, the MICS group (n=16), and the conventional (median sternotomy) group (n=6). The changes in, and the factors influencing, the amount of physical activity after surgery, were analyzed and compared between the two groups.

The cardiac rehabilitation program for all patients before and after surgery complied with The Japanese Circulation Society Guidelines for Rehabilitation in Patients with Cardiovascular Disease (JCS 2007)[8]. Preoperative instructions, including breathing exercises, were given to all patients in terms of the target for mobilization postoperatively, and all patients were instructed regarding the amount of physical activity. The target of independent walking within the ward by the eighth postoperative day was in accordance with the guidelines. Once independent walking, within the ward, was achieved, patients performed aerobic exercises using a bicycle ergometer every day until discharge.

A triaxial accelerometer (Active Style Pro, Omron, Japan) was used to measure physical activity, and the total number of steps per day was adopted as the index for the amount of physical activity. The triaxial accelerometer was attached to the waist and the measurements collected continuously from the day after admission, until the day before discharge, excluding during bathing or medical tests. The preoperative amount of physical activity was calculated as the mean number of steps per day, from the day after admission until the day before surgery. The postoperative amount of physical activity was calculated as the mean number of steps per day from the day of achieving a 100 m independent walk, until the day before discharge. Physical activity analysis software (Bi-Link Physical Activity Professional Edition Version 1.0, Omron, Japan) was used to analyze the amount of physical activity.

The χ^2 test and unpaired t-test were used to analyze patient characteristics, and the paired t-test was used to analyze the amount of physical activity before and after surgery. The rate of change after surgery was calculated using the formula: (postoperative mean number of steps − the preoperative mean number of steps)/preoperative mean number of steps ×100 (%). Software (SPSS Statistics Version 23.0, IBM Corporation) was used for statistical analysis, and the level of statistical significance was set as 5%.

This study was undertaken with the approval of The Sakakibara Heart Institute of Okayama ethical review board (Approval number: 20100901). Written informed consent was obtained from all patients participating in the study.

RESULTS

The patient characteristics are shown in Table 1. In the MICS group, age was significantly younger (60.7 ± 8.3 vs. 74.5 ± 6.5 years, $p<0.001$) and the incidence of diabetes mellitus was significantly lower (0 vs. 2, $p<0.05$). The preoperative cardiac and renal functions were significantly better in the MICS group than in the conventional group (left ventricular ejection fraction 65.4 ± 11.5 vs. 55.0 ± 16.3%, $p<0.05$; serum creatinine 0.8 ± 0.1 vs. 1.1 ± 0.3 mg/dl, $p<0.001$; estimated glomerular filtration rate 81.6 ± 16.6 vs. 53.7 ± 12.7 ml/min/1.73 m^2, $p<0.001$). Significant differences were found in terms of surgical procedures ($p<0.05$). The maximum level of C-reactive protein in the MICS group, reflecting postoperative inflammatory response, was significantly lower than in the conventional group (14.8 ± 6.2 vs. 19.8 ± 2.7 mg/dl, $p<0.05$).

Postoperative rehabilitation data is shown in Table 2. Postoperative progress was quicker in the MICS group than in the conventional group (day of standing at the bedside 1.3 ± 0.4 vs. 1.8 ± 0.8 days, $p<0.05$; and 100-m independent walking 3.6 ± 1.0 vs. 5.7 ± 1.9 days, $p<0.01$). There was no significant difference in the length of hospital stay.

The amount of physical activity in both groups before and after surgery is shown in Table 3. The mean days of analysis for the amount of physical activity was 1.4 ± 0.7 days before surgery, and 11.7 ± 5.1 days after surgery. There was no significant difference in the number of preoperative daily steps between the two groups. The number of daily steps showed a significant increase in the MICS group (preoperative 2,740.4 ± 1,330.2 vs. postoperative 3,536.8 ± 1,885.3, $p<0.05$), but was decreased in the conventional group (2,889.9 ± 1,106.0 vs. 2,014.3 ± 1,579.6, $p=0.08$). The rate of changes in amount of physical activity in both group is shown in table 4. This meant the rate of change in daily steps, pre- and postoperatively, was significantly

Table 1. Patient characteristics and surgical data

	MICS group (n=16)	Conventional group (n=6)
Age (years)	60.7 ± 8.3	74.5 ± 6.5***
Gender (male/female)	11/5	5/1
Body mass index (kg/m^2)	23.5 ± 3.3	23.7 ± 2.1
Co-morbidity		
Hypertension	9 (56)	5 (83)
Dyslipidemia	4 (25)	2 (33)
Diabetes mellitus	0 (0)	2 (33)*
Preoperative cardiac function		
LVEF (%)	65.4 ± 11.5	55.0 ± 16.3*
LVDd (mm)	53.4 ± 7.1	56.8 ± 7.1
Preoperative renal function		
Serum creatinine (mg/dl)	0.8 ± 0.1	1.1 ± 0.3***
eGFR (ml/min/1.73 m^2)	81.6 ± 16.6	53.7 ± 12.7***
Surgical procedure		
Isolated valve replacement	7 (41.2)	2 (33.3)*
Valvuloplasty	7 (41.2)	0 (0)
Combined surgery	2 (17.6)	4 (66.7)
Time of surgery (min)	246.8 ± 33.6	241.8 ± 25.5
Blood loss during surgery (ml)	390.0 ± 215.0	518.3 ± 173.5
Postoperative inflammation		
Maximum level of WBC (μl)	12,717.6 ± 4,116.8	15,160 ± 3,740.7
Maximum level of CRP (mg/dl)	14.8 ± 6.2	19.8 ± 2.7*

CRP: C-reactive protein; eGFR: estimated glomerular filtration rate; LVDd: left ventricular end-diastolic dimension; LVEF: left ventricular ejection fraction; MICS: minimally invasive cardiac surgery; WBC: white blood cell count
*p<0.05, **p<0.01, ***p<0.001

Table 2. Postoperative rehabilitation data

	MICS group	Conventional group
Standing at the bed side (POD)	1.3 ± 0.4	1.8 ± 0.8*
Walking around the bed (POD)	2.5 ± 0.6	2.3 ± 0.5
100 m independent walking (POD)	3.6 ± 1.0	5.7 ± 1.9**
Length of hospital stay (days)	16.4 ± 4.7	20.3 ± 7.8

POD: postoperative days
*p<0.05, **p<0.01

Table 3. The amount of physical activity before and after surgery

	MICS group	Conventional group
The amount of physical activity before surgery (steps/day)	2,740.4 ± 1,330.2	2,889.9 ± 1,106.0
The amount of physical activity after surgery (steps/day)	3,536.8 ± 1,885.3*	2,014.3 ± 1,579.6

*The amount of physical activity: before surgery vs. after surgery, p<0.05

Table 4. The rate of changes in amount of physical activity

	MICS group	Conventional group
The rate of changes in amount of physical activity (%)	39.3 ± 58.5	–34.3 ± 44.7*

*p<0.01

higher in the MICS group than the conventional group (39.3 ± 58.5 vs. −34.3 ± 44.7%, p<0.01).

DISCUSSION

Minimally invasive valve surgery via intercostal mini-thoracotomy has some advantages in terms of postoperative physical activity, such as early recovery towards normal activity and improved quality of life during hospitalization[9]. However,

there are no reports regarding the amount of physical activity following MICS. To our knowledge, this is the first study evaluating the recovery of physical activity after MICS, looking particularly at the amount of activity.

Although there was no significant difference between the two groups in time to the day of walking around the bed, 100 m independent walking was significantly earlier in the MICS group. This result was compatible with a previous study comparing the clinical progress of elderly patients following minimally invasive mitral valve surgery and conventional surgery[10]. The reduction in invasiveness from avoiding sternotomy is the main contribution to earlier start of independent walking in the MICS group. Furthermore, the day of standing at the bedside was also earlier in the MICS group. This result might indicate the possibility of the prompt increase in the amount of physical activity after surgery.

There was a significant difference in physical activity between the two groups postoperatively. In the MICS group, the amount of physical activity increased postoperatively by 39.3%, while in the conventional group it decreased by 34.4%. Hence, there was a significant difference in the rate of change in the amount of perioperative physical activity between the two groups. With active rehabilitation interventions in both groups of patients, the data showed no significant difference in the day of walking around the bed. Despite this, our results showed that patients who underwent conventional surgery did not achieve the same amount of physical activity as preoperatively. In contrast, patients who underwent MICS achieved amounts of physical activity, by the time of discharge, which were higher than those at the time of admission. The indicated patient in the MICS group was active throughout the day, in addition to scheduled rehabilitation time. In contrast, the patient in the conventional group was relatively sedentary, although the amount of steps in scheduled rehabilitation time was almost the same. Thus, the significant difference in the amount of postoperative physical activity is the result of physical activity outside of scheduled rehabilitation time. The surgical invasiveness of sternotomy was shown by the significantly lower maximum levels of CRP in the MICS group compared with the conventional group. The invasiveness of a sternotomy may have a larger effect on postoperative recovery of physical activity than the valve surgery as such. In addition, previous research demonstrated that patients undergoing MICS had little postoperative pain and a faster return to normal activity[11]. Therefore, the decrease in pain might be another factor contributing to the increase in the amount of postoperative physical activity.

Our study has some limitations. This was a prospective study; however, the sample size was small and significant differences were found in some patient characteristics. Selection bias might have some impact on the results. To evaluate the efficacy of MICS on the amount of physical activity, a propensity-score matched study with a larger sample size is required, with parameters investigated in more detail.

In conclusion, the minimally invasive cardiac surgery can effectively prevent the decrease in the amount of physical activity after conventional surgery.

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