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Effect of minimally invasive cardiac surgery compared with conventional surgery on post-operative physical activity and rehabilitation in patients with valvular heart disease

Hossam salaheldin Abdelmohsen Labib[1*], Shereen I. Fawaz[1], Mohamed El Ghanam[2] and Moustafa Gamal ELBarbray[2]

Abstract

Background Minimally invasive cardiac surgery (MICS) has steadily become more and more popular. MICS is less invasive and has a faster return to normality after surgery. Patients who had MICS continue to exercise more frequently than those who had the conventional median sternotomy surgery. It is generally established that physical activity lowers mortality and the risk of cardiac disease. The purpose of the study: is to evaluate and compare physical activity levels in MICS and conventional surgery.

Result The level of preoperative physical activity did not significantly differ between the two groups. However, the MICS group significantly exceeded the conventional group in terms of postoperative progress, amount of physical activity, and 6-minute walking test. Also, Visual Analog Scale (VAS) score was significantly less.

Conclusion Minimally invasive cardiac surgery has a higher margin of benefit, and speedy recovery to normality, which is accompanied by a lower VAS score and increased physical activity in comparison to conventional surgery.

Keywords Physical activity, 6-minute walking test, Postoperative cardiac surgery rehabilitation, Minimally invasive cardiac surgery

Background

Minimally invasive cardiac surgery (MICS) refers to procedures that require only a small chest incision. Additionally, MICS minimizes the need for blood products, shortens the duration of mechanical ventilation, decreases hospital stays, and reduces postoperative discomfort [1]. Over the past 20 years, MICS procedures have become more common. Such procedures are carried out through tiny incisions, which restrict visibility and the surgeon's range of motion in comparison to conventional techniques. As a result, two-dimensional or three-dimensional thoracoscopic cameras are frequently used to improve visibility. The MICS needs a well-trained skilled surgeon [2].

The prognosis after cardiac surgery is correlated with the level of postoperative physical activity and the level of activity during hospitalization. There has been an increase in interest in measuring physical activity,

*Correspondence:
Hossam salaheldin Abdelmohsen Labib
dr.sam789@yahoo.com; hossam_salah@med.asu.edu.eg
[1] Physical Medicine, Rheumatology and Rehabilitation Department, Ain Shams University, Cairo, Egypt
[2] Cardiothoracic Surgery department, Ain Shams University, Cairo, Egypt

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and numerous subjective and objective methods have been developed [3].

In this study, we aimed to assess and compare the amount of physical activity in patients who had MICS versus those who had conventional surgery.

Subjects and methods

The trial was prospectively authorized by the FMASU (faculty of medicine Ain Shams University) Research Ethics Committee (R 65/2022), and when it was retroactively submitted to the Pan African Clinical Trial Registry (PACTR), the registration number was PACTR202209591144366.

Our study abided by the Declaration of Helsinki; patients gave informed written consent and were aware of the procedure. This prospective comparative study included 60 patients who had elective mitral valve repair and were recruited from the authors' institution's cardiothoracic department between May 2020 and May 2022. Ten patients did not complete the study (two patients died after surgery and eight patients refused to use the triaxial accelerometer after the surgery). Patients who had not been dependent on their daily activities (ADL) before the operation or who recorded 1,000 steps or fewer before the operation were excluded.

According to the surgical procedure, the patients were divided into two groups: MICS and conventional surgery (median sternotomy). The MICS group received mitral valve replacement through a right small thoracotomy incision (less than 10 cm) using femoral arterial and venous cannulation, however, the conventional surgery group underwent a median sternotomy and central cannulation to replace the mitral valve.

All patients received the same basic rehabilitation program that followed the Japanese Circulation Society Guidelines [4].To improve postoperative mobility, all patients received preoperative physical exercise and breathing exercises. Walking independently within the ward was completed by the eighth day postoperatively, according to the guidelines. The patients had daily aerobic training on a bicycle and treadmill, as well as unassisted walking throughout the hospital until they were discharged.

All the participants were subjected to (i) measurement of the pre and post-operative physical activity (ii) Postoperative Assessment: using a Visual Analogue Scale (VAS), the day of standing at the bedside, and the day on which the subject had the ability to walk independently for 100 m (iii) 6-Minute Walk Test before and after surgery.

Measurement of the pre and post-operative physical activity

It was measured by a triaxial accelerometer (Active Style Pro, Omron, Japan). The daily average steps were recorded and served as an indicator of physical activity measurements. The accelerometer was left in place around the waist and measurements were taken every day from the hospitalization time to discharge, with the exception of bathing and diagnostic testing. The preoperative activity was calculated using the daily average number of steps from the day of hospitalization to the day of surgery. The postoperative activity was calculated using the average number of steps taken from the day the patient could perform a 100-meter unassisted walk until the day of the discharge [5].

Visual analog scale (VAS)

For postoperative pain was done seven days after reaching a 100 m independent walk; zero represents (lack of pain) and ten denotes (pain) (maximum feeling the pain). VAS is a reliable and acceptable tool for assessing pain [6].

6-minute walk test (6-MWT)

Was conducted on a 30-meter corridor in accordance with recommendations from the American Thoracic Society. It was done one day prior to surgery and seven days following the completion of a 100-meter independent walk. The patients were instructed to walk in a quiet manner for six minutes. Ordinary verbal instructions were softly delivered each minute, and every 15 seconds inside the last minute, the remaining time was revealed [7]. When signs or symptoms such as severe dyspnea, confusion, exhaustion, chest pain, or significant musculoskeletal pain appeared, patients were instructed to stop and then resume testing until the sex minute was reached. Furthermore, the test was terminated once the Borg scale reached 15 or more out of 20 [8].The distance was measured in meters and the heartbeat and rhythm were checked using an ECG [8]. The Borg scale is a reliable indicator for monitoring and guiding exercise intensity. The scale allows individuals to descriptively rate their level of exertion throughout the activity or exercise testing, with 6 indicating "no exertion at all" and 20 indicating "maximal exertion" [9].

Statistical analysis

The Statistical Package for Social Science (IBM SPSS) version 23 was used to collect, edit, code, and enter the data for statistical analysis. When the quantitative data were parametric, they were displayed as means, standard deviations, and ranges; when they were non-parametric,

Table 1 Demographic data and the patient characteristics and surgical data

		Conventional surgery group No. = 25	MICS group No. = 25	Test value	P-value	Sig.
Age	Mean ± SD	49.08 ± 12.91	48.68 ± 12.77	0.110•	0.913	NS
	Range	26 – 68	22 – 70			
Gender	Female	16 (64.0%)	12 (48.0%)		0.254	NS
	Male	9 (36.0%)	13 (52.0%)	1.299*		
Body mass index	Mean ± SD	26.41 ± 4.62	26.50 ± 4.31		0.947	NS
	Range	19.3 – 36	18.3 – 34	-0.066•		
Diabetes mellitus	No	21 (84.0%)	20 (80.0%)		0.713	NS
	Yes	4 (16.0%)	5 (20.0%)	0.136*		
Hypertension	No	13 (52.0%)	14 (56.0%)		0.777	NS
	Yes	12 (48.0%)	11 (44.0%)	0.081*		
Liver disease	No	22 (88.0%)	22 (88.0%)		1.000	NS
	Yes	3 (12.0%)	3 (12.0%)	0.000*		
LVEF	Mean ± SD	59.08 ± 9.18	60.40 ± 8.86	-0.517•	0.607	NS
	Range	39 – 71	38 – 72			
LVDd (mm)	Mean ± SD	51.56 ± 9.01	52.88 ± 7.37	-0.567•	0.573	NS
	Range	33 – 70	39 – 66			

LVEF: Left ventricular ejection fraction, *LVDd*: Left ventricular end-diastolic dimension

MICS: Minimally invasive cardiac surgery

P is significant at ≤ 0.05, *P* is non-significant at > 0.05

*:Chi-square test; •: Independent t-test

they were displayed as medians and interquartile ranges (IQR). Numbers and percentages were also displayed for the qualitative factors. Based on qualitative data, groups were compared using the Chi-square test. Two independent groups with parametric distribution and quantitative data were compared using an independent t-test. The Mann-Whitney test for nonparametric distribution was used. the P-value was considered significant at the level of ≤ 0.05.

Results

A Prospective comparative study. Prospectively recruited 50 patients who had elective mitral valve surgery and were divided into MICS group and Conventional surgery group.

I Demographic data and the preoperative data

There were no significant differences in age, height, weight, or preoperative cardiac functioning across groups. (Table 1).

II. Result of VAS, pre and post-operative physical activity Assessment

The group of MICS recovered quicker than the group of conventional surgery (postoperative standing day at the bedside was 1.84 ± 0.37 vs. 2.28 ± 0.68, t =2.840, *P*= 0.007) and postoperative 100-m independent walking was 3.24 ± 0.72 vs 5.08 ± 0.70 days, t =9.12, *P*<0.001). In addition, MICS group showed significantly less postoperative VAS compared to the group of Conventional surgery group (t= -5.352 , *P*<0.001) (Table 2). Before and after surgery, the two groups' physical activity levels were measured (Figure 1&2). There was no significant difference between the two groups as regards the preoperative daily step number. However, in MICS group, the number of daily steps increased significantly (preoperative 2,740 ± 1,330 vs. postoperative 3,536 ± 1,885) with a significantly faster improvement rate than the other group (793.2± 543.2 vs. 181.9 ± 205, t= -4.569, *P*<0.001)(Table 3).

III. The result of the 6-Minute Walk Test

The preoperative test revealed no significant difference between them. The MICS group scored significantly higher improvement (preoperative 346.72 ± 55.76 vs. postoperative 506.56 ± 86.9, *P*< 0.001) (Table 4).

Discussion

In our research, the MICS group showed significantly less post-operative VAS compared to the conventional surgery group and performed significantly better in terms of standing at the bedside, 100 m independent walking,

Table 2 Postoperative Assessment

		Conventional surgery group No. = 25	MICS group No. = 25	Test value	P-value	Sig.
Standing at the bed side (Postoperative day)	Mean ± SD	2.28 ± 0.68	1.84 ± 0.37	2.840•	0.007	HS
	Range	1 – 3	1 – 2			
100 m independent walking (Postoperative day)	Mean ± SD	5.08 ± 0.70	3.24 ± 0.72	9.124•	<0.001	HS
	Range	4 – 6	2 – 5			
VAS	Median (IQR)	4 (5 - 6)	4 (3 - 4)	-5.352‡	<0.001	HS
	Range	4 – 8	3 – 6			

P is significant at ≤ 0.05 and *P* is highly significant (HS) at ≤ 0.01

MICS group: Minimally invasive cardiac surgery group, *VAS*: Visual Analogue Scale

•: Independent t-test; ‡: Mann Whitney test

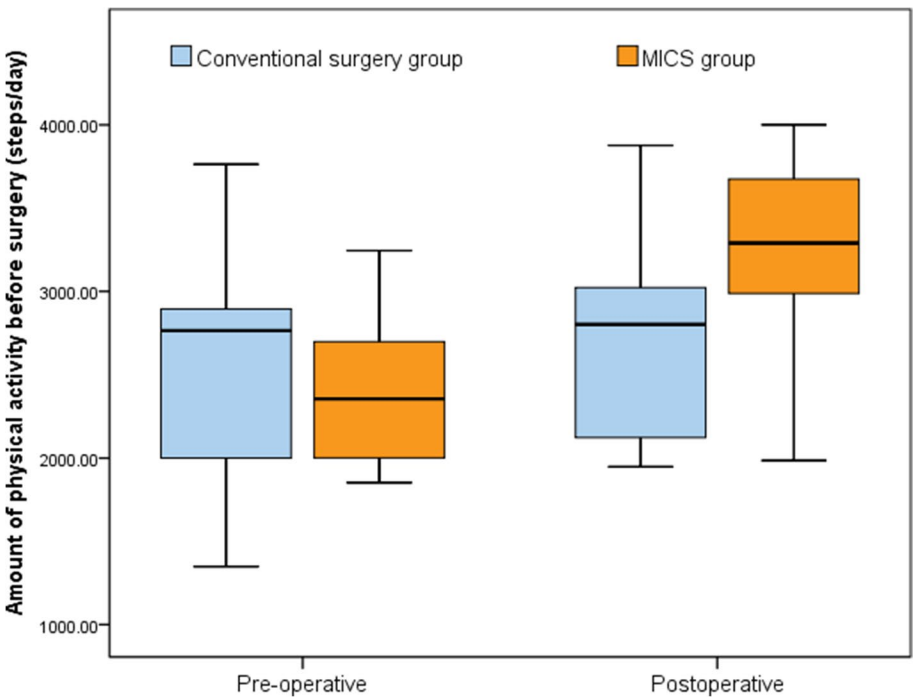

Fig. 1 The amount of physical activity before and after surgery measured by triaxial accelerometer (steps/ day)

Triaxaile accelerometer findings, and 6MWT ($P< 0.05$). Previous studies have found that MICS patients had less postoperative pain and returned to normal activity sooner (10, 11). In individuals who had a minimally invasive method, recovery wasshown to be quicker and less painful following conventional surgery. Minimal bleeding decreased ventilation periods, wound infections, and shorter hospital stays.

Our results were in line with those of Nakajima and his colleagues, who compared the physical activity in the MICS group with that in the conventional median sternotomy group and noted that the group of MICS was statistically earlier at 100 m independent walking [5]. Our findings were also aligned with those of the Iribarne et al. study, which compared the clinical outcomes of elderly patients after MICS to those after conventional surgery [12]. Their theory was that avoiding sternotomy was the key contributor to the MICS group's earlier commencement of independent walking. This finding may point to the possibility of a rapid rise in physical activity following MICS.

Physical activity assessment has piqued the curiosity of many people, and several subjective and objective approaches have been established. Triaxial

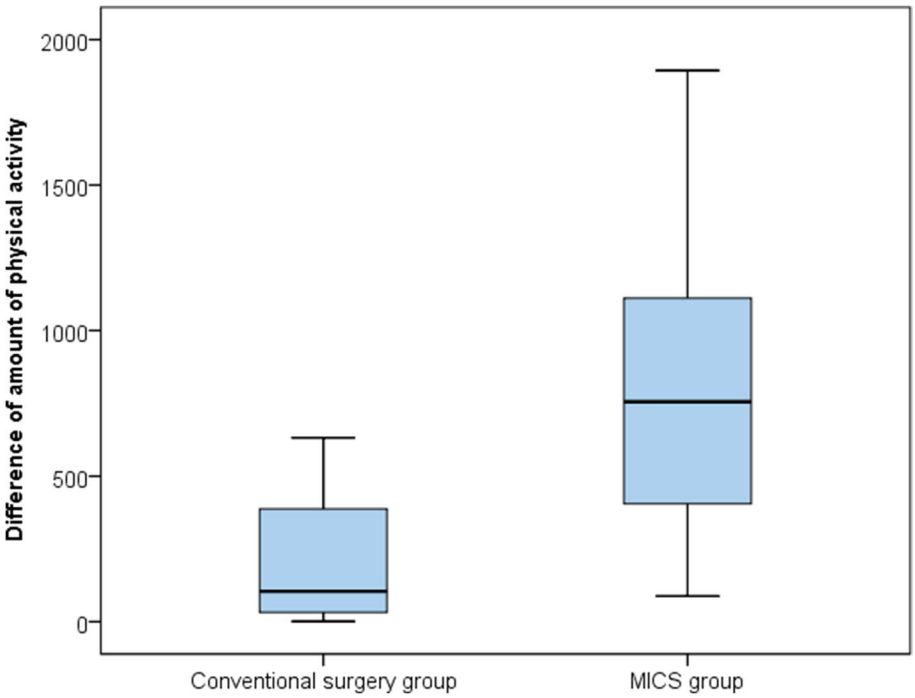

Fig. 2 The deference of The amount of physical activity before and after surgery measured by triaxial accelerometer (steps/ day)

Table 3 Physical activity assessment by using triaxial accelerometer (steps/ day)

Physical activity amount before surgery (steps/day)		**Conventional surgery group No. = 25**	**MICS group No. = 25**	**Test value**	**P-value**	**Sig.**
Pre-operative	Mean ± SD	2534.68 ± 584.86	2418.60 ± 418.41	0.807•	0.424	NS
	Range	1348 – 3764	1853 – 3245			
Post-operative	Mean ± SD	2716.64 ± 584.53	3211.88 ± 594.94	-2.969•	0.005	HS
	Range	1949 – 3876	1986 – 4001			
Difference	Mean ± SD	181.96 ± 205.00	793.28 ± 543.29	-4.569‡	<0.001	HS
	Range	1 – 632	88 – 1894			
Paired t-test		**4.438**	**7.301**			
P-value		**<0.001 (HS)**	**<0.001 (HS)**			

P is significant at ≤ 0.05, *P* is highly significant (HS) at ≤ 0.01, and *P* is non-significant at > 0.05

MICS group: Minimally invasive cardiac surgery group

*: Chi-square test‡: Mann Whitney test

accelerometers are sensitive to both gravity and dynamic momentum, allowing them to detect motion intensity and physical activity [13, 14]. The triaxial accelerometers were used to evaluate the physical activity levels in elderly patients while they were hospitalized, as well as their functional capacity and physical activity in various positions [15].

Postoperatively, both groups showed improvement as regards the quantity of physical activity but the MICS group showed significantly higher improvement, Participants in the group of MICS were physically active during the day compared to those in the conventional surgery group, which could be attributed to the absences of the invasiveness of a sternotomy and its impact on postoperative physical activity recovery. Furthermore, Individuals who had MICS recovered more quickly from surgery and felt less postoperative pain.

These outcomes are Similar to Marin et al., who observed that MICS, when compared to conventional median sternotomy, offers comparable

Table 4 The result of 6MWT in both groups before and after surgery

6MWT		Conventional surgery group	MICS group	Test value	P-value	Sig.
		No. = 25	No. = 25			
Pre operative	Mean ± SD	340.88 ± 69.53	346.72 ± 55.76	-0.328•	0.745	NS
	Range	209 – 493	289 – 488			
Post operative	Mean ± SD	410.56 ± 86.61	506.56 ± 86.92	-3.912•	<0.001	HS
	Range	291 – 596	339 – 632			
Difference	Mean ± SD	69.68 ± 56.11	159.84 ± 77.35	-3.784‡	<0.001	HS
	Range	6 – 197	6 – 312			
Paired t-test		**6.209**	**10.333**			
P-value		**<0.001 (HS)**	**<0.001 (HS)**			

6MWT: Sex minute walking test, *MICS* group: Minimally invasive cardiac surgery group

P is significant at ≤ 0.05, *P* is highly significant (HS) at ≤ 0.01, and *P* is non-significant at > 0.05

*: Chi-square test‡: Mann Whitney test

effectiveness and safety, as well as reduced postoperative morbidity and mortality. In addition, better aesthetic outcomes, shorter recovery times, and less physical activity restriction all contribute to higher patient acceptance [16]. On the other hand, Nakajima et al. discovered that the level of physical activity reduced postoperatively in the conventional group [5]. This could be due to the small number of patients in their study (the conventional group had only six), their age being significantly older than the MICS group, and the presence of significant comorbidity in this group While in our study, the numbers in each group, as well as age and comorbidity, were matched.

Compared to the bicycle or treadmill, the 6MWT is a more "natural" type of fitness test, and it may accurately reflect daily activity. The 6MWT has several benefits over traditional stress tests, including its flexibility and low price. It is generally well tolerated by participants, is simple to give, and has satisfactory repeatability [17].

In order to establish the comparison between MICS and the conventional methods using a reliable test. We utilized the 6 MWT because it is simple to administer, well-tolerated, and more representative of daily activity [18]. This test is ideal for use in older individuals with cardiac problems since it allows for the estimation of the cardiovascular system's capability as well as the evaluation of the symptoms connected with it [19, 20].

There was a significant improvement in the MICS group in terms of functional capacity, which was determined by the walked distance in meters during the 6MWT. This resulted from subjects in the group of MICS recovered more quickly from the surgery group and experienced less postoperative pain.

Our results concur with those of Chen et al. Their major goal was to determine if the 6MWT might be used to assess physical performance and thus use it for the assessment postoperatively. They reported that there was a moderate to strong correlation between the 6MWT distances at baseline and at the 3-month follow-up and physical functioning and activities [8]. In cardiac rehabilitation, 6MWT is a valid test that could be used in conjunction to evaluate a patient's compliance with recommended levels of physical activity during a post-rehabilitation checkup [21].

The limitation of the study

This research has certain drawbacks. For starters, the 6MWT results were not compared to those of a reference test, such as the maximum exercise test with oxygen uptake measurement. Second, the sample size was small. Finally, a brief time of review following surgery. Future research should assess physical activity over longer time periods in broader patient populations.

Conclusion

Minimally invasive cardiac surgery has a higher margin of benefit, and speedy recovery to normality, which is accompanied by less VAS score and an increase in the amount of physical activity during hospitalization in comparison to the conventional surgery.

Abbreviations

ADL	Activity of Daily Life
FMASU	Faculty of Medicine, Ain Shams University
MICS	Minimally invasive cardiac surgery
PACTR	Pan African Clinical Trial Registry
VAS	Visual Analogue Scale
6MWT	Sex minute walking test

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Authors' contributions
HL make the following: formal evaluation, Data gathering, writing the first draught, editing and reviewing it, contributing to the design of the work, doing clinical work, interpreting data, and revising are all examples of data curation . SF Has taken part in Conceptualization, Formal analysis, revised the draft paper. ME put study design, followed the patients after surgery and revised the draft paper and MGE gave idea and collected the patients' data and analyze them.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by Ain Shams University, Faculty of Medicine Research Ethics Committee (REC) FWA 000017585. FMASU (R 65/2022) A written informed consent was obtained from patients sharing in the study.

Consent for publication
A written consent was taken from the patients and available upon request.

Competing interests
The authors declare that they have no competing interests.

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