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Comparison of Postoperative Outcomes Between Robotic Mitral Valve Surgery and Conventional Mitral Valve Surgery

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Abstract

A total of 130 patients who underwent robotic mitral valve surgery and conventional mitral valve surgery with full sternotomy between 2014 and 2020 were included in our study. All patients were divided into two groups; Group I, with 64 patients who underwent robotic mitral valve replacement, and Group II, with 66 patients with conventional full sternotomy. General demographic data (age, gender, body weights, etc.), comorbidities (hypertension, diabetes mellitus, chronic obstructive pulmonary disease, peripheral artery disease, hyperlipidemia, etc.), intraoperative variables (cardiopulmonary bypass times, cross-clamp times) postoperative ventilation times, drainage amounts, transfusion amount, inotropic need, revision, arrhythmia, intensive care and hospital stay times and mortality were analyzed retrospectively. According to conventional methods, robotic mitral valve replacement is an effective and reliable method, since total perfusion and cross clamp times are longer, drainage amount and blood transfusion need are less, ventilation time, intensive care and hospital stay time are shorter. Compared to conventional methods, robotic surgery is an increasingly widespread successful treatment option because of its early mobilization, rapid recovery, better cosmetic outcome and improving quality of life.

INTRODUCTION

Valvular heart diseases are quite common in developed countries and have a high incidence rate. Among the heart surgeries performed in these countries, heart valve surgeries rank second in number. [1]. In recent years, the number of patients with advanced age and serious risk profile undergoing cardiac surgery has been increasing. Despite this negativity, surgery is a safe treatment method with low morbidity and mortality for almost all patients, thanks to the progress in cardiac anesthesia and surgical techniques [2]. In previous studies, the mortality rate following heart valve replacement has been reported to be between 4.3% and 14% [3].

The most important purpose in mitral valve surgery; It is the preservation of left ventricular function by preventing left ventricular dilatation before an irreversible damage occurs in the myocardium, and if it is not possible, it is the replacement of the valve that has lost its function before serious symptoms appear [4]. In the treatment of valve diseases, the surgical treatment that will contribute the most to the dimensions and functions of the left ventricle is the repair of the valve without damaging the anatomical structure of the valve and using a prosthetic valve. Prosthetic valve replacement is applied for valves that are severely degenerated and not suitable for repair. Preservation of the subvalvular structure consisting of the chordae and papillary muscles, which are the elements of the functional apparatus of the mitral valve, provides a positive effect on left ventricular function and helps prevent left ventricular dilatation and left ventricular segmental wall motion disorder [4,5]. However, the lack of randomized studies comparing long-term results is evident. It is known that heart surgeries performed with minimally invasive methods and robotic surgery generally decrease the morbidity associated with surgery and have good early results.

However, they must prove themselves within the framework of this equation by showing that the long-term results of this technique are also good. In this study we have done, we aimed to compare the results of conventional mitral valve surgery performed with sternotomy for many years and robotic mitral valve surgery, which continues to develop.

METHODS

In our study, a total of 130 patients who underwent robotic and conventional mitral valve replacement between 2014 and 2020 in Health Sciences University Gulhane Training and Research Hospital Cardiovascular Surgery Clinic were retrospectively analyzed. Ethics committee approval was obtained from Health Sciences University Gülhane Non-Invasive Research Ethics Committee, dated 25.02.2020 and numbered 2020/73 project / decision.

All patients were divided into two groups; 64 patients who underwent robotic mitral valve replacement in Group I, and 66 patients who underwent conventional mitral valve replacement with classical full sternotomy in Group II. Preoperative general demographic data of the patients (age, gender, body weight), comorbidities (hypertension, diabetes mellitus, chronic obstructive pulmonary disease, peripheral artery disease, hyperlipidemia), intraoperative variables (cardiopulmonary bypass times, cross clamp times), postoperative ventilation times, the amount of drainage, the amount of transfusion, the need for inotropes, revision, rhythm disturbance, length of stay in the ICU and hospital and mortality were analyzed retrospectively.

Statistical analysis

Descriptive statistics are given along with percentage, mean, standard deviation, minimum and maximum values. Pearson chi-square test or Fisher's Exact Test was used in the analysis of the relationships between categorical variables. The normal distribution assumption of independent variables was checked by Kolmogorov-Smirnov Test and Shapiro-Wilk Test. The relationship between the dependent variables and the dependent variables were evaluated using the Student-T Test when they fit the normal distribution, and the Mann-Whitney U Test when they did not fit the normal distribution. Analysis results are considered statistically significant if the confidence interval is 95% and p values are less than 0.05. The length of stay in the intensive care unit and hospital was obtained using the Kaplan Meier method. The possible effect of the type of surgery on the duration of ICU and hospital stay was evaluated using the log-rank test. Analyzes were made with SPSS 23.0 package program.

RESULTS

A total of 130 patients who underwent robotic and conventional mitral valve replacement between 2014 and 2020 were included in our study. The demographic data of the patients in Group I (Robotic mitral valve replacement) and Group II (Conventional mitral valve replacement) are given in Table 1. The patients included in our study were selected among patients who underwent mitral valve replacement only, and patients who underwent mitral valve repair, mitral ring annuloplasty, tricuspid valve replacement, tricuspid valve repair, reoperation, and additional coronary surgery were not included in our study.

In the conventional mitral valve replacement group, 36 (54%) female, 30 (46%) male 66 patients, and the robotic group 38 (59%) female, 26 (41%) male 64 patients in total 130 the patient was included in the study. No statistically significant difference was found between the two groups in terms of age, smoking history, COPD, HT, DM, HL, CRF, CVA and peripheral artery disease ($p > 0.05$).

Average X-clamp times are 143 $\pm$ 27.4 minutes in Group I; It was found as 69 $\pm$ 15.2 minutes in Group II and this time was found to be significantly higher in the r-MVR group ($p < 0.001$)(Table 1)(Figure 1). In the same direction, CPB duration is 204 $\pm$ 45.8 minutes in Group I; It was found to be 98 $\pm$ 17.8 minutes in Group II. In the comparison between the two groups, this period was found to be significantly higher in the

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r-MVR group (p <0.001)(Table 1)(Figure 1). The reason for the significant difference between the two groups is that providing appropriate exposure and access technique in robotic surgery, which is a minimally invasive method, is more difficult than open surgery and requires more experience. While the average amount of drainage was 290 ± 129 in Group I, it was 561 ± 136 in Group II. When the mean drainage amounts of both groups were compared, it was found that the drainage amount was significantly lower in the r-MVR group compared to the c-MVR group (p <0.001)(Table 2). While the need for erythrocyte suspension transfusion, which is thought to be directly proportional to the amount of drainage, is 0.4 ± 0.3 in Group I; It was found as 0.9 ± 1.2 in Group II, and a significant difference was found between them in the comparison (p = 0.014).

The average length of stay in the intensive care unit of patients who underwent robotic mitral valve replacement was 1.6 ± 0.8 days; In the patient group who underwent conventional mitral valve replacement, this period was 2.6 ± 1.0 days. Comparing the average length of stay in the intensive care unit in both patient groups, these durations were found to be significantly lower in Group I than in Group II (p=0.006). Kaplan Meier analysis was performed and the difference between them was confirmed by Log-Rank test (Log-Rank = 9.33; p <0.001)(Figure 2). The mean hospital stay of patients who underwent robotic mitral valve replacement was 7.9 ± 2.9 days; It was found to be 9.4 ± 3.1 days in the patient group who underwent conventional mitral valve replacement. Comparing the average length of hospital stay in both patient groups, this period was found to be significantly lower in Group I than Group II (p = 0.003). Again, Kaplan Meier analysis was performed and the difference between them was confirmed by Log-Rank test (Log-Rank = 8.66; p = 0.003) (Figure 2).

In the robotic surgery group, a total of 3 patients developed lymphoresis in the femoral cannulation area during the postoperative period, and recovery was achieved without the need for a major surgical intervention. 3 in group I; 4 patients in group II were revised due to bleeding(Table 3). In the postoperative period, neurological complications developed in 1 (1.5%) patient in Group I and 2 (3.0%) in Group II during the period that the patients spend in the hospital until discharge; postoperative renal dysfunction developed in 6 (9.3%) patients in Group I and 9 (13.6%) patients in Group II. Temporary ultrafiltration was required in a total of 3 patients in Group II among the patients with renal dysfunction.Pneumonia developed in 2 (3.1%) patients in Group I and in 3 (4.5%) patients in Group II and clinical improvement was achieved with medical treatment. Wound infection not requiring surgical intervention was observed in 2 (3.1%) patients in Group I and 3 (4.5%) patients in Group II. In patients with arrhythmia in both groups, rhythm restoration was achieved with medication or cardioversion in the postoperative period.

DISCUSSION

The introduction of minimally invasive techniques in cardiac surgery and the general acceptance of these techniques in the cardiac surgery community was later and slower than other branches. Advances in percutaneous techniques and the emerging competition since the 1990s have led surgeons to try to achieve these excellent results with less invasive methods [6]. Beyond the good cosmetic results, minimally invasive procedures are preferred because of the small size of the incision, less wound infection, less postoperative bleeding, and therefore less need for blood and blood products, and shorter intensive care and hospital stays[7].

With the da Vinci robotic system, the most important disadvantage of endoscopic surgery, the necessity of performing a mirror image operation, has been overcome. These features have provided great advantages for surgeons in terms of endoscopic cardiac surgery. Despite these features, the use of the robotic surgical system in cardiac surgery requires a difficult and long learning curve and process [7]. The disadvantages of the robotic surgery technique are the longer cardiopulmonary bypass and total ischemic time and the possibility of increased morbidity due to these, the possibility of retrograde aortic dissection due to peripheral cannulation, innominate artery occlusion or embolism due to migration if endoaortic clamp is used, and also causing neurological damage by causing aortic dissection. the possibility of air extraction at the end of the operation, the long learning curve due to the difficulty of the technique, and the expensive materials used [8].

The development process of minimally invasive methods has caused some complications. Falk et al. performed

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a minimally invasive mitral valve operation in 24 patients in the University of Leipzig experience, and aortic dissection occurred in one patient [9]. One patient developed deep venous thrombosis in two video-mediated minimally invasive cases in which Chitwood et al. directly clamped the aorta using right anterolateral thoracotomy and femoral artery and vein cannulation [10]. Glower et al. recommended direct aorta cannulation with a special aortic cannula in order to prevent complications related to embolization and peripheral vessels in operations performed with port accessory technique. [11]. In our study, femoral artery cannulation was preferred due to the fact that our cases were mitral valve patients and the patients did not have peripheral vascular disorders, because it was easier and cheaper, and there were no intraoperative complications. During the postoperative follow-up period, lymphoresis was detected in the femoral cannulation area in 3 patients, and complete recovery was achieved with medical treatment. We think that this complication is caused by the damage to the lymphatic ducts due to the incision parallel to the inguinal ligament we made to achieve better cosmetic results.

During the widespread use of robotic mitral valve surgery, studies on this method have begun to enter the literature. In a meta-analysis by Cao et al., in which 960 robotic and 690 conventional mitral valve surgeries were compared, six studies in which 1650 patients underwent a total of 1650 patients were included, there was no difference between stroke and reoperations, while CPB and cross clamping times were longer in robotic groups, and intensive care and hospital stays were shorter than methods [12]. In the meta-analysis of Takagi et al., in which a total of 3764 patients who underwent robotic and conventional mitral valve surgery in 2020 were compared, it was stated that the CPB and cross clamping times were longer in the robotic group. It has been observed that the need for erythrocyte transfusion is higher in the conventional method, and the duration of intensive care and hospital stay is longer. There was no difference between the two groups in terms of valve dysfunction, renal dysfunction, pneumonia, stroke and mortality [13]. n a study of 2300 patients who underwent mitral valve surgery by Hawkins et al., it was stated that the intraoperative procedure times were longer in the robotic surgery group [14]. In the study group of 142 patients made by Kesavuori et al., there was no difference in perioperative complications in both groups, and 3 patients in the robotic group required ECMO due to low cardiac output, and one patient from the robotic group died [15]. Among the patients we operated in our clinic, there were no patients who needed ECMO due to low flow, but there were 2 patients in the robotic group and 3 patients in the conventional group, who received high-dose inotropic support.

In a population analysis study of 3145 patients undergoing robotic mitral valve surgery performed by Paul et al., it was found that hospital stay was shorter in the robotic group and there was no difference between the two groups in terms of complications [16]. In the study conducted by Wang et al., a total of 1006 patients who underwent 503 robotic and 503 conventional mitral valve surgery were compared, while CPB and cross clamp times were found to be higher in the robotic group, it was observed that the duration of ICU stay and the incidence of atrial fibrillation were lower [17]. The results we obtained in our study also show similar features with the literature data and are supportive.

The removal of air in the heart cavities becomes important in terms of neurological complications in operations performed with robotic surgery technique. As soon as the thorax is opened, it was thought that air embolism, which could cause serious neurological complications, could be prevented by continuously administering carbon dioxide and controlling the removal of air with TEE. As a result of operations in the patients included in our study, neurological complications were observed in 1 patient in the robotic group and 2 patients in the conventional group. Mihaljevic et al. [18] performed a study comparing robotic mitral valve repair (n = 261) versus full sternotomy (n = 114), partial sternotomy (n = 170), and mini thoracotomy approach (n = 114). There was no significant difference between the groups in terms of postoperative mortality, pulmonary complications, neurological complications, and renal failure rates. The incidence of atrial fibrillation and pleural effusion was lowest in the robotic group, resulting in a significant reduction in hospital stay compared to the other groups[19]. However, cardiopulmonary bypass time was significantly longer in the robotic group than in the other groups [19]. We think this is related to the steep learning curve associated with robotic surgery.

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Although the number of patients is small in terms of providing a sufficient evaluation in the studies up to date, the main advantages and disadvantages between robotic surgery and sternotomy methods have been clearly demonstrated in the series. The biggest benefit of robotic surgery operations compared to sternotomy is that patients return to their normal activities more quickly. As can be seen in our study, a significant difference was found between the duration of intensive care and hospital stay, especially in young and physically active patients, quicker mobilization and patient comfort were provided, and in older and sedentary patients, a faster recovery process, less pain and more rapid mobilization has been observed. This rapid recovery process is the result of the robotic surgery method that does not disrupt the integrity of the sternum and preserves the sternum integrity with a 4-5 cm smaller incision, creating less tissue damage, less infection possibility, and providing a quick and comfortable recovery. Thoracotomy incision infections are less morbid and cheaper than sternotomy incisions that require muscle flap to close when infected [20]. Another major limitation in robot use is the steep learning curve associated with it; A competent operator requires 150-250 procedures to become a master [21]. However, proponents argue that the costs can be offset by reduced intensive care and hospital stays. There are publications stating that total operational hospital costs do not increase significantly with robotic technology when the advantages are taken into account [22].

CONCLUSION

Minimally invasive techniques, which are successfully performed thanks to technological developments, are becoming more and more common. Robotic surgery systems have emerged as a potential facilitating factor for mitral valve surgery procedures. Nowadays, robotic mitral valve surgery has an important place in clinical practice in today's technology. Proper patient selection is important in robotic heart surgery. In cases such as the presence of severe peripheral vascular disease, chest deformities such as pectus excavatus where adequate exposure cannot be provided, severe aortic insufficiency, ascending aortic aneurysm or atherosclerotic plaques in the ascending aorta, having advanced lungs attached to the thorax due to previous operations needs to be well evaluated.

When the results are evaluated as a whole, robotic mitral valve replacement surgery is an effective and reliable method due to the lower drainage and less need for blood transfusion compared to conventional methods, shorter ventilation time, intensive care and hospital stay. Despite the disadvantages of longer total perfusion and cross clamp times and technical equipment and trained personnel that require additional costs for operating theaters, it is an increasingly successful treatment method due to its early mobilization, faster recovery, better cosmetic result and increased quality of life compared to conventional methods. Our results, which are compatible with similar studies in the literature, show that the importance of robotic mitral valve surgery will continue to increase and become widespread. Thanks to the promising postoperative results of robotic surgery, we think that surgery will take its place in routine clinical applications in the future with technological developments.

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Table 1. Comparison of intraoperative data

	r-MVR (n=64) Mean ± SD (Median / Min-Max)	**c-MVR (n=66)** Mean ± SD (Median / Min-Max)	**p**
X-klemp (min.)	143,22 ± 27,4 (140 / 92-214)	69,16 ± 15,2 (65 / 49-96)	**p<0,001***

CPB (min.)	204,12 ± 45,8 (201 / 146-310)	98,23 ± 17,8 (101 / 93-124)	**p<0,001***

* Statistically significant, SD: Standard deviation, min: Minimum, max: Maximum, CPB: Cardiopulmonary bypass, r-MVR: Robotic mitral valve replacement, c-MVR: Conventional mitral valve replacement

Table 2. Comparison of postoperative data

	r-MVR (n=64) Mean ± SD (Median / Min-Max)	**c-MVR (n=66)** Mean ± SD (Median / Min-Max)	**p**
Drainage amount (cc)	290 ± 129 (305 / 75-675)	561 ± 136 (592 / 350-855)	< **0,001***
ES transfusion (unit)	0,4 ± 0,3 (0 / 0-3)	0,9 ± 1,2 (1 / 0-5)	**0,014***
Ventilation time (hours)	5,3 ± 3,9 (5 / 3-21)	9,6 ± 4,2 (8 / 6-28)	**0,001***
Intensive care stay (day)	1,6 ± 0,8 (1 / 1-5)	2,6 ± 1,0 (2 / 1-9)	**0,006***
Hospitalization (days)	7,9 ± 2,9 (7 / 6-14)	9,4 ± 3,1 (7 / 6-14)	**0,003***

* Statistically significant, SS: Standard deviation, min: Minimum, max: Maximum, r-MVR: Robotic mitral valve replacement, c-MVR: Conventional mitral valve replacement, ES: Erythrocyte suspension

Table 3. Comparison of patients in terms of postoperative complications

	r-MVR Grup I (n=64) Grup I (n:64)	**c-MVR Grup II (n=66)**	**p**
Stroke	1 (%1,5)	2 (%3,0)	0.58 0.58
Postoperative Arrhythmia	12 (%18)	14 (%21)	0.72 0.72
Pneumonia	2 (%3,1)	3 (%4,5)	0.67
Postoperative renal dysfunction	6 (%9,3)	9 (%13,6)	0.52
Wound infection	2 (%3,1) 2 (%19.4)	3 (%4,5) 3 (%3.9)	0.67
Revision	3 (%4,6)	4 (%6,0)	0.73
Mortality	2 (%3,1)	2 (%3,0)	0.97

r-MVR: Robotic mitral valve replacement, c-MVR: Conventional mitral valve replacement

Figure 1. Comparison of intraoperative X-clamp and CPB times

Figure 2. Analysis of intensive care and hospital stays with the Kaplan-Meier Method

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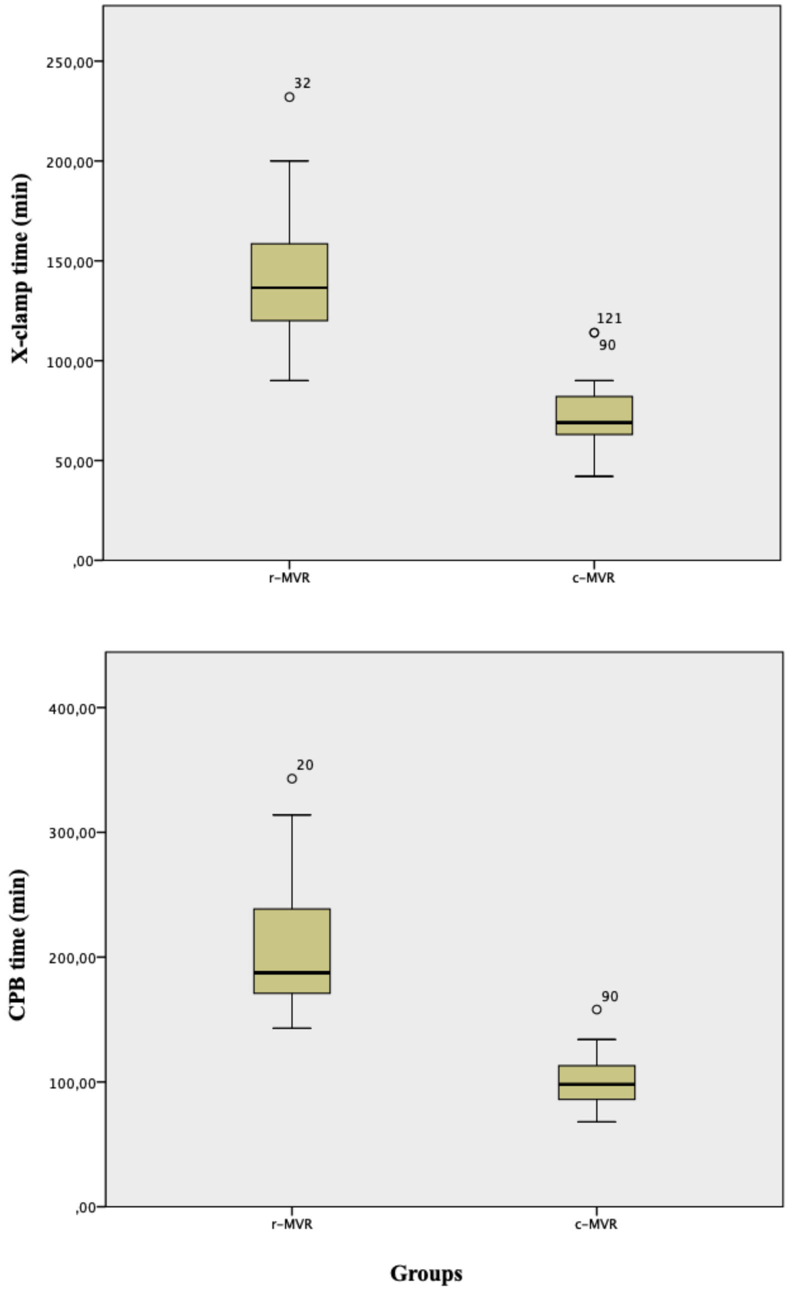

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