Medico-Economic Evaluation of Minimally Invasive Thoracotomy Versus Sternotomy in Heart Valve Surgeries: An Observational Study

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ABSTRACT

Objectives: Minimally invasive surgery has many outstanding advantages that make it increasingly popular for the treatment of heart valve disease. However, this approach has been criticised for its long operative aortic clamping times and increased treatment costs. The aim of this study was to compare the cost and clinical effectiveness of minimally invasive surgery and conventional sternotomy in mitral and aortic surgery.

Methods: A prospective observational analysis of patients who had undergone mitral aortic valve surgery via minimally invasive approach or sternotomy between 1 May 2021 and 31 July 2021. The statistical analysis focused on differences in cost and advantages between the two surgical approaches. A correlation analysis was conducted to identify key contributors to the overall cost variation.

Results: A total of 44 patients met the study criteria. Patients were divided into two groups: minimally invasive surgery and traditional sternotomy. There was no significant difference between the two groups in preoperative status, most patients were in good health, without comorbidities such as kidney disease, thrombosis, hypertension, diabetes, chronic lung disease. The time spent in the operating room (from patient admission to exit), the surgery time, and cardiopulmonary bypass duration were significantly higher for minimally invasive aortic valve replacement than for sternotomy aortic valve replacement (operating room time: 305 ±56 min vs. 249 ±53 min, p=0.029; operative time: 198 ± 54 min vs. 150 ± 54 min, p=0.046; CPB time: 129 ± 53 min vs. 80 ± 31 min; p=0.034). Mortality and complications during hospitalisation were similar between both groups for both mitral and aortic valve replacements. Total cost analysis revealed no statistically significant difference between the two methods (mitral valve replacement: 22 510 ± 6 672 euros vs 24 979 ± 10 196 euros, p=0.438; aortic valve replacement: 16 651 ± 2 855 euros vs 18 202 ± 6 261 euros, p=0.087).

Conclusion: In modern clinical practice, minimally invasive surgery is an effective strategy that provides good outcomes with comparable mortality, complications, duration of

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treatment, and hospital cost, compared with conventional approaches for mitral valve and aortic valve replacements.

Key words: *minimally invasive surgery, mitral valve replacement, aortic valve replacement, hospital cost*

INTRODUCTION

Heart valve surgery, including valve repair and replacement, are routinely performed by a traditional full sternotomy approach with low rate of complications and mortality. This approach is still considered the gold standard for the treatment of mitral and aortic valve diseases[1-3]. However, in the past three decades, minimally invasive (MI) surgery techniques, including minithoracotomy and upper hemisternotomy, have been introduced as new surgical procedures for heart valve surgery [3-5]. Minimally invasive mitral valve replacement (MVR) and minimally invasive aortic valve replacement (AVR) have been associated with improved post-operative outcomes, such as aesthetics, pain, blood transfusion rates, lengths of stay in the ICU and fast recovery and rehabilitation [6-8]. However, this approach has been criticised because of its long cross-clamping and cardiopulmonary bypass times. The increased operative time is related to the greater complexity of the MI surgery techniques [9-11]. Furthermore, performing MI in any centre requires certain conditions, like qualified surgeons and surgical teams, specific instruments (monitors, trocars, camera retention systems, soft tissue retractors, automatic knot fasteners [e.g. Cor-knot®] and cannulas) and this increases the operative cost [12-14].

Several studies have indicated an advantage regarding hospital costs for MI surgery, [7,15] but most of these were retrospective studies. Prospective reports and randomised comparisons between the costs and clinical efficacy of MI valve replacement versus sternotomy (ST) are scarce. The aim of this prospective study was therefore to assess the costs and clinical effectiveness of MI vs. conventional full sternotomy for mitral and aortic valve surgery.

METHODS AND PATIENTS

Population study

This prospective cohort study was approved by the CHU Clermont-Ferrand ethics committees with registration number **M210404**. Perioperative data was collected from 44 patients undergoing isolated mitral valve or aortic valve replacement surgery at our centre between 1 May 2021 and 31 July 2021. Ethical borad approval was obtained for the use of patient data. All patients were informed about the purpose of the study, and none declined to participate.

The patients were divided in two groups according to the surgical approach used. Exclusion criteria included any concomitant surgical procedure, such as multiple valve replacement, coronary artery bypass grafting (other than in patients undergoing tricuspid valve repair and atrial fibrillation ablation). Endocarditis, emergency surgery and reoperated cases were also excluded to guarantee equivalent cost comparisons. Due to technical differences and cost variability, patients who underwent valvular repair were not included in our study. In total, 44 patients met the defined inclusion criteria (Table 1).

Data were obtained based on patient billing records for total costs or partial costs related to valve replacement surgery. The cost components were also grouped by category for comparison purposes. Demographic data, preoperative history, postoperative period and complications were also analysed between groups using the Epicard database.

Operative technique

The patient with MI was placed in the supine position and their right thoracic cage was raised with a small cushion placed under the right shoulder. The anaesthesiologist placed a central line in the right internal jugular vein, as well as a sheath was prepared from the internal jugular, into the field for percutaneous superior vena cava cannulation. Arterial and inferior vena cava cannulas were placed through the femoral artery and vein.

The primary access to the thoracic surgery was performed through a four cm right mini thoracotomy for MVR, made at the fourth intercostal space; for AVR, it was in the second or third intercostal space. A trocar (12 mm) was placed in the third intercostal space on anterior axillary line side to bring the camera to the surgical field. The aorta was clamped with a Chitwood cross clamp inserted into the thorax through a small skin incision at the second intercostal space anterior axillary line. The aortic root suction line and the cardioplegia fluid pump line were placed at the same site in the ascending aorta. For the MVR-MI group, cardiac arrest was achieved with a single infusion of 1500 ml to 2000 ml Custodiol®, with a safety protection for 180 min (beyond this time limit, the infusion can be repeated). For the other patients, warm blood cardioplegia was used. Surgical techniques on the valve were similar for both methods, although the valve placement sutures could vary according to the surgeon's experience and/or preference. Valve sutures in the MI group were performed with a Cor-knot® device for mitral valve surgery, as this shortened the time needed to fasten secure the prosthetic valve to the annulus.

Cost outcomes

The main objective of this study was to compare the total cost of the entire treatment course of patients from the hospital perspective. We considered the total cost to represent all costs incurred from hospital admission to discharge, including intraoperative and postoperative costs. Hospital cost data were obtained from our hospital finance department data system. We analysed in detail the standard cost categories of the organisation, including the costs of the intensive care unit, pacemaker, reintervention, operating room, diagnostic imaging, care, surgical instruments and medical devices used in surgery. We used the technique of Micro costing in economy to provide detailed calculations of each type of equipment used in the surgery (sutures, artificial valves, camera wraps, surgical tissue protectors, Cor-knot® device, steel sutures, cardioplegia solution types, and cannula types) to determine the cost differences between the two surgical methods.

Clinical outcomes

We analysed short-term clinical outcomes to evaluate the efficacy of the two techniques. We evaluated outcome endpoints between the two methods for cardiopulmonary bypass (CBP) time, cross clamp time, length of hospital stay, duration of hospital stay, and the most common postoperative complications (for example, intubation for more than 72 h, renal failure, sepsis, reoperation for bleeding, stroke after surgery, myocardial infarction, severe arrhythmia requiring pacemaker implantation, and pulmonary complications). Valve-related events in the early postoperative period were assessed for 3 months. Echocardiography before and after surgery to assess cardiac function was also analysed in our study.

Statistical analysis

The statistical approach mostly focused on differences in cost and behaviour between the different surgeries. On one hand, a standard description of most variables was done by estimating the mean and standard deviations for each surgery group (and percentages for the categories). On the other hand, group differences were tested using the Wilcoxon rank sum test (for quantitative variables) and Chi-square or Fisher's test (for categorical variables). A correlation analysis showed the most significant contributors to the overall cost variation.

A graphical analysis suggested that most quantitative variables were not Gaussian. All reported P values are 2-sided. All statistical analyses were performed using Stata 15 (Stata Corp, College Station, TX).

RESULTS

Patient Characteristics

A total of 44 patients who underwent valve replacement from 1 May 2021 to 31 July 2021 met the study criteria, and all their data were collected for study. The patients' preoperative baseline characteristics are listed in Table 1. The two surgical groups involving aortic and mitral valves were analysed separately. All continuous variables were compared between MI and ST surgery on a whole sample basis. However, no differences were detected in the preoperative characteristics for most variables. Most patients were in good condition, without comorbidities such as kidney disease, thrombosis, hypertension, diabetes or chronic lung disease.

The mean age was similar in both groups for MI patients and ST patients: MVR 69 ± 16.1 and 68.7 ± 10.7, respectively, p=0.698; AVR 70.8 ±3.7 and 69.4± 7.8, respectively, p=0.774. The gender distribution showed a difference in the MVR group, with men accounting for the majority of ST patients and women accounting for most of the MI patients (100% men in ST and 75% women in MI, p=0.01). By contrast, no gender distribution differences were noted in the AVR group. The majority of hospitalised patients had NYHA II. No differences were noted in the etiology of valve disease among the groups, which all showed a predominance of valvular degenerative type disease (83.3% MVR-ST, 62.5% MVR-MI, 83.3% AVR-ST and 100% AVR-MI).

Heart risks factors were similar in all group. Preoperative echocardiography showed preservation of left ventricular systolic function in most patients (50–60%), and most patients did not have severe pulmonary systolic hypertension.

Operative Characteristics

The surgical data are listed in Table 1. MI surgery was performed in 14 patients, with six as aortic valve replacements (20%) and eight as mitral valve replacements (57.1%).

The time spent in the operating room

(calculated from time of patient admission to the time the patient left the operating room), the surgery time and the CPB duration were significantly higher in the AVR-MI group than in the AVR-ST group (operating room time: 305 ±56 minutes and 249 ±53 minutes, p=0.029; operative time: 198 ± 54 minutes and 150 ± 54 minutes, p=0.046; CPB time: 129 ± 53 minutes vs. 80 ± 31 minutes; p=0.034)). For the MVR group, these time differences were not statistically significant. No patient was switched from a mini thoracotomy to a sternotomy during investigation. For the combined procedures, only three of the 44 patients had tricuspid valve repair and only one of the 44 had radiofrequency ablation in combination with valve replacement surgery. Theses data did not make significant difference between the groups.

Cost analysis

Table 3 presents observed variables related to the categories of patient costs during their hospital stays. No statistically significant difference in total cost was observed between the MI and ST methods (MVR-MI: 22510 ± 6672 euros vs MVR-ST: 24979 ± 10196 euros, p=0.438; AVR-MI: 16651 ± 2855 euros vs AVR-ST: 18202 ± 6261 euros; p =0.087). Among our payment categories, the cost of operating room surgical supplies was higher for the MI group than for the ST group for both MVR and AVR (MVR-MI: 2076 ± 787 euros and MVR-ST: 173 ± 229 euros, p=0.006; AVR-MI: 1263 ± 948 euros and AVR-ST: 151 ± 60 euro, p=0.005). The operating room cost was greater for patients in the AVR-MI group than in the AVR-ST group (3290 ± 599 euros and 2686 ± 570 euros, p=0.029), whereas this difference was not statistically significant in the patients with MVR. The costs related to the postoperative stay in the ward and the ICU length of stay were similar in both the ST and MI groups.

The cost for diagnostic imaging for patients with MVR was higher for the MI group (particularly because of the need for preoperative computerised tomography) than for the ST group. A proportion of costs was associated with reoperation and pacemaker placement in the ST group, but the difference was not significant compared with the MI group.

Clinical Outcomes

Postoperative outcomes and complications for all patients (Table 2). The length of ICU stay and total hospital stay were comparable for both the MI and ST groups, regardless of the aortic or mitral surgery. Hospital and 3-month mortality were null. Postoperative complications, such as atrial fibrillation and stroke, showed no statistically significant differences between the MI and ST groups. Notably, the ST group had three cases of conduction disturbance that required pacemaker implantation and one case reoperation for a cardiac tamponade. One patient in the AVR-ST group had a postoperative paravalvular leak, which did not require reoperation but was followed up by periodic clinical condition and echocardiography evaluations.

DISCUSSION

Our study showed that minimally invasive surgery was more expensive when compared with sternotomy in terms of the surgical instrument fee. The operative time was also longer for the AVR MI group longer, but this did not affect clinical outcomes.

Preoperative characteristics

The preoperative patient characteristics were similar for all groups in our prospective observation; therefore, these data provide an excellent basis for comparing research outputs. The mean age of the patients in our study placed them in the group of over 60 years old, which could explain why the rate of valvular pathology was mainly of the degenerative valve type in both the AVR and MVR groups. This result is also consistent with previous studies [13,16,17]. Furthermore, the limitations in maintaining sternal precautions in elderly patients with mobility problems would be improved by the MI approach [13].

All the patients in this observation were either overweight or obese; this was particularly the case for the minimally invasive MVR group. In fact, overweight patients are those at high risk for sternum complications, so the advantage of MI surgery can be exploited [13]. Most patients in our study were healthy, with well-preserved cardiac function and no or mild comorbidities; therefore, they were classified as low risk by the EuroSCORE II mortality prediction index. A previous study at our centre [17] also found similar preoperative characteristics of patients undergoing video-assisted mitral valve and aortic valve surgery to those of the patients in the current study, thereby giving an overview of the general pathological features related to Auvergne, France.

Operative characteristics

Cross clamp time, CBP duration, and surgery time are crucial issues considered by surgeons when choosing right thoracotomy in cardiovascular surgery. Concerns have been raised related to increased operative and ischemic time by many authors due to the complexity of the surgical operation relative to the difficulties in approaching the lesion during valve replacement. Earlier studies [16, 18] demonstrated CBP time differences between MI and ST in mitral valve surgery. Our study showed no such difference, probably due to the systematic utilisation of the Corknot®. Nevertheless, some differences in surgery duration persisted during aortic valve replacement, probably related to the greater difficulty in exposing the aorta and the aortic orifice and in controlling bleeding after aortic clamp release through a right anterior mini thoracotomy. The experience of the surgeon also plays an important role in the decreased duration of this surgery, such as reduced cross clamp time, as shown by comparison with our previous study [17] (MVR MI 2018: 123 minutes, 2021: 96 ± 26 minutes; AVR MI 2018: 96 minutes, 2021: 84 ± 32 minutes).

Treatment outcome, complications

Some authors still point out that the risk of stroke is increased in patients with minimally invasive MVR; therefore, this approach has not been widely adopted [19]. However, most of the stroke patients included in these reports were in the group using either intraoperative ventricular fibrillation or beating heart surgery or using an intra-aortic balloon occlusion device [19]. By contrast, trend-fit comparisons in a single large hospital series have shown similar complication rates with MI and conventional sternal surgery in the treatment of mitral valve disease; in that series, intra-aortic occlusion was used with low frequency or not at all, and no electrically induced fibrillation was used [20, 21]. All our patients underwent surgery through cardioplegia, with cross clamping with a Chitwood clamp, and our analysis showed no significant difference in stroke rates among patients in either the MI or ST group. The results showing a low complication rate, short recovery time and short hospital stay are factors that verify the safety and effectiveness of the MI approach in heart valve surgery.

Economic efficiency

A recent review[14] based on clinical evidence studies has demonstrated many outstanding benefits in terms of the safety, effectiveness and cost-effectiveness of applying MI surgery for MVR, rather than conventional ST. In that review, Santana[14] used the BEST process to assess clinical and economic results of the MI surgical approach in mitral valve surgery compared with the conventional approach with seven representative publications. The authors gave numerous reasons for the economic efficiency of the MI approach, including the reduction in costs for echocardiography and testing, reduced consumption of blood products, prevention of perioperative contamination, shortened hospital stays, rapid recovery, reduced need for postoperative rehabilitation and mitigation of recurrence after surgery. Consensus on the cost-effectiveness of minimally invasive approach in aortic valve surgery has been reported [22, 23].

Several other studies showed comparable cost-effectiveness between MI and ST groups. Pojar [18] published the results of his study in 2021 on 525 patients undergoing mitral valve surgery and showed that the MI approach was feasible and safe, with medium-term outcomes and efficacy comparable to those of conventional surgery and with comparable economic benefits. Downs [13] reported no difference in cost between the MI and the ST, despite the need for specialised instruments and a longer operative time for MI. The authors implied that factors which help economise hospital charges or additional fees incurred by applying the MI method come from less blood transfusions in the MI group, shortening the length of stay or the ICU stay, and fewer postoperative complications, with significant clinical improvement, in the MI group.

The cost-effectiveness results in our study were in concordance with findings of other previous reports [13,19]. This indicates that although differences are evident in the specific costs associated with surgical instruments, the lower cost of other categories results in similar total costs of treatment across study groups.

Iribarne [16] demonstrated that differences in hospital costs between groups are mainly due to differences in direct medical costs and non-medical costs (hospital maintenance and utilities). A significant difference in the cost of supplies was noted for the MI surgery group in both mitral and aortic valve replacement patients ($p < 0.01$), which was expected due to the need for additional equipment when implementing a new technique at a centre. In addition, in the aortic valve surgery group, the cost of stays in the operating room group was about 600 euros more for the minimally invasive surgery group than for the sternotomy group, mainly due to a 60-minute longer length of stay in the operating room. In our case, the excess cost for the MVR-MI group was related to the use of computed tomography, which was needed to assess pulmonary adhesions, the degree of calcification of the femoral and iliac arteries and the presence of venous thrombosis.

An early cohort study[16] reported a significant positive correlation between length of stay and inpatient and nursing costs. Individuals who spend fewer days in the hospital incur fewer inpatient and nursing costs and may also have lower costs associated with routine activities, such as day-to-day laboratory tests and diagnostics imaging. We have analysed the correlation between total costs and important variables in our study, and the results show a correlation between increased length of stay in resuscitation, length of hospital stay and increased treatment costs per patient (Table 4).

Limits

This study has some limitations. One is that the sample size was small, although we collected prospectively data from all eligible patients according to three-month study. This affects the reliability of the statistical analysis. In terms of patient selection criteria, we excluded all emergency cases. This study may also have missed cases of readmission after discharge. A second limitation is that this analysis was limited to the patient's stay in the hospital until discharge; thus, a longer follow-up period is needed to assess long-term survival and treatment outcomes. In terms of cost analyses, we did not assess the indirect costs of individual patient treatment. Furthermore, despite our analysis of various direct costs, the costs of laboratory tests and therapeutic medications should also be collected.

CONCLUSION

In modern clinical practice, minimally invasive surgery is an effective strategy that provides good outcomes with comparable mortality, complications, and duration of treatment compared with conventional approaches for replacement of mitral or aortic valves. In terms of medical economics, the total treatment cost of the minimally invasive surgical technique in the treatment of valvular heart disease is no more expensive than that of traditional methods, although the cost of materials is higher. As technology continues to advance more and more rapidly, minimally invasive surgery can become a representative for comparison with other advanced methods, such as robotics and percutaneous interventions, in cardiovascular surgery.

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Table 1. Preoperative patient data and perioperative parameters

	Mitral valve			**Aortic valve**		
	ST (n = 6)	**MI (n = 8)**	**P value**	**ST (n = 24)**	**MI (n=6)**	**P value**
Age (years), mean ± SD	68.7 ± 10.7	69 ±16.1	0.698	69.4 ± 7.8	69.7 ± 7.1	0.774
Gender, n (%)						
Female	0 (0)	6 (75)	**0.01**	9 (37.5)	1 (16.8)	0.633
Male	6 (100)	2 (25)		15 (62.5)	5 (83.2)	
BMI, mean ± SD	25.5 ± 4.2	30 ± 4.3	0.156	27.2 ± 4.6	28.2 ± 2.1	0.678
EuroScore II, mean ± SD	2 ± 1.1	3.5 ± 2.9	0.199	1.5 ± 0.9	1 ± 0	0.059
NYHA class, n (%)						
I	0 (0)	0 (0)		2 (8.3)	0 (0)	
II	4 (66.7)	5 (62.5)	0.748	18 (75)	5 (83.3)	1
III, IV	2 (33.3)	3 (37.5)		4 (16.7)	1 (16.7)	
Hypertension, n (%)	2 (33.3)	2 (25)	1	17 (70.8)	6 (100)	0.290
Diabetes, n (%)	1 (16.7)	0 (0)	0.429	6 (25)	2 (33.33)	0.645
COPD, n (%)	0 (0)	0 (0)	.	1 (4.17)	2 (33.33)	0.094
History of embolism, n (%)	0 (0)	0 (0)		1 (4.17)	0 (0)	1
Renal disease, n (%)						
None	4 (66.6)	5 (62.5)	0.748	19 (79.2)	6 (100)	0.553
Mild	1 (16.7)	3 (37.5)		5 (20.8)	0 (0)	
Severe	1 (16.7)	0 (0)		0 (0)	0 (0)	
Ventricular arrhythmia, n (%)	0 (0)	2 (25)	0.473	0 (0)	0 (0)	

LVEF, mean ± SD	54.7 ± 14.3	59.9± 9.7	0.431	50.1±10.3	59 ± 8	0.841
History of systemic disease, n (%)	0 (0)	1 (12.5)		0 (0)	0 (0)	
Cigarette smoking, n (%)	4 (66.7)	0 (0)		10 (41.7)	3 (50)	
Serum Creatinine, mean ± SD	115 ± 53	101 ± 25	0.698	88 ± 25	78 ± 25	0.337
Systolic pulmonary artery pressure, mean ± SD	42.2 ±17.2	50.9±22.5	0.650	29±13.1	25.2±12.3	0.665
Severe pulmonary hypertension (>60 mmHg), n (%)	2 (33.3)	2 (25)	1	1 (4.2)	0 (0)	1
General condition						
Healthy, n (%)	4 (66.7)	5 (62.5)	1	17 (70.8)	6 (100)	0.290
Moderate, n (%)	2 (33.3)	3 (37.5)		7 (29.2)	0 (0)	
Valve disease						
Regurgitation, n (%)	6(100)	8(100)		4 (16.7)	1 (16.7)	1
Stenosis, n (%)	0	0		19 (79.2)	5 (83.3)	
Combined, n (%)	0	0		1 (4.1)	0 (0)	
Mitral valve pathology						
Degenerate, n (%)	5 (83.3)	5 (62.5)	0.720	0	0	.
Rheumatic, n (%)	1 (16.7)	1 (12.5)		0	0	
Other, n (%)	0 (0)	2 (25)		0	0	
Aortic valve pathology						
Degenerate, n (%)	0	0	.	20 (83.3)	6 (100)	0.557
Congenital, n (%)	0	0		4 (16.7)	0 (0)	
Combined surgery						
Tricuspid valve repair, n (%)	2 (33.3)	2 (25)	1	0	0	1
Atrial fibrillation ablation, n (%)	0 (0)	0 (0)	.	1 (4.2)	0	
Operating room time	292 ±73	334 ±25	0.438	249±53	305 ±56	**0.034**
Operative time, mean ± SD	192 ±72	240 ±54	0.302	150 ±54	198 ±54	**0.046**
Aortic cross clamp time, mean ± SD	84 ±34	96 ±26	0.606	62 ±27	84 ±32	0.108
CPB time, mean ± SD	113 ±31	160 ±48	0.053	80 ±31	129±53	**0.034**

Legends: ST: sternotomy**; MI** minimally invasive**; BMI:** body mass index; **COPD:** chronic obstructive pulmonary disease; **CPB:** cardiopulmonary bypass**; LVEF:** left ventricle ejection fraction**; NYHA:** New York Heart Association

Table 2. Early outcome; postoperative complications and effectiveness

	Mitral valve			Aortic valve		
	ST	**MI**	**P**	**ST**	**MI**	**P**
Postoperative LVEF (%), mean ± SD	55.2 ±8.6	56.3 ±5.8	0.9	55.8±6.4	58.3±4.1	0.448
Time to extubation (hours), mean ± SD	5.5 ± 2.8	5.6 ± 2.9	0.9	5.9 ± 4.5	6.2±1.7	0.276
ICU time (days), mean ± SD	4.4 ± 3.5	4.7 ± 2	0.366	3.5 ± 1.5	2.4 ± 0.9	0.078
Hospital stay (days), mean ± SD	14.5± 4.8	12.4± 3.8	0.471	11± 3.6	9.7 ±3.3	0.283
Vasopressor with 2 or more drugs, n (%)	1 (16.7)	4 (50)	0.301	2 (8.3)	0 (0)	1
Reintervention, n (%)	0	0	.	1 (4.2)	0 (0)	1
Pulmonary complication, n (%)	1 (16.7)	0 (0)	0.429	1 (4.2)	0 (0)	1
Arrhythmia, n (%)	4 (66.7)	4 (50)	0.627	5 (20.8)	2 (33.3)	0.603
Pacemaker, n (%)	2 (33.3)	0 (0)	0.165	1 (4.2)	0 (0)	1
Transfer to another care unit for continued, n (%)	4 (66.7)	4 (50)	0.627	12 (50)	3 (50)	1

Legends: ST: sternotomy**; MI** minimally invasive**; LVEF:** left ventricle ejection fraction**; ICU:** intensive care unit

Table 3. Summarize costs through each detailed item (Euros)

	Mitral valve			Aortic valve		
	ST mean ± SD	**MI mean ± SD**	**P**	**ST mean ± SD**	**MI mean ± SD**	**P**
Supplies related to surgery	173 ± 229	2076±787	**0.006**	151 ±60	1263 ±948	**0.005**
Pacemaker	4332 ± 170	0	0.090	4312	0	0.617
Reintervention	0	0		972	0	
Operating room	3157 ± 789	3607 ± 757	0.438	2686 ± 570	3290 ± 599	**0.034**
ICU	8397 ± 6711	8980± 3863	0.366	6762 ± 2884	4667 ±1737	0.078
Diagnostic imaging	8 ± 21	51 ± 27	**0.012**	23 ± 39	34± 41	0.447
Care costs	14957 ±6458	11370±3767	0.245	11045 ±4529	10687±3998	0.897
Total hospital costs	24979 ±10196	22510±6671	0.438	18202± 6261	16651± 2855	0.876

Legends: ST: sternotomy**; MI** minimally invasive**; ICU:** intensive care unit

Table 4. Correlation of total hospital cost with related variables

	Correlation coefficient (R)	P value
Baseline characteristics		
Length of stay in ICU	0.76	0
Length of hospital stay	0.978	0

CI: Confidence interval; **ICU:** intensive care unit