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Beating heart mitral valve surgery: results in 120 consecutive patients considered unsuitable for conventional mitral valve surgery†

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ADULT CARDIAC

Abstract

OBJECTIVES: The purpose of the study was to test whether a beating heart mitral valve operation was a valuable option in a heterogeneous group of patients considered very high risk for conventional mitral valve surgery.

METHODS: We conducted a retrospective, single-centre, observational cohort study of 120 patients (mean age 63.7 ± 12.1 years, range 25.3–88.8 years; mean logistic EuroSCORE 26.1 ± 20.6%, range 1.5–84.3%) undergoing beating heart mitral valve operations using normothermic cardiopulmonary bypass without aortic cross-clamping and without cardioplegia between September 2002 and April 2014. Preoperatively, 14 (11.7%) patients were in cardiogenic shock, 16 (13%) on a ventilator, 33 (27.5%) receiving inotropic support, 12 (10%) on dialysis and 1 on extracorporeal membrane oxygenation. Sixty-five (54%) patients had had at least 1 (range 1–6) previous heart operation. The mean follow-up period was 920 ± 973 days.

RESULTS: A mitral valve procedure was performed alone in 75 (62.5%) patients and combined with additional cardiac procedures in 45 (37.5%). Fifty-eight (49%) patients had emergency or urgent procedures and 62 (51%), elective procedures. The mean cardiopulmonary bypass time was 103 ± 39 min (median 94 min, range 45–252, interquartile range 75–121.5 min). There were no conversions to conventional procedures and no intraoperative deaths. The 30-day mortality rate for patients without cardiogenic shock was 7.5% (8 deaths among 106 patients). Among 14 (11.7%) patients who underwent an operation in cardiogenic shock, 4 died during the first 30 days (30-day mortality rate = 28.6%, Fisher's exact test $P = 0.338$ versus patients without shock). The lowest 30-day mortality rate was in patients operated on with the beating heart because of a porcelain aorta ($n = 8$ patients, 30-day mortality rate = 0%).

CONCLUSIONS: Patients considered unsuitable for a conventional mitral valve operation had favourable postoperative outcomes if the operation was performed on the beating heart.

Keywords: Beating heart • Mitral valve • Cardiogenic shock • Surgery • Surgical technique

INTRODUCTION

Patients with mitral valve disease are sometimes considered high-risk candidates for conventional operations or even inoperable. The reasons are either an extremely comorbid risk profile (e.g. cardiogenic shock or severe endocarditis) or technical surgical reasons (e.g. porcelain aorta). An alternative option for these patients is for the surgeon to perform a mitral valve procedure on the beating heart using cardiopulmonary bypass (CPB) but without cardioplegic arrest and without aortic cross-clamping. We introduced this strategy into our clinical practice in 2002 and applied it exclusively in patients with an extremely high risk for conventional operations.

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We postulated that the group of patients with mitral valve diseases of different origins might have improved outcomes if the mitral valve procedure was performed on the beating heart. To test this hypothesis, we conducted a single-centre, retrospective study in a series of 120 consecutive patients undergoing mitral valve surgery on the beating heart. We examined early outcomes, surgical parameters and mid-term survival rates and subsequently assessed ('aim of the study') whether beating heart mitral valve surgery in heterogeneous, extremely high-risk patients is a useful strategy.

MATERIALS AND METHODS

Study design

This project was a retrospective, observational, single-centre cohort study of data from a heterogeneous group of patients

with mitral valve diseases of different origins and different risks factors who underwent beating heart mitral valve surgery at the Deutsches Herzzentrum Berlin (Berlin, Germany) from the beginning of its clinical introduction in September 2002 to April 2014. The study is reported following the STROBE statement [1].

Patients

A heterogeneous group of 120 consecutive high-risk patients with mitral valve diseases of different origins who were considered unsuitable for conventional mitral valve procedures and who underwent normothermic beating heart mitral valve surgical procedures (without aortic cross-clamping and without cardioplegia) were included in the study ('study cohort'). Any combined simultaneous heart operation was also performed on the beating heart. All patients or their representatives gave informed consent. The study was approved by our institutional review board.

Evaluation and selection of patients and procedural criteria

The patients were evaluated by the team of cardiologists and surgeons with expertise in conservative and surgical treatment of patients with chronic heart failure. The surgical strategy to perform mitral valve surgery on the beating heart was considered only in extremely high-risk patients in order to minimize the procedural risk of the conventional procedure. Previous cardiac surgery was not considered *per se* an indication for beating heart mitral valve surgery. The preoperative evaluation of the patients was the same as that for persons having conventional mitral valve surgery. No special examinations were necessary. An absolute contraindication for beating heart mitral valve strategy was moderate (Grade $\geq$II) or severe aortic valve insufficiency. Aortic valve insufficiency of less than Grade II was only a relative contraindication. There were no contraindications for a beating heart mitral valve operation with regard to technical surgical considerations.

Surgical procedure

In general, the procedure was performed using a conventional surgical approach for mitral valve surgery but on the beating heart and without aortic cross-clamping and without cardioplegic arrest. No special equipment was necessary. This modified technique differs from the standard surgical technique in several points. A precise description of all surgical procedural details is given in the Supplementary Material. The operation was performed either in isolation or in combination with simultaneous additional cardiac surgical procedures (all were performed on the beating heart). All procedures were performed by the same surgeon (M.P.). The surgical access was either a median sternotomy or a right anterior thoracotomy. The standard monitoring for a heart procedure was used. Transoesophageal echocardiography and ECG monitoring were performed continuously during the procedure. Carbon dioxide was continuously insufflated into the operating field throughout the procedure.

Definition of outcomes

The primary end-point was the 30-day mortality rate. It was defined as death of any cause and irrespectively of where the death occurred from Day 0 to Day 30 (30th day included) after the index procedure.

Secondary end-points were survival at follow-up and intraprocedural, procedural and post-procedural variables. Technical complications were considered surgical complications if they necessitated revision and were directly caused by surgical technical failure: conversion to conventional valve surgery, moderate mitral valve insufficiency (Grade II) or higher, paravalvular leakage, revision for bleeding, iatrogenic aortic dissection, deep wound infection and stroke. Stroke was categorized according to clinical examination into disabling and non-disabling stroke and sub-classified into haemorrhagic, ischaemic and undetermined according to the modified VARC 2 criteria [2]. For data collection and stratification, we defined cardiogenic shock using modified clinical and instrumental criteria [3, 4]. Cardiogenic shock was diagnosed only if all the following criteria were present: unstable haemodynamic condition, requirement for increasing dosage of adrenaline and upcoming or evident multiorgan failure, including anuria and pulmonary congestion diagnosed from chest radiography [4]. Patients with chronic terminal heart failure and preoperative intravenous inotropic support but without sudden acute deterioration were defined as 'under preoperative inotropic support'.

Control group

A control group with a historical cohort treated with conventional mitral valve surgery ('surgery with cardioplegia') at our institution comprising patients with ischaemic cardiomyopathy with mitral insufficiency and low ejection fraction [5] was compared with our subgroup of patients with ischaemic cardiomyopathy. Additionally, we compared our historical cohort of patients in cardiogenic shock and severe aortic valve stenosis treated with transcatheter aortic valve implantation [4] to our patients in shock.

Follow-up and data collection

Follow-up was 100% complete. The most recent data collection was in April and May 2014. The last patient had over 30 days of follow-up. The information about deaths of German patients was obtained from the official state administrative office. Patients from outside Germany or their families were contacted by telephone. All data concerning patients' comorbidities, morbidity and deaths were stored in an electronic database and analysed.

Statistical analysis

Continuous variables are presented as mean ± standard deviation or median with interquartile range (IQR). Categorical variables are described as numbers and percentages. The 30-day rates during the study period are presented as percentages. Fisher's exact test was used to test the differences in mortality rates between groups and to assess the binary risk factors for mortality. The Mann–Whitney test was used to analyse continuous risk factors for mortality. Univariate logistic regression was applied to analyse the influence of risk factors on survival. Overall survival was presented using the Kaplan–Meier procedure. The data were evaluated by IBM SPSS Statistics software 22 (SPSS Inc., Chicago, IL, USA). A P-value <0.05 was considered statistically significant.

RESULTS

Baseline patient characteristics

The study cohort comprised 39 (32.5%) female and correspondingly 81 (67.5%) male patients. The mean age of the patients was 63.7 ± 12.1 years [median 64.6, range 25.3–88.8, IQR 58.1–73.1].

The predominant indication for a surgical procedure was mitral valve insufficiency [*n* = 115 (95.8%)], endocarditis (with or without mitral insufficiency) and only exceptionally valve stenosis. The main diseases were ischaemic cardiomyopathy [*n* = 66 (55%)], dilative cardiomyopathy [*n* = 22 (18%)], endocarditis [*n* = 16, (13%)] and porcelain aorta [*n* = 8 (7%)]. Failed previous mitral surgery was the indication for surgery in 23 (19%) patients. Coronary artery disease was present in 80 patients (67%) with acute [*n* = 4 (3%)], recent [*n* = 12 (10%)] or old myocardial infarction [*n* = 51 (42.5%)] (Table 1).

Fourteen (11.7%) patients had cardiogenic shock and 33 (27.5%) received inotropic support preoperatively; one patient was on extracorporeal membrane oxygenation. Sixteen (13%) patients were mechanically ventilated and 12 (10%) were on dialysis. Sixty-five (54%) patients had had at least 1 (range 1–6) previous conventional cardiac surgical procedure. The mean serum creatinine value was 1.6 ± 1.0 mg/dl (median 1.3, range 0.6–7.2, IQR 1.0–1.7).

Table 1: Preoperative patients' characteristics

Variable (unit)	Value or mean ± SD	Percentage or range
Male (*n*)	81	67.5
Age (years)	63.8 ± 12.1	25.3–88.8
Logistic EuroSCORE	26.1 ± 20.6	1.5–84.3
EuroSCORE II	14.6 ± 13.6	0.7–56.6
Ischaemic cardiomyopathy	66	55
Dilatative cardiomyopathy	22	18
Endocarditis	16	13
Porcelain aorta	8	7
Preoperative ventilation	16	13
Intravenous inotropic support	33	27.5
Dialysis	12	10
Creatinine (mg/dl)	1.6 ± 1.0	0.6–7.2
COPD	19	16
Previous stroke	21	17.5
IDDM	27	22.5
Severe peripheral arterial disease	10	8
Arterial hypertension	75	62.5
Pulmonary hypertension	75	62.5
Atrial fibrillation	48	40
Coronary artery disease	80	67
Acute myocardial infarction	4	3
Recent myocardial infarction	12	10
Old myocardial infarction	51	42.5
Previous heart surgery	65	54
Coronary artery bypass grafting	41	34
Aortic valve replacement	22	18
Mitral valve surgery	23	19
TAVI	2	1.7
Pacemaker or ICD implantation	32	27

SD: standard deviation; EuroSCORE: European System for Cardiac Operative Risk Evaluation; COPD: chronic obstructive pulmonary disease; IDDM: insulin-dependent diabetes mellitus; TAVI: transcatheter aortic valve implantation; ICD: internal cardioverter defibrillator (numbers are rounded).

The mean logistic European system for cardiac operative risk evaluation (EuroSCORE) of the study cohort was 26.1 ± 20.6% (median 18.8, range 1.5–84.3, IQR 10.8–37.4) (Table 1).

The mean follow-up was 920 ± 973 days with a range from 0 (in the case of death during the procedural day) to 3863 days (median 476, IQR 118–1558), with a total of 302.2 patient years. At the time of the last data collection, 51 (42.5%) patients were alive and 69 (57.5%) had died during the follow-up period. The patients' characteristics are summarized in Table 1.

Preoperative echocardiographic data

The mean preoperative left ventricular ejection fraction (LVEF) was 36 ± 17% (range 10–80%) and the mean left ventricular end diastolic diameter (LVEDD) was 61 ± 12 mm (Table 2). There were 63 (52.5%) patients with LVEF <30%; 39 (32.5%) patients had an LVEDD >70 mm with the largest LVEDD being 86 mm. The mean preoperative grade of mitral insufficiency was 2.7 ± 0.7 (range 0–4). In total, 115 (95.8%) patients had mitral valve insufficiency as a main pathological feature. The mean grade of tricuspid valve insufficiency was 1.3 ± 1.1 (range 0–4).

Procedural characteristics

One hundred twenty procedures were performed in 124.7 months. These 120 operations represented only 1.7% of all conventional mitral valve procedures—including combined procedures with mitral valve surgery—performed at our institution during the study period (*n* = 6732 procedures). Intraprocedural and post-procedural data are given in Table 3. Isolated mitral valve procedures were performed in 75 (62.5%) study patients and mitral valve surgery combined with additional simultaneous cardiac surgery (Fig. 1) in 45 (37.5%); all procedures were performed on the beating heart. Emergency operations were performed in 13 (10.8%) patients, urgent operations in 45 (37.5%) and elective procedures in 62 (51.7%). A right anterior thoracotomy was used as surgical access in 42 (35%) patients and a median sternotomy in 78 (65%) (Table 3).

The mean CPB time for the whole group was 103 ± 39 min (median 94, range 45–252, IQR 75–121.5), for isolated mitral valve surgery 94.5 ± 35.3 min (median 89, range 45–252, IQR 72.5–110.5) and for combined procedures 116.8 ± 42.1 min (median 104.5, range 64–242, IQR 86–141.3). The longest CPB time was 252 min in a patient with cardiogenic shock in whom additional reperfusion was done for recovery of the unloaded heart while the LV vent was *in situ*. There were no conversions to

Table 2: Preoperative echocardiographic data

Variable (unit)	Mean ± SD	Range
LVEF (%)	36 ± 17	10–80
LVEDD (mm)	61 ± 12	30–86
RVEF (%)	45 ± 12	15–70
RVEDD (mm)	32 ± 6	7–50

SD: standard deviation (numbers are rounded); LVEF: left ventricular ejection fraction; LVEDD: left ventricular end diastolic diameter; RVEF: right ventricular ejection fraction; RVEDD: right ventricular end diastolic diameter.

conventional cardiac procedures with cardioplegic arrest. Primary weaning from CPB was successful in all patients. An intra-aortic balloon pump was 'prophylactically' placed in 18 (15%) patients in order to facilitate both weaning from CPB and the postoperative course (especially during the awakening phase).

Table 3: Surgical data

Variable (unit)	Value or mean ± SD	Percentage or range
CPB time (min)	103 ± 39	45–252
Procedure time (min)	260 ± 78	165–385
Lateral thoracotomy (*n*)	42	35
Median sternotomy	78	65
Mitral valve repair	31	25.8
Mitral valve replacement	87	72.5
Paravalvular leak closure	2	1.7
Tricuspid valve repair	20	17
Tricuspid valve replacement	1	0.8
Coronary artery bypass grafting	23	19
Left ventricular aneurysmectomy	6	5
Wrapping of the ascending aorta	3	2.5
TAVI	2	1.7
Intra-aortic balloon pump	18	15

Patent foramen ovale closure was not counted as an additional combined surgical procedure; numbers are rounded.
SD: standard deviation; *n*: total number of procedures; CPB: cardiopulmonary bypass; TAVI: transcatheter aortic valve implantation.

Thirty-day mortality rate

The overall 30-day mortality rate for the whole study cohort of 120 patients, including those with cardiogenic shock, was 10% (12 of 120). It ranged from 7.5% in patients without cardiogenic shock to 28.6% in patients with cardiogenic shock (Fisher's exact test $P = 0.338$ versus patients without shock). Patients operated on with a beating heart because of a porcelain aorta had no 30-day deaths (0%). There were no intraoperative deaths in the whole study cohort. The cause of death during the first postoperative 30 days was multiorgan failure in all, except 1 patient who suffered sudden death after an initially uneventful postoperative course. The univariate model was not significantly predictive for early survival because of the limited number of events. Similarly, due to the small number of deaths, no multivariate analysis was performed.

Comparisons with the historical control group—ischaemic cardiomyopathy

Forty-one patients (mean age 64.7 ± 9.2 years; range 41.9–83.3 years; mean logistic EuroSCORE II, 15 ± 14%) with ischaemic heart failure and LVEF ≤30% underwent mitral valve operations on the beating heart. The mean LVEF was 23 ± 5.5% and the mean LVEDD was 69 ± 7 mm (range 53–82 mm). Procedures conducted simultaneously with mitral valve surgery included coronary artery bypass grafts [mean 1.9 ± 1.2 grafts (range 1–5) per patient] in 18 patients, tricuspid valve repair in 8 and left ventricular aneurysmectomy in 4. Postoperatively, LVEF increased

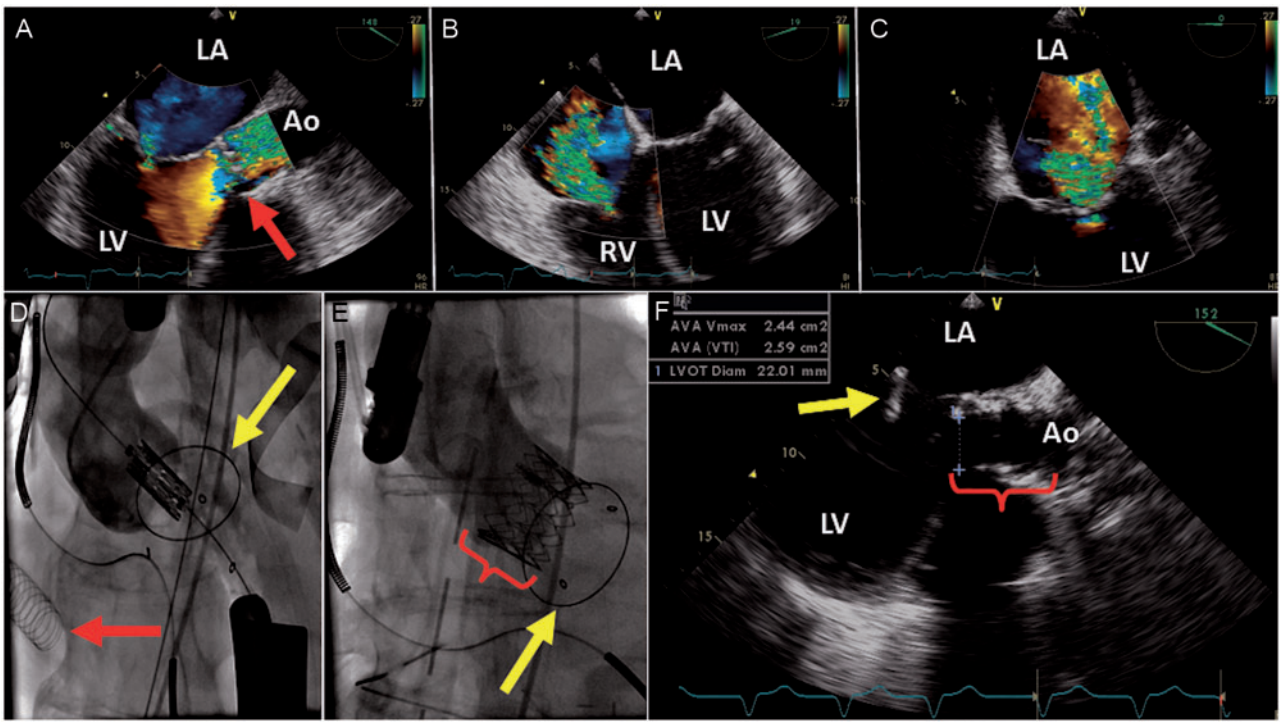

Figure 1: Combined procedure with mitral valve replacement, tricuspid valve reconstruction and TAVI in a 72-year-old patient in prolonged cardiogenic shock with anasarca and aortic valve stenosis (panel **A**), severe tricuspid (panel **B**) and mitral valve insufficiency (panel **C**) and poor left and right ventricular function. The combined procedure consisted of mitral valve replacement with a biological 33-mm prosthesis (yellow arrow, panels **D**–**F**), tricuspid valve reconstruction and modified transapical TAVI (panels E and F) using an Edwards SAPIEN 29-mm (red bracket, panels **E** and **F**). The procedure was performed through a median sternotomy on the beating heart using normothermic cardiopulmonary bypass (bypass time, 125 min) without aortic cross-clamping and cardioplegia. Note the venous cannula (red arrow, panel **D**) used for cardiopulmonary bypass. Weaning from cardiopulmonary bypass was uneventful under low-dose inotropic support. LA: left atrium; Ao: ascending aorta; LV: left ventricle; RV: right ventricle.

(mean improvement = +7%; $P < 0.0001$) and LVEDD decreased (mean reduction = -7 mm; $P < 0.0001$). Overall 6-month, 1-year, 2-year and 5-year survival rates were 87, 73, 65 and 37%, respectively.

The 30-day mortality rate in our study group operated on with a beating heart and without cardioplegia was 2.4% (1 death among 41 patients). In comparison, our historical group of patients [5] with ischaemic cardiomyopathy and an LVEF of 10–30% operated on using cardioplegic arrest had a significantly increased early mortality rate of 33.3% after mitral valve repair and 30.3% for patients with mitral valve replacement.

Comparisons with the historical control group—cardiogenic shock

Preoperative cardiogenic shock was present in 21 patients (EuroSCORE, 73.1 ± 18.9%; LVEF, 26.0 ± 13.1%) with aortic valve stenosis treated with transcatheter aortic valve implantation who had an increased 30-day mortality rate of 19% and a 1-year survival rate of 46% [4]. The increased mortality rate (28.6%) was also found in our study group with 14 (11.7%) patients who were preoperatively in cardiogenic shock and who underwent mitral valve surgery on the beating heart without cardioplegia.

Technical procedural and postoperative complications

None of the following surgical complications arising from the technical parameters of the procedure occurred: conversion to conventional valve surgery, mitral valve insufficiency of Grade > I, paravalvular leakage or iatrogenic aortic dissection. One (0.8%) patient had postoperative deep wound healing problems. The most frequent complication was prolonged postoperative pulmonary weaning from the respirator [48 (40%) patients] (Table 4). A total of 5 (4.2%) patients underwent postoperative re-thoracotomy for bleeding complications during the first 7 postoperative days. The postoperative neurological complication rate was 4.2% (5 patients): 3 (2.5%) patients had a disabling stroke and 2 (1.7%), a non-disabling stroke.

Table 4: Postoperative complications

Variable	Number patients	Percentage
Myocardial infarction	1	0.8
Pneumonia	30	25
Multiorgan failure	12	10
Suboptimal haemodynamics	17	14
Sepsis	14	12
Prolonged respirator weaning	48	40
Tracheostomy	18	15
Reintubation	14	12
Continuous venovenous filtration	15	12.5
Acute kidney injury	9	7.5
Disabling stroke	3	2.5
Non-disabling stroke	2	1.7
Re-thoracotomy for bleeding	12	10
Sternal wound infection	1	0.8
Pacemaker implantation	1	0.8

Numbers are rounded.

Late survival and events

The overall 6-month, 1-year, 2-year and 5-year survival rates of this heterogeneous group of extremely high-risk patients were 73.0 ± 4.2, 63.5 ± 4.6, 56.5 ± 4.8 and 37.4 ± 5.0%, respectively (Fig. 2). The overall 6-month, 1-year and 3-year survival rates of the control group (patients in shock underwent transcatheter aortic valve implantation) were 46, 46 and 46%, respectively. The 1-year survival rates of this heterogeneous group of patients differed according to the primary disease; it was 83% for patients with 'porcelain aorta' and 54, 62 and 68% for patients with endocarditis and dilatative and ischaemic cardiomyopathy, respectively. Thirteen (10.8%) patients underwent a redo operation during the late follow-up period: 3 (2.5%) had a heart or heart–lung transplant, 5 (4.2%) had left ventricular assist device (VAD) implantation and 5 (4.2%) had redo mitral valve surgery.

Association of baseline and procedural characteristics with follow-up survival

Univariate analysis revealed that the variables age ($P < 0.001$), logistic EuroSCORE ($P = 0.007$), additive EuroSCORE ($P < 0.001$), preoperative creatinine value ($P < 0.001$), glomerular filtration rate ($P = 0.009$), peripheral arterial disease ($P = 0.049$) and mitral valve repair versus replacement ($P = 0.060$) were related to an increased number of deaths in the follow-up period. Multivariate analysis revealed only age [hazard ratio (HR) 1.04, 95% confidence interval 1.01–1.06, $P = 010$] and preoperative creatinine value (HR 1.53, 95% confidence interval 1.23–1.91, $P < 0.001$) as relevant for late survival.

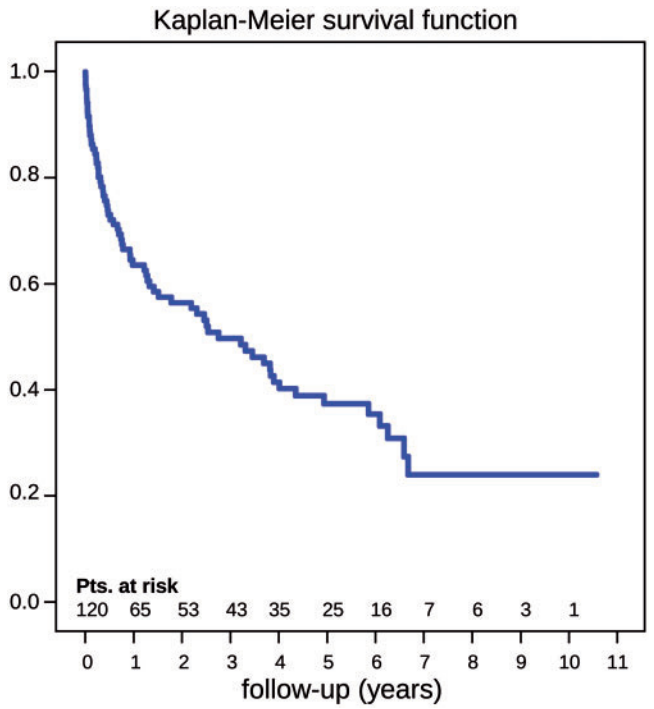

Figure 2: Kaplan–Meier survival curve.

DISCUSSION

The major finding of the present study is an acceptable early mortality rate after beating heart mitral valve surgery in our heterogeneous group of high-risk patients considered unsuitable for conventional mitral valve surgery. The second important finding is the lack of an increased rate of procedural complications. Our experience with 120 patients, although limited, has clearly shown that this surgical strategy may improve overall results of the management of these patients.

Our study group was a mixture of patients with varied mitral valve diseases of different origins and different surgical risks with different grades of comorbidities. Despite the apparent differences, these patients were all united by 2 facts: (i) all of them were considered inoperable using the standard surgical technique and (ii) all of them were treated by the same surgical strategy—the modified surgical technique. The most important point of the paper is that the modified surgical strategy used with these patients—who were considered otherwise inoperable using the conventional surgical technique—made them operable with an acceptable risk. The results of the study proved that this modified technique is useful in all of these different surgical categories. Although survival of the whole group is reduced, one should bear in mind that many of these patients would not survive without surgery; the described technique was a valuable option to prolong survival for some of them.

Rationale for beating heart mitral valve surgery

In this series, all operations, including the combined procedures, were performed on the beating heart using normothermic CPB without aortic cross-clamping and without cardioplegia. Theoretically, this strategy omits aortic cross-clamping and cardioplegia and, therefore, should eliminate additional ischaemic trauma to the heart [6]. Cardioplegic cardiac arrest is considered a major cause of postoperative morbidity in patients with severely reduced left ventricular function [7, 8]. Compared to patients with cardioplegic arrest, those undergoing beating heart surgery had lower postoperative creatine kinase-MB levels and a shorter period of postoperative inotropic support [9]. When postoperative inotropic support is avoided and mitral valve surgery is performed on the beating heart, the early outcome is improved [10, 11]. Importantly, weaning from CPB was successful in all our patients. We believe that the modified technique without the use of cardioplegia is the most relevant factor in patients with a highly reduced LVEF. In our experience, this modification is of enormous importance during the end of the surgical procedure and for uneventful weaning from the heart–lung machine. The modified technique differs in several important details from the conventional surgical mitral valve technique. Especially, it is of enormous importance to prevent air embolization during surgical procedures on the beating heart. The technique has a learning curve and should be performed by experienced surgeons.

The failing heart

Some extremely high-risk patients with severe mitral valve disease in whom the maximal pharmacological therapy fails may be considered not amenable to conventional cardiac surgery due to the high surgical risk. The remaining therapeutic possibilities are a mechanical assist device implant or a heart transplant. Both strategies have their own, possibly serious complications. Another option is to operate on these patients on the beating heart. Should the procedure not be successful, a VAD can be implanted in the same session or later: The present strategy does not preclude subsequent mechanical assist device implantation. If the beating heart strategy is successful, VAD implantation may be postponed or avoided, enabling a 'VAD-free period'. Therefore, these 2 methods can be combined. It remains unclear who should have benefited from VAD therapies instead of undergoing mitral valve surgery. In our patient group, 5 (4.2%) patients received left VADs and 3 (2.5%) underwent heart or heart–lung transplant during the follow-up period. Furthermore, beating heart mitral valve surgery can be an alternative to the use of a MitraClip or a solution for the patients in whom the MitraClip procedure failed.

Combined procedures, redo procedure and porcelain aorta

The reported strategy is also attractive for high-risk patients with complex cardiac disease [12, 13]. A further advantage of the technique is that it facilitates reoperation in patients with repeated previous cardiac surgical procedures. Extensive dissection of the aorta and potential injury of a patent bypass graft or a dilated right ventricle can be avoided if a right thoracotomy approach is applied. The other group of patients who can profit from mitral valve surgery on the beating heart is the group with diffuse severe calcification of the ascending aorta or porcelain aorta [14, 15].

Feasibility of the beating heart mitral valve procedure

Although generally not widely popularized and accepted, different types of beating heart mitral valve procedures have already been established in some centres [6, 9–11, 12, 15–21]. There are 2 reports with a large number of patients [18, 19] showing 30-day mortality rates of 6.5 and 6.4%, respectively. The beating heart strategy can also be applied for 'minimally invasive mitral valve surgery' through a key-hole incision (using a special armamentarium) [21]. A meta-analysis of beating heart valve procedures by Salhiyyah and Taggart [6] that includes 39 publications concluded that heart valve operations with a beating heart had good safety outcomes. However, they considered the analysed studies to have weaknesses so that no conclusions could be drawn as to the superiority of either technique [6].

Mitral valve replacement versus repair

From the beginning of the introduction of the modified technique, we adopted the policy of performing primarily mitral valve replacement rather than repair for four reasons. First, mitral valve replacement is technically easier to perform under beating heart conditions than valve repair under the same conditions. Second, our intention was to prevent an increased rate of air embolization that could occur in some technically difficult valve repairs using this modified technique. Third, because our strategy was to eliminate possible early problems that occur after valve repair, we replaced rather than repaired the valve to exclude the possible need for early surgical reintervention. We published the results of our early institutional experience in 1997 and 1999 [5].

This policy has been partially proved by the recent randomized studies that showed increased (up to 30%) recurrence of mitral insufficiency during the first 30 postoperative days [22]. Fourth, this subgroup of patients has reduced life expectancy and therefore, in our opinion, the possible advantages of mitral valve repair are not to be expected in these patients. Additionally, it is to be stressed that 19% of our patients already had mitral valve operations requiring mitral valve replacement. All these were factors for an increased number of valve replacements in comparison with mitral valve repair.

Interventional mitral valve procedure

Presently most of these patients are treated with the MitraClip. This alternative therapy was introduced during the late years of the study period; as a result, the number of patients treated with the modified surgical technique steadily decreased. Today, the modified surgical technique is used primarily in patients considered unsuitable for MitraClip implantation or after failed MitraClip implantation.

Limitations

The study possesses several limitations, including the retrospective design, the small number of patients and the lack of an adequate comparable study group because we have as a control group a historical cohort treated with conventional surgery. A prospective randomized study with a control group would make possible more precise comparisons between beating heart and conventional surgical cases. On the basis of our increasing and favourable experience with beating heart mitral valve surgery for carefully selected patients with an extremely high surgical risk, it has become the 'gold standard' at our institution to treat these patients. However, our experience does not necessarily mean it should be adopted by all unless consistent and robust data are provided in the future.

CONCLUSIONS

In our high-risk patients considered unsuitable for conventional mitral valve surgical procedures, the postoperative course is favourable if the mitral valve procedure is performed on the beating heart instead of with cardioplegic arrest.

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SUPPLEMENTARY MATERIAL

Supplementary material is available at *ICVTS* online.

Conflict of interest: none declared.

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