General Thoracic and Cardiovascular Surgery (2019) 67:577–584
https://doi.org/10.1007/s11748-019-01065-y

ORIGINAL ARTICLE

Transfer of a minimally invasive mitral valve repair program from a high-volume center to a very low volume center: how many cases are necessary to maintain acceptable results?

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Received: 25 April 2018 / Accepted: 7 January 2019 / Published online: 18 January 2019

Abstract

Objective To investigate whether minimally invasive mitral valve repair (MIMVR) can be transferred from a high-volume center into a very small volume center and to clarify how many cases are necessary for maintenance of this program, early outcomes of MIMVR in Asahikawa Medical University were compared with those results in patients operated by a single surgeon in Duesseldorf University Hospital.

Methods Sixty-five patients who underwent MIMVR in Asahikawa Medical University (group A) between May 2014 and July 2018 and 134 patients who underwent MIMVR in Duesseldorf University Hospital (group D) between September 2009 and January 2014 by a surgeon who started MIMVS later in Asahikawa were retrospectively analyzed.

Results In group D, there were more patients with ischemic mitral valve regurgitation and with annular calcification than in group A. Survival rate at 6 months and 1 year was 98.5% and 98.5% in group A and 92.9% and 91.3% in group D, respectively. EuroSCORE II was significantly higher in patients dead within 30 days and within the first year.

Conclusions The present study demonstrated that MIMVR programs can be transferred with acceptable early results into very low volume centers, if the team is developed by surgeons who are well trained and experienced in MIMVR. Moreover, the present study suggested that case number for maintenance of acceptable results may be obviously less than the previous recognition that this kind of specialized surgery could be maintained with at least 50 cases annually. However, meticulous preparations for surgery are essential for satisfactory surgical outcomes.

Keywords Minimally invasive cardiac surgery · Mitral valve repair · Low-volume center

Introduction

Minimally invasive cardiac surgery (MICS) through a small right thoracotomy is now a well-established technique. With this approach, a wide variety of procedures can be performed, including mitral valve repair, aortic valve replacement, and coronary artery bypass grafting. Mitral valve surgery is the most common procedure to perform via MICS, and several reports have shown acceptable outcomes for minimally invasive mitral valve repair (MIMVR) [1–5]. However, compared with conventional approaches, certain technical difficulties exist with MIMVR, and the number of cases required to overcome the learning curve and for maintenance of acquired skills has been discussed. The Leipzig group reported that the typical number of cases required to overcome the learning curve for MIMVR was between 75 and 125, with about 50 cases annually needed to maintain optimal results [6]. The Leipzig Heart Center is the largest MICS institute in the world, and its MIMVR protocol has been considerably standardized. In such a large center employing a multidisciplinary approach, not only surgeons, but also cardiologists, anesthetists, scrub nurses,

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perfusionists, and more are aware of the MICS approach, including associated tips and pitfalls.

In Japan, many cardiac surgical centers exist and the annual report released by the Japanese Association for Thoracic Surgery has revealed that a total of 66,453 cardiovascular operations were performed in 561 institutions in 2014 alone, and the average number of cardiac operations per institute was 118 [7]. Under such circumstances, establishing an MIMVR program from scratch may be very difficult, even if a participating surgeon has been trained at a large-volume MIMVR center, because a multidisciplinary team approach is absolutely necessary for an MIMVR program. However, difficult does not mean impossible, and many Japanese centers have introduced MIMVR programs safely with very small number of cases initially. Unfortunately, these experiences have not been well reported.

In our institute, two surgeons have been trained in MIMVR in a large German center (Duesseldorf University Hospital), with a total number of 134 MIMVS procedures led by the more experienced of these two surgeons, and they transferred this experience to a low-volume Japanese center (Asahikawa Medical University) without any prior expertise in MICS surgery. We report this experience in detail herein to clarify the number of cases that may be needed to establish and maintain a MIMVR program in a low-volume center when conducted by a surgeon who has already been well trained in MIMVR in the frame of an established program elsewhere. For this purpose, we compare early and mid-term outcomes of MIMVR in Asahikawa Medical University with those results in patients operated by a single surgeon (H.K.) in Duesseldorf University Hospital to investigate whether the MIMVR program in Asahiakawa Medical University could be established at the same level as the respective program of Duesseldorf University Hospital, where the operating surgeons had learned MIMVR.

Methods

Selection criteria for MIMVR

For the safe introduction of MIMVR, certain conditions are considered as contraindications in our institute. Whenever these contraindications are absent, patients requiring an isolated mitral valve procedure with or without tricuspid valve repair are considered as candidates for MICS, independent of the complexity of the mitral valve disease. Absolute contraindications include (1) massive mitral annular calcification (difficult to expect the operative time); (2) history of previous operation on the right lung; or (3) shaggy aorta. Relative contraindications are (1) calcification of the ascending aorta; (2) redo cardiac operation; (3) ongoing cardiogenic shock; or (4) thrombus in the left atrium (cross-clamping the aorta as soon as possible to prevent stroke).

Surgical procedure

This operation is performed in the supine position with slight elevation of the right hemi-thorax. For mechanical ventilation, a double-lumen endotracheal tube is inserted to enable one-sided lung ventilation in emergency situations. However, one-sided ventilation has not been needed in any case to date. In patients requiring tricuspid valve repair, a venous cannula (HLS Cannula; Maquet, Rastatt, Germany) is percutaneously inserted through the right internal jugular vein by the anesthetist before the procedure commences. After draping, heparin is administered and the right groin is opened to access the right femoral artery and vein. A second venous cannula (QuickDraw 22 Fr or 25 Fr, usually the latter size; Edwards Lifesciences, Irvine, CA, USA) is inserted under trans-esophageal echocardiography guidance. The tip of the cannula is placed in the superior vena cava, or alternatively in the inferior vena cava when performing concomitant tricuspid valve repair. An arterial cannula (Fem-Flex II; Edwards) is then inserted into the right common femoral artery, after which cardiopulmonary bypass is established. Ventilation is then stopped and both lungs are fully collapsed, and a right anterolateral mini-thoracotomy is made in the 4th intercostal space. A thoracoscope is inserted via the 2nd intercostal space and a Chitwood aortic clamp is inserted via the 3rd intercostal space (Fig. 1). The pericardium is opened longitudinally about 2 cm ventral to the right phrenic nerve. In cases of simultaneous tricuspid valve repair, both venae cavae are snared. A cannula for antegrade cardioplegia is introduced into the ascending aorta, which is then cross-clamped and a blood cardioplegia solution

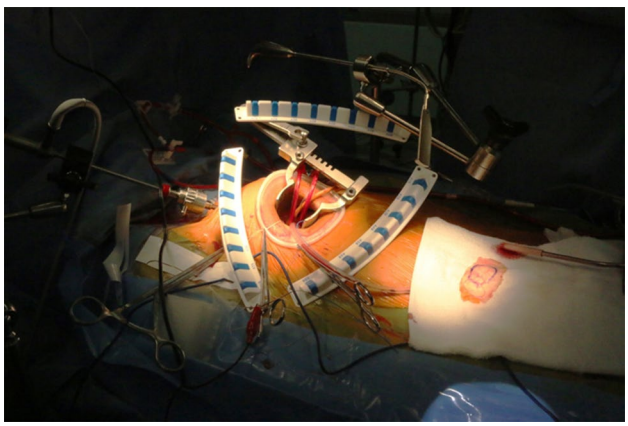

Fig. 1 Intraoperative setup for minimally invasive mitral valve surgery. Mini-thoracotomy was done in the 4th intercostal space. A thoracoscope was inserted into the 2nd intercostal space and an aortic clamp was inserted into the 3rd intercostal space

is administered. The left atrium is opened in Waterston's groove and the atrial septum is elevated using a special hook (Adams-Yozu; Geister, Tuttlingen, Germany). Pulmonary vein isolation with a cryo instrument is then performed if needed. Subsequently, the mitral valve is inspected and repaired with diverse techniques. In cases with mitral valve stenosis, the mitral valve is replaced. After the mitral valve procedure, the left atrium is closed. In cases requiring tricuspid valve repair, repair is performed under cardioplegic arrest. The aortic clamp is then removed and de-airing is performed through the aortic root vent. After evaluation of the mitral valve, the root cannula is removed. Ventilation is started and the patient is weaned from the cardiopulmonary bypass. After the procedure, the patient receives a paraspinal block and is extubated in the operating room, if possible.

Patients

In our institute, the MIMVR project started in May 2014. In the 4 years between May 2014 and July 2018, MIMVR was employed in 65 patients (in average 17 MIMVR cases annually). Those 65 patients were analyzed retrospectively and categorized as group A. On the other hand, 134 patients underwent MIMVS in Duesseldorf University Hospital between September 2009 and January 2014 by the same surgeon who started MIMVR later in Asahikawa. Data of those patients were also analyzed as a control group (group D).

Institutional Review Board of Asahikawa Medical University and Duesseldorf University waived ethical compliance for this retrospective study.

Description of mitral regurgitation

All patients in groups A and B had severe mitral regurgitation (MR). All surviving patients underwent transthoracic echocardiography prior to discharge and postoperative MR was graded as 0, no or trivial MR; 1+, mild MR; 2+, moderate MR; 3+, moderate–severe MR; and 4+, severe MR.

Follow-up

Follow-up information on all patients was collected through planned outpatient visits in the course of regular clinical follow-up. In group A, no patient was lost to follow-up and the mean duration of follow-up was 788 ± 412 days. Principally, all patients in group A have been followed-up with transthoracic echocardiography (TTE) in the outpatient clinic in Asahikawa Medical University at least annually; therefore, follow-up for group A was very precise. On the other hand, 6 patients were lost to follow-up and the mean duration of follow-up was 508 ± 311 days in group D. Generally, group D was in follow-up care by family doctors and ambulatory practicing cardiologists. All surviving patients were asked to come to outpatient clinic in Duesseldorf University Hospital for TTE evaluation; however, it was difficult to do TTE evaluation annually. Because of the heterogeneity of follow-up period between groups, the follow-up period in the present study was cut off at 1 year after surgery because all patients except the above-mentioned 6 patients with loss of follow-up were followed-up with TTE.

Statistical analysis

Results are expressed as mean ± standard deviation. Statistical analysis was performed using Student's t test for continuous variables or χ^2 tests (Fisher's exact tests if $n < 5$) for categorical variables. Kaplan–Meier analysis was used to compare late mortality between subjected groups. A p value less than 0.05 was considered significant. All statistical analyses were performed using SPSS 22.0 software (SPSS Inc., Chicago, IL).

Results

Patient characteristics

Preoperative patient characteristics are summarized in Table 1. Age and gender distributions were similar in both groups. Regarding the etiology of mitral valve disease, there were more patients with anterior prolapse in group A than in group D ($p = 0.002$). In group D, there were more patients with ischemic mitral valve regurgitation ($p = 0.026$) and with annular calcification ($p = 0.003$) than in group A.

Intraoperative data

The intraoperative parameters noted in this study are listed in Table 2. Conversion to full sternotomy was done in 3 patients in group D. The percentages of concomitant procedures regarding tricuspid valve repair and ablation surgery were similar between groups. Operation time, cardiopulmonary bypass time and cross-clamping time were also similar between groups.

Surgical techniques for repair

Surgical techniques for repair are summarized in Table 3. Very interestingly, there were obvious differences regarding repair techniques between groups, although both cohorts were operated principally by the same surgeon. In brief, those technical differences included the following: neo-chordae and open ring were more applied in group D, whereas triangular resection and close ring were more applied in group A. In group D, almost all patients having mitral valve prolapse were treated with neo-chordae and close ring in the

Table 1 Patient characteristics

	Group A ($n=65$)	Group D ($n=134$)	p value
Age (years)	62.3 ± 13.9	63.3 ± 13.1	0.613
Male (n, %)	33 (50.7%)	61 (45.5%)	0.483
Etiology			
Prolapse of posterior leaflet	27 (41.5%)	65 (48.5%)	0.331
Prolapse of anterior leaflet	16 (24.6%)	11 (8.2%)	0.002
Prolapse of both leaflets	8 (12.3%)	21 (15.7%)	0.528
Isolated annular dilatation	12 (18.4%)	21 (15.6%)	0.636
Ischemic mitral regurgitation	1 (1.5%)	12 (8.9%)	0.026
Active infective endocarditis	6 (9.2%)	5 (3.7%)	0.114
Annular calcification	3 (4.6%)	20 (14.9%)	0.033
Previous operation	1 (1.4%)	2 (1.2%)	0.850
EuroSCORE II	2.47 ± 2.80	2.61 ± 3.45	0.778

Table 2 Intraoperative data

	Group A ($n=65$)	Group D ($n=134$)	p value
Conversion to sternotomy	0 (0%)	3 (2.2%)	0.224
Concomitant tricuspid valve repair	18 (27.7%)	26 (19.4%)	0.186
Concomitant ablation surgery	16 (24.6%)	24 (17.9%)	0.268
Operation time (min)	210 ± 60	208 ± 73	0.851
Cardiopulmonary bypass time (min)	154 ± 46	153 ± 59	0.918
Aortic clamp time (min)	95 ± 36	93 ± 31	0.831

Table 3 Used techniques in patients undergoing mitral valve repair

	Group A ($n=65$)	Group D ($n=134$)	p value
Triangular resection (n, %)	24 (36.9)	27 (20.1)	0.012
Quadrangular resection (n, %)	0 (0)	6 (4.5)	0.180
Neo-chordae (n, %)	14 (21.5)	51 (38.1)	0.018
Chordal transfer (n, %)	3 (4.6)	12 (8.9)	0.271
Folding plasty (n, %)	10 (15.3)	0 (0)	0.0001
Sliding plasty (n, %)	1 (1.5)	13 (9.7)	0.038
Indentation closure (n, %)	8 (12.3)	18 (13.4)	0.810
Commissural edge-to-edge (n, %)	6 (9.2)	1 (0.7)	0.005
Central edge-to-edge (n, %)	1 (1.5)	0 (0)	0.711
Secondary chordal cutting (n, %)	1 (1.5)	0 (0)	0.711
Pericardial patch (n, %)	1 (1.5)	2 (1.5%)	0.699
Ring annuloplasty alone (n, %)	15 (23.0)	35 (26.1)	0.622
Used annuloplasty technique			
Without ring annuloplasty (n, %)	2 (3.1)	1 (0.7)	0.211
Complete ring (n, %)	35 (53.8)	51 (38.1)	0.035
Partial ring (n, %)	28 (43.1)	82 (61.2)	0.016
Ring size (mm)	29.3 ± 2.3	31.6 ± 2.9	0.0001

early period. In the middle phase, strategy with neo-chordae and open ring was preferred. At the last half period of group D, triangular resection with open ring was applied for posterior prolapse, and neo-chordae with close ring was applied for anterior or commissural prolapse. This strategy was carried over to Asahikawa Medical University with only minor modification as described below. This strategic change in the study period from 2009 to 2018 influenced the difference of surgical technique for repair in both groups.

At present, regarding repair techniques, folding technique or triangular resection was the preferred modality for prolapse of the posterior leaflet, while neo-chordae implantation

was performed in patients with prolapse of the anterior leaflet. Neo-chordae implantation was also performed in cases with prolapse of the posterior leaflet if the prolapse site was very near the commissure. Indentation closure and commissural edge-to-edge (so-called Alfieri stitch) repair were performed in very selected patients.

Postoperative outcomes are summarized in Table 4 and those were similar between groups. Mean postoperative MR grade prior to discharge was 0.2 ± 0.4 in group A and 0.3 ± 0.5 in group D ($p = 0.629$). Frequency of postoperative complications was also similar between groups. Reoperation for bleeding was necessary for 2 patients in group A and 7 patients in group D ($p = 0.494$).

One patient died in the early postoperative period in group A. This 64-year-old man had undergone coronary artery bypass grafting and stem cell implantation for ischemic cardiomyopathy 4 years previously. The patient had severely impaired left ventricular function with a left ventricular ejection fraction of 15% and severe functional mitral valve regurgitation. Ventricular-assist device implantation followed by heart transplantation seemed to be the best strategy for this patient, but he declined. As a last resort, restrictive annuloplasty was performed using MICS. The initial postoperative course was good, but the patient died suddenly on postoperative day 8. On the other hand, 3 patients in group D died within 30 days postoperatively; 2 patients having ischemic MR died due to low-output syndrome and one died due to intraoperative aortic dissection. Early mortality was 1.5% in group A and 2.2% in group D ($p = 0.630$).

The survival curve within the first postoperative year is shown in Fig. 2a. Among patients who survived beyond 30 days, no patient died during study period in group A. On the other hand, in group D, 8 patients who survived beyond 30 days died during the later course. Causes of death were cardiac in 2 patients, non-cardiac in 6 patients. Survival rate at 6 months and 1 year was 98.5% and 98.5% in group A and 92.9% and 91.3% in group D, respectively.

Freedom from re-operation and MR > 1 + in patients undergoing mitral valve repair is shown in Fig. 2b. In the cohort of 65 patients undergoing mitral valve repair,

Table 4 Postoperative outcomes

	Group A ($n = 65$)	Group D ($n = 134$)	p value
Postoperative mitral regurgitation	0.2 ± 0.4	0.3 ± 0.5	0.629
Reoperation for bleeding	2 (3.0%)	7 (5.2%)	0.494
Stroke	0 (0%)	2 (1.5%)	0.322
Prolonged ventilation	0 (0%)	8 (4.8%)	0.104
Renal failure	0 (0%)	6 (4.4%)	0.197
Re-expansion pulmonary edema	0 (0%)	2 (1.4%)	0.816
Groin complication	3 (4.6%)	8 (5.9%)	0.951
Thirty-day mortality	1 (1.5%)	3 (2.2%)	0.630

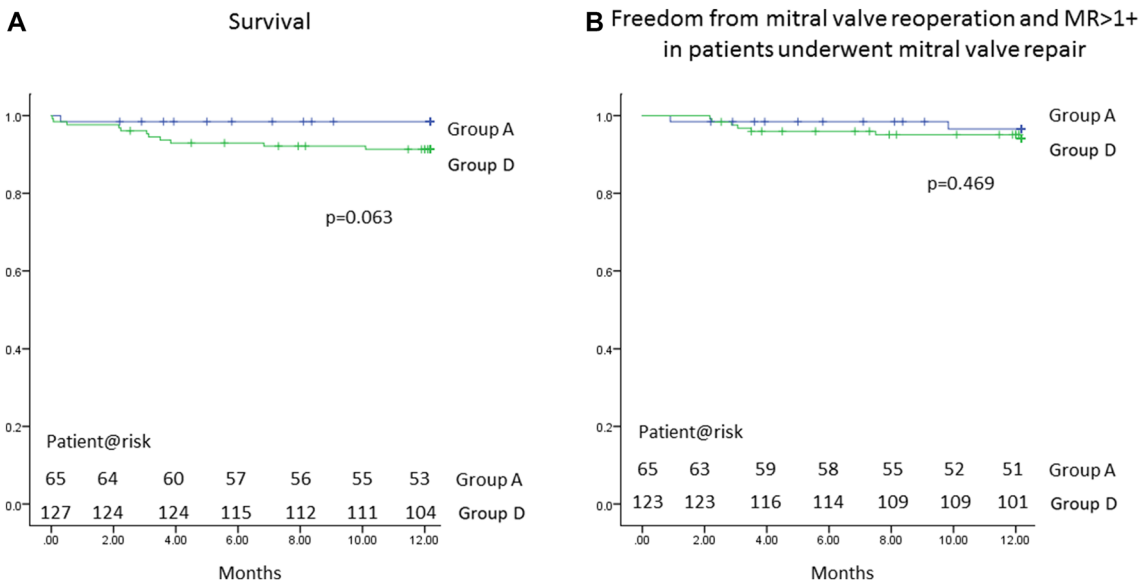

Fig. 2 **a** Survival rate in each cohort during the study period. **b** Freedom from re-operation and MR > 1 + in each cohort during the study period

re-operation was done in 3 patients. Among them, re-operation due to recurrence of MR was done in 2 patients in group A (re-repair in 1 and replacement in 1) and re-operation due to endocarditis was done in 1 patient (replacement). In the remaining 61 patients, no patient has MR > 1 + during follow-up period. On the other hand, in 126 patients surviving beyond 30 days after initial surgery in group D, 5 patients received a re-operation. Among them, reason for re-operation was recurrence of MR in 3 patients (re-repair in 2 and replacement in 1) and endocarditis in 2 patients (replacement in 2). In remaining 121 patients, 2 patients have MR > 1 + without re-operation. Thus, freedom from reoperation and MR > 1 + in patients undergoing mitral valve repair at 6 months and 1 year was 98.4% and 96.6% in group A and 95.9% and 94.2% in group D, respectively.

The relationship between postoperative mortality and calculated EuroSCORE II was demonstrated in Fig. 3. In this analysis, patients in both groups were analyzed together. In entire cohort, 4 patients died within 30 days and the EuroSCORE II in those patients was 14.3 ± 9.3, whereas those 195 surviving patients had an EuroSCORE of 2.3 ± 2.5 ($p = 0.0001$). Similar to this, 12 patients died within the first year (overall mortality) and their EuroSCORE II was 9.0 ± 8.3; on the other hand, the EuroSCORE of patients surviving beyond the first year ($n = 187$) was 2.1 ± 2.1.

Discussion

The present study demonstrates that it has been possible to transfer a MIMVR program safely and with acceptable early results from a high-volume center to a very low volume center. Of note, acceptable results could be maintained only with 17 cases annually, contrary to previous recognition that this kind of specialized surgery could be maintained with at least 50 cases annually.

An important question for spreading of novel surgical techniques is whether a surgeon can provide the same level of performance as perceived in an old familiar place in the case that she/he moves to a new environment. This issue has been very often discussed in our daily practice, sometimes with malicious interests. Indeed, it may represent a remarkable challenge to a surgical team to work in a totally new environment, especially if this environment comprises another country with a very different healthcare system. However, reports on such experiences have not been published. To the best of our knowledge, this is the first report on such an experience with the question whether a surgeon can provide the same performance as observed in an old familiar place in case that she/he moves to a new professional environment. The result of this study suggests that it is possible, but one may need meticulous preparation because MIMVR represents a highly specialized surgical procedure.

Few publications have investigated the introduction of a new program in the field of cardiac surgery [8–12]. Casselman et al. emphasized the importance of a step-by-step approach for endoscopic mitral valve surgery [8]. They described this approach from the perspective of surgeons and noted that regardless of how surgeons acquire the technical ability to perform endoscopic heart surgery, that performance requires the surgeon to adopt a different 'state of mind' compared to that adopted during the classical median sternotomy approach [8]. However, Nguyen et al. [10] and Vohra et al. [11] reported the importance of a team approach in building a minimally invasive aortic valve surgery program. They noted that a good multidisciplinary team comprising surgeons, cardiologists, anesthesiologists, perfusionists, operating room technicians, and nurses should first be formed. Based on this, besides the surgeon who has learned MIMVR in Duesseldorf, another surgeon (S.N.) was sent to Duesseldorf as a MIMVR team member. Moreover, several team meetings were organized to discuss the MIMVR strategy prior to the first case. We consider that the acceptable initial results in our series were due to our careful preparation.

Regarding starting MIMVR, Hunter advised an initial selectiveness and employing a straightforward P2 prolapse for approximately the first 20 cases, because they are the

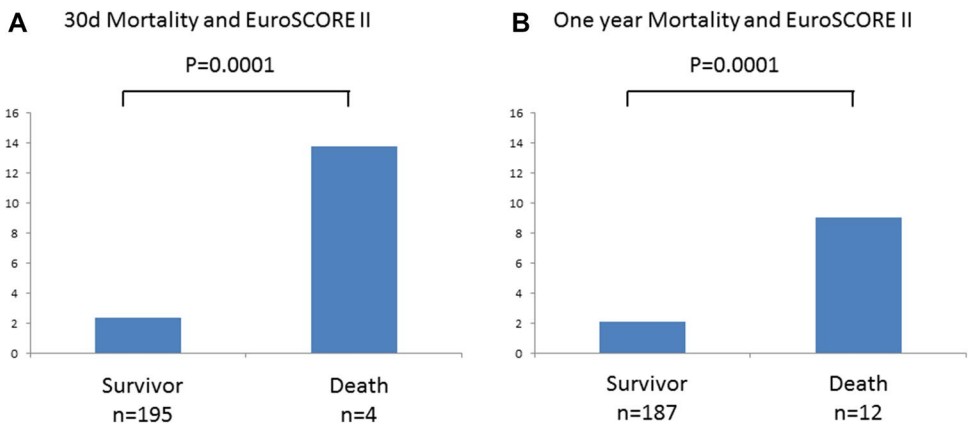

Fig. 3 **a** Relationship of EuroSCORE II regarding 30-day mortality. **B** Relationship of EuroSCORE II regarding 1-year mortality

most common cases and can be comfortably performed by most surgeons [12]. However, if patients should be strictly selected, the average case number further decreases as a matter of course and overcoming learning curve and maintenance of performance will be even more difficult in a very small volume center. In our herein-presented series, we defined three absolute contraindications and four relative contraindications, and we selected patients regardless of the complexity of the mitral valve lesion, experiencing only one early failure due to endocarditis. Our experience suggests that MIMVR programs can be safely performed with a liberal patient selection policy even in a small-volume center.

Once started, even with careful preparation, the learning curve is the second essential issue [13]. In the present study, one may discuss a certain personal learning curve of a surgeon when directly comparing results from group D to group A, as previously described by others. However, discussing the institutional learning curve appears even more interesting because a MIMVR program did not exist before 2014 at the institution where group A was treated.

Murzi et al. investigated the time required for learning by institutional and individual surgeons with respect to 936 procedures performed by 7 surgeons [14]. In that analysis, complications in institutes decreased consistently over the first 100 cases, then became stable. Notably, the surgeons who introduced MIMVS also needed approximately 100 cases to overcome the learning curve, but subsequent surgeons in the same institute needed only 23–48 procedures to overcome the learning curve [14]. That study suggested the importance of the team approach. However, as mentioned in "Introduction", the Leipzig group reported that the number of operations needed to overcome the learning curve ranged between 75 and 125, whereas individual learning curves varied markedly [6]. This level of about 100 cases may never be achieved in a very low volume center. On the other hand, De Praetere et al. reported that 30 cases were sufficient to overcome the learning curve in MIMVS [15].

Contrary to those previous reports, operation time, conversion rate and early mortality were comparable among Duesseldorf cohort and Asahikawa cohort, suggesting a remarkable learning curve in MIMVR at the new institution. Moreover, early results were also comparable. This finding suggests that beyond the successful and safe start of MIMVR in Asahikawa Medical University, the maintenance of the institutional curve in the following time may not require as many cases as previously reported. Thus, one may conclude that MIMVR programs could be started in very low volume centers if a team is developed by surgeons who are well trained in MIMVR in the frame of an established program elsewhere and second, if preparations are adequate. In other words, the present study demonstrated that a MIMVR program can be safely transferred from a large-volume center to a very small volume center if participating surgeons were trained under favorable circumstances, e.g., in the large-volume center.

Another important issue is the maintenance of performance after overcoming the learning curve. Although it has been intensively discussed in Japan how many cases may be necessary for maintenance of a favorable MIMVR performance, there have been only few reports focusing on this issue because cardiac surgery has been well consolidated in other countries where MIMVR has been well established. The Leipzig group mentioned that an MICS surgeon needed to perform more than 50 cases a year to maintain optimal results [6]. Here a study using a nationwide surgical database in Japan should be noted; Nishi et al. [16] analyzed the relationship between surgical volume and clinical outcome regarding MIMVS, and no institute performed more than 50 MIMVR cases annually in Japan. If the Leipzig experience could be generally true, MIMVR may be absolutely impossible in Japan. Nevertheless, Japanese results with this regard have been outstanding, with a 30-day mortality of 0.3%, notably better than observed in previous reports from high-volume centers outside of Japan [1–6].

However, the study by Nishi et al. was done using a nationwide surgical database and it is difficult to extract from this report in detail how many cases may be necessary for maintenance of a MIMVR program. The Japan MICS Summit is now establishing a new database dedicated to MICS surgery, and this issue will be well investigated in next few years. But in the present phase, accumulation of reports from each single center may be helpful to confirm the previous hypothesis that 50 cases per year is an absolute MUST for MIMVR or to put this hypothesis into perspective for country-specific circumstances as present in Japan. In this sense, we believe that so-called 'cut-offs' and volume targets regarding the annual number of cases may not be directly transferable from other countries to Japan when used for prediction of health care quality. The present study demonstrates that the 17 MIMVR cases encountered annually may be sufficient to maintain favorable surgical performance. This fact suggests that maintenance of an MICS program may be possible in a low-volume center under 50 cases per year after successful transfer of experience gained under favorable circumstances, e.g., from a large-volume center.

Limitations

Some limitations need to be considered when interpreting the present results. First, the study was retrospective and could not exclude the biases inherently associated with this study type. Second, the sample size in the present study was unavoidably very small since this study was focused on surgical outcomes in a low-volume institute. Nevertheless, a multicenter study of low-volume institutions could help to verify our outcomes. Third, the operating surgeon in the

present study had learned MIMVR in a so-called large-volume center, and the program analyzed here was not started from scratch in a low-volume center. Our study thus did not clarify how many cases are necessary to overcome the personal learning curve if a surgeon without any previous experience in MIMVR starts the program at a very low volume center.

Conclusion

The present study demonstrated that MIMVS programs can be safely transferred with acceptable early results from large-volume centers into very low volume centers, if the team is developed by surgeons who are well trained and experienced in MIMVR. Moreover, the present study suggested that case number for maintenance of acceptable results may be obviously less than previous recognition according to which this kind of specialized surgery could be maintained with at least 50 cases annually. However, thorough preparations for surgery are essential for satisfactory surgical outcomes.

Compliance with ethical standards

Conflict of interest The authors have declared that no conflict of interest exists.

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