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Early and midterm results of minimally invasive aortic and mitral valve surgery via right mini-thoracotomy

Taisuke Nakayama MD, PhD | Yoshitsugu Nakamura MD, PhD | Kohei Kanamori MD | Takahisa Hirano MD | Miho Kuroda MD | Shuhei Nishijima MD | Yujiro Ito MD | Ryo Tsuruta MD, PhD | Takaki Hori MD, PhD

Department of Cardiovascular Surgery, Chiba-Nishi General Hospital, Chiba, Japan

Correspondence
Yoshitsugu Nakamura MD, PhD, Department of Cardiovascular Surgery, Chiba-Nishi General Hospital, Chiba, Japan, 107-1 Kanegasaku Matsudo-shi, Chiba-Ken 2702251 Japan.
Email: ystgnkmr@gmail.com

Abstract

Objectives: There are few reports regarding minimally invasive aortic valve replacement concomitant with mitral valve surgery (MIAMVS). The aim of this study was to evaluate early and midterm MIAMVS results.

Methods: We reviewed the medical records of 21 consecutive patients (nine females, 43%) who underwent MIAMVS through a right mini-thoracotomy from December 2014 to April 2017. Mean patient age was 73 ± 7.4 years and four (19%) were New York Heart Association Class III or IV. Aortic stenosis and mitral valve insufficiency were the most common pathologies. All patients were followed for a mean period of 30 ± 8.5 months.

Results: The types of surgery consisted of aortic valve replacement with mitral valve repair in 11 (52%) patients, and replacement of both aortic and mitral valves in 10 (48%), while a tricuspid valve repair, was performed in four. No conversion to a full sternotomy was necessary in any of the cases. Postoperatively, the median intensive care unit and hospital stays were 4.7 and 11.8 days, respectively, with no in-hospital mortality. Following the initial treatment, all 21 patients were followed for a mean period of 30 ± 8.5 months (14-45 months). All patients returned to NYHA Class I or II following the procedure. During the follow-up period, there was no need for a heart valve reoperation for any of the patients and none showed recurrent mitral regurgitation (>mild), though one died from respiratory failure caused by pneumonia.

Conclusions: MIAMVS can be performed via a right mini-thoracotomy, with acceptable early and midterm results expected. This may be a feasible alternative to the standard median sternotomy approach.

KEYWORDS
aortic valve, minimally invasive surgery, mitral valve, right mini-thoracotomy

1 | INTRODUCTION

Valve surgery via a median sternotomy has historically been the standard of care, though various minimally invasive approaches have gained increasing acceptance during the most recent decade. As compared to that standard approach, the benefits of minimally invasive cardiac surgery have been well recognized in terms of blood loss reduction, lower morbidity, and shorter intensive care unit and in-hospital stay.[1,2] Overall, most studies presented have been in regard to single-valve surgery in lower-risk patients, and data useful for evaluating the feasibility and benefits of minimally invasive double-valve surgery are limited.[3-5] In the present study, we analyzed

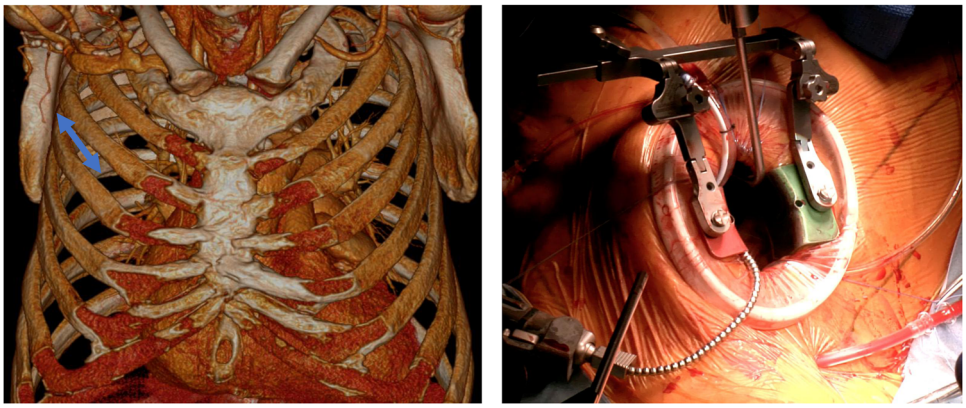

FIGURE 1 A 6- to 7-cm incision was made over the third intercostal space, starting at the mid-subclavicular line. The arrow indicates the incision line

early and midterm outcomes of patients who underwent minimally invasive aortic valve replacement concomitant with mitral valve surgery (MIAMVS) performed via a right thoracotomy approach.

2 | MATERIALS AND METHODS

Between December 2014 and April 2017, 21 patients treated at our department underwent MIAMVS. Patients requiring aortic and mitral valve procedures, with or without concomitant tricuspid valve surgery, were included, while patients in cardiogenic shock or requiring emergency surgery, as well as those with endocarditis, were excluded from the analysis.

At our institution, in the majority of cases, a femoral platform or right axillary artery is utilized to establish cardiopulmonary bypass. We performed preoperative screening of the aorta or peripheral vasculature in all of the present patients, with careful attention given during passage of the wire and subsequently the cannula. MIAMVS was performed via a 6- to 7-cm incision over the third intercostal space starting at the mid-subclavicular line (Figure 1). This access allows excellent visibility of the aortic valve, though limits exposure of the mitral valve as well as the ability to perform complex mitral valve repairs. To obtain improved visibility of the mitral valve with this approach, an additional venous cannula in the superior vena cava is required and the long femoral venous cannula must be withdrawn into the inferior vena cava. Our myocardial protection strategy includes antegrade cold-blood cardioplegia (6°C) delivered through a cannula placed in the ascending aorta, with repeated doses given directly to the coronary ostia. The first dose includes a potassium concentration of 10 mEq/L with flow at 400 mL/minute for a concentration of 15 mL/kg, then repeated doses every 40 minutes including a potassium concentration of 5 mEq/L with flow at 400 mL/minute for the same dose, delivered by a selective coronary cannula (LCA 60%, RCA 40%). In the present patients, the aorta was opened in a transverse manner, then native valve removal and decalcification of the aortic annulus were performed (Figure 2A). Next, the mitral valve was approached through Sondergaard's groove and replaced or repaired (Figure 2B). Finally, the selected aortic prosthesis was implanted.

Follow-up examinations were scheduled at the time of hospital discharge, then again at 6 months and annually after the operation. At each examination, the patients were evaluated in regard to clinical

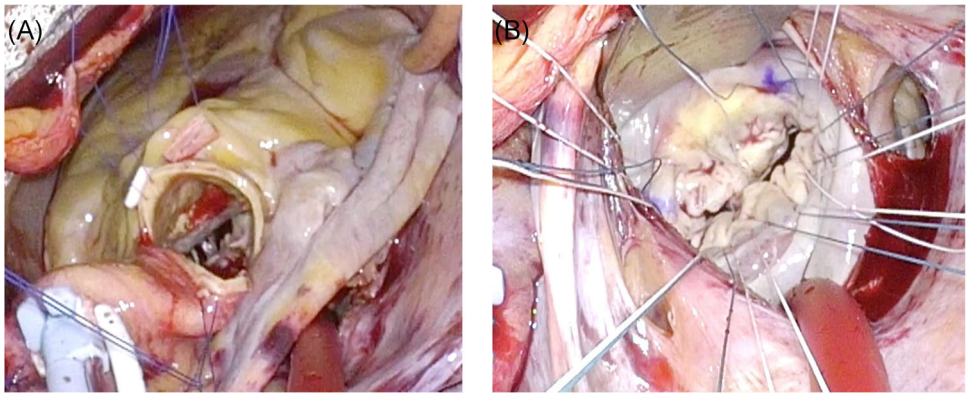

FIGURE 2 A, Exposure of aortic valve. The aorta was opened in a transverse manner. B, Exposure of mitral valve through Sondergaard's groove, with repair performed using NeoChord

TABLE 1 Patient demographic and echocardiographic data

Variables	n = 21
Mean age ± SD, y	73 ± 7.4
Female, n (%)	9 (43)
Congestive heart failure, n (%)	9 (43)
NYHA class III or IV	4 (19)
Diabetes, n (%)	0
Extracardiac arteriopathy, n (%)	2 (9.5)
COPD, n (%)	1 (4.8)
Atrial fibrillation, n (%)	6 (28.6)
Permanent pacemaker, n (%)	1 (4.8)
Chronic renal failure, n (%)	1 (4.8)
Dialysis-dependent	0
Previous cerebral infarction, n (%)	2 (9.5)
LVEDD (mean ± SD), mm	53.6 ± 8.4
LVESD (mean ± SD), mm	34.7 ± 7.1
LVEF (mean ± SD), %	62.3 ± 9.6
LVEF < 45%, n (%)	3 (14.3)
Log. EuroSCORE, median (IQR), %	6.64 (1.26–5.22)
Aortic stenosis/regurgitation, n/n (%/%)	12/9 (57/43)
Mitral stenosis/regurgitation, n/n (%/%)	7/14 (33/67)

Abbreviations: COPD, chronic obstructive pulmonary disease; IQR, interquartile range; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; NYHA: New York Heart Association.

status, including NYHA classification, blood analysis, coagulation profile, and occurrence of early or late complications. Preoperative and postoperative echocardiographic studies were routinely performed in all.

TABLE 2 Operative characteristics

Variables	n = 21
Operative time (mean ± SD), min	305 ± 50
AVR and MVR, n (%)	10 (48)
AVR and mitral valve repair, n (%)	11 (52)
Combined procedures	
Tricuspid valve annuloplasty, n (%)	4 (19)
Atrial fibrillation surgery, n (%)	4 (19)
ASD closure, n (%)	2 (9.5)
Conversion to sternotomy, n (%)	0
Cardiopulmonary bypass time (mean ± SD), min	212 ± 36.7
Cross-clamp time (mean ± SD), min	179 ± 30.6
Arterial cannulation, femoral/rt. axillary artery, n/n (%/%)	9/12 (42/58)
Venous cannulation, femoral/femoral + SVC, n/n (%/%)	18/3 (86/14)

Abbreviations: AVR, aortic valve replacement; MVR, mitral valve replacement; SVC, superior vena cava.

TABLE 3 Postoperative outcomes

Variables	n = 21
Mortality, n (%)	0
Intensive care unit stay (median, IQR), d	4.7 (2-4)
Hospital stay (median, IQR), d	11.8 (8-10)
Ventilation time (median, IQR), h	16.3 (9-19.5)
Acquisition of 150-m walking capacity (median, IQR), d	5.5 (3-6)
Blood transfusion (intra or post op), n (%)	10 (47.6)

Abbreviation: IQR, interquartile range.

3 | RESULTS

A total of 21 patients underwent MIAMVS during the study period, consisting of nine (43%) females and 12 (57%) males. The mean age was 73 ± 7.4 years and the mean left ventricular ejection fraction value was 62.3 ± 9.6%. A total of nine (43%) patients had congestive heart failure, one (4.8%) had chronic obstructive pulmonary disease, and one (4.8%) had a history of chronic kidney disease (Table 1).

The types of surgery performed included aortic valve replacement with mitral valve repair in 11 (52%) patients, and replacement of both aortic and mitral valves in 10 (48%). The cardiopulmonary bypass and aortic clamp times were 212 ± 36.7 and 179 ± 30.6 minutes, respectively. All patients received aortic valve replacement with a stented biological prosthesis, except one (4.8%) who underwent implantation of a mechanical prosthesis. The mitral valve was repaired in 11 (52.4%) and replaced in 10 (47.6%), while four patients underwent tricuspid valve repair. No patient required conversion to a median sternotomy (Table 2).

3.1 | Early results

The median postoperative intensive care unit and hospital stay periods were 4.7 (range, 2-4) and 11.8 (8-10) days, respectively, and there were no in-hospital mortalities. Median times to extubation and acquisition of 150-m walking capacity were 16.3 (9-19.5) hours and 5.5 (3-6) days, respectively (Table 3). The most common complications included atrial fibrillation in six (28.1%) patients and respiratory insufficiency requiring a temporary tracheotomy in one (4.8%). Other causes of early postoperative morbidity are listed in Table 4.

TABLE 4 Early term results

Variables	n = 21
Low cardiac output syndrome, n (%)	0
Re-exploration, n (%)	0
Respiratory insufficiency, n (%)	1 (4.8)
Gastrointestinal bleeding, n (%)	0
Temporary renal replacement therapy, n (%)	0
Wound complication, n (%)	0
Pacemaker implantation, n (%)	0
Atrial fibrillation, n (%)	6 (28.1)

TABLE 5 Midterm results

Variables	n = 21
Follow-up term (months ± SD)	30 ± 8.5
Mortality, n (%)	1 (4.8)
Recurrence of MR (>mild), n (%)	0
Prosthetic valve deterioration, n (%)	0
Reoperation, n (%)	0
Heart failure, n (%)	1 (4.8)
NYHA class	1.4 ± 0.4

Abbreviations: MR, mitral regurgitation; NYHA, New York Heart Association.

3.2 | Midterm results

Following the initial treatment, all 21 patients were followed for a mean period of 30 ± 8.5 months (14-45 months). Improvement in functional status was observed in each, and all patients returned to NYHA Class I or II. There was no need for a heart valve reoperation for any of the patients and none showed recurrent mitral regurgitation (MR) (>mild) during the follow-up period. A stroke event was documented in one and one patient died from respiratory failure due to pneumonia during follow-up, while one patient required hospitalization for heart failure because of tachycardia atrial fibrillation (Table 5).

4 | DISCUSSION

Aortic and mitral valve surgeries account for 5.8% of all valve procedures performed in Japan.[6] Patients requiring a multiple valve operation have been reported to have a 30-day mortality and hospital mortality cases are two to three times more common as compared to single-valve operations, with rates of 4.6% and 7.7%, respectively, reported for patients who have undergone combined aortic and mitral valve surgical procedures. In the present study, excellent in-hospital mortality (0%), along with acceptable outcomes regarding the incidence of postoperative cerebrovascular accidents, wound complications, and reoperation for bleeding were demonstrated.

Two previous studies regarding the feasibility of MIAMVS via a right mini-thoracotomy procedure have been conducted by Lamelas[7] and Lio et al,[8] with excellent results reported (Table 6). The results of the present study are favorable as compared with both of those, though remaining issues related to our method are longer prolonged cardiopulmonary bypass (CPB) and cross-clamp times as compared to those previous findings. Lamelas[7] used a myocardial protection strategy consisting of a single dose of a modified Del Nido solution (4:1 blood/crystalloid) delivered antegrade followed by a subsequent retrograde dose given using a cannula inserted via the right atrial appendage. Our myocardial protection strategy consists of an antegrade system alone with cold-blood cardioplegia. This technical difference in regard to myocardial protection had the greatest impact

TABLE 6 Summary of reports regarding minimally invasive aortic and mitral valve surgery via right mini-thoracotomy

Author (year)	No. of patients	In-hospital mortality, n (%)	Hospital stay (mean ± SD) or median (IQR), d	Conversion to sternotomy, n (%)	CPB time (mean ± SD) or median (IQR), min	Cross-clamp time (mean ± SD) or median (IQR), min	Skin incision, cm	Types of valve operations	Myocardial protection strategy	Introduction of sutureless prosthesis
Lamelas[7]	169	6 (3.5)	7 (6-12)	0 (0)	145 (121-178)	116 (91-138)	6	AVR + MVP (72%) DVR (28%)	Antegrade + retrograde	Not described
Lio et al[8]	69	0 (0)	6 (5-8)	1 (1.5)	135 ± 41	95 ± 32	5-7	AVR + MVP (50%) DVR (40%) AVP + MVP (10%)	Not described	Perceval S (70%)
Present study	21	0 (0)	11.8 (8-10)	0 (0)	212 ± 36.7	179 ± 30.6	6-7	AVR + MVP (52%) DVR (48%)	Antegrade	None

Abbreviations: AVP, aortic valve repair; CPB, cardiopulmonary bypass; DVR, double valve replacement; IQR, interquartile range; MVP, mitral valve repair.

on the cross-clamp time differences between that report and the present study. The reason why we did not use retrograde cardioplegia was because of concern regarding the insertion of such a cannula into the coronary sinus with a blind technique. Lio et al[8] found that the introduction of a sutureless prosthesis method at their institution enabled a significant reduction in CPB and cross-clamp times. That study reported cases of implantation of a sutureless aortic prosthesis (Perceval S; LivaNova) in 48 patients (70%) who underwent MIAMVS via a right mini-thoracotomy, in which the mean CPB and cross-clamp times were 135 ± 41 and 95 ± 32 minutes, respectively. Furthermore, following the introduction of sutureless prosthesis usage, significant reductions in CPB (120 ± 23 vs 160 ± 67 minutes for stented prosthesis) and cross-clamp (85 ± 19 vs 110 ± 40 minutes) times were noted. They concluded that it is feasible to perform MIAMVS along with the utilization of sutureless devices.

To the best of our knowledge, this is the first report to show midterm results of MIAMVS via a right mini-thoracotomy. Talwar et al[9] reported early and midterm results of aortic valve replacement performed with mitral valve repair (76 patients) or replacement (293 patients) through a median sternotomy with aortic and bi-caval cannulation and a normothermic cardiopulmonary bypass. The survival rate in the mitral valve repair group was 80.5% at more than 3 years after surgery, while that was 73% in the mitral valve replacement group. In addition, major adverse event-free survival at 60 months was 78.3% in the repair group and 48.4% in the replacement group. The midterm outcome findings for the present cases were not adversely affected by the implementation of this less invasive method, though the number of patients investigated was small. Additional experience with MIAMVS will be necessary to establish this approach as an alternative option for a median sternotomy.

5 | CONCLUSION

We consider that MIAMVS via a right mini-thoracotomy can be performed with acceptable early and midterm results. In view of increasing evidence showing safety and feasibility, this should be considered as a reasonable alternative to the standard median sternotomy approach.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

ORCID

Taisuke Nakayama http://orcid.org/0000-0002-7107-933X
Yoshitsugu Nakamura http://orcid.org/0000-0003-2510-081X

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