

The Left Atrial Roof Incision: An Asset for Minimally Invasive Mitral Valve Surgery

(#2001-6685 ... June 27, 2001)

Dumbor Laateh Ngaage FRCS, Unnikrishnan R Nair FRCS

Department of Cardiothoracic Surgery, Yorkshire Heart Center, United Kingdom.

Presented at the Fourth Annual Scientific Meeting of the International Society for Minimally Invasive Cardiac Surgery, June 27-30, 2001, Munich, Germany.

Address correspondence and reprint requests to: D L Ngaage Department of Cardiothoracic Surgery, Yorkshire Heart Center, Leeds General Infirmary, Great George street Leeds, West Yorkshire LS1 3EX, United Kingdom, Phone: (44) 113 39 26901, Fax: (44) 113 39 28092, Email: dumbor@ngaage.freeserve.co.uk

ABSTRACT

Background: The focus in minimally invasive mitral valve surgery has been on reducing thoracic incisions. Several cardiac incisions described in these procedures do not conform with the philosophy of 'minimal invasiveness'. We describe the left atrial roof incision which has the potential of facilitating an excellent mitral valve exposure through a limited cardiac incision, without major cardiac trauma. The safety, efficacy and technical ease of this technique for minimally invasive mitral valve surgery is evaluated.

Methods: From July 1998 to December 2000, 95 consecutive patients underwent mitral valve surgery by the same surgeon. The patients were divided into 2 groups on the basis of the cardiac incision used for correction of mitral valve disease. Group I patients had left atrial roof incision and group II patients had the traditional paraseptal incision. Each group was further classified into the minimally invasive sternotomy and standard sternotomy subgroups.

The clinical variables and complications in the 2 groups were compared.

Results: There were 40 male and 55 female patients with a mean age of 63 ±12yrs (range 29 to 88yrs). LARI was used for mitral valve exposure in 81 patients (85%). In 18 patients (19%), surgery was by minimally invasive technique. The mitral valve was replaced in 82% of patients and repaired in 18%. LARI provided a better exposure of the mitral valve in its anatomical and physiological disposition, without distortion. There was no significant difference in the cross clamp times and postoperative complications between the 2 groups. More patients in the LARI group regained sinus rhythm at discharge.

Conclusion: LARI is safe and technically easy to perform. It provides an excellent exposure of the mitral valve and left heart cavities in its anatomical disposition with minimal cardiac trauma, making it ideal for minimally invasive mitral surgery.

INTRODUCTION

Adequate exposure and access to the mitral valve is important in both conventional and minimally invasive surgery of the valve. Many surgeons achieve this through a longitudinal incision on the right side of the left atrium, posterior and parallel to the interatrial groove (paraseptal). Extensive left lateral retraction combined with tilting of the operating table is usually required for exposure. Other techniques sometimes involve extensive cardiac incisions into other chambers and structures, have been described [Pezzella 1983, Barner 1985, Smith 1992, Kon 1993, Sirvydis 1994, Machiraju 2000].

In minimally invasive mitral valve surgery (MIMS), operating field limitation exaggerates the difficulty of achieving optimal mitral valve exposure. A superior wall approach through the dome of the left atrium has the potential of combining adequate mitral valve exposure with minimal tissue trauma. First described in 1965 [Meyer BW 1965] this has not been adequately explored because of technical difficulties and potential complications associated with the technique [Saksena 1971, Hirst 1988, Barner 1992].

The left atrial roof incision (LARI), is a simplified modification of the superior approach, which has not been described in MIMS. We describe the LARI and compared the clinical outcome with the traditional paraseptal incision, to determine its safety, efficacy and technical ease.

MATERIALS AND METHODS

Patients

The clinical data of all patients who had mitral valve surgery by a single surgeon between July 1998 and December 2000 were prospectively collated. Based on the type of left atrial incision used for mitral valve exposure, 2 groups of patients emerged. Group I patients had LARI and group II had the traditional paraseptal incision. Each group was further classified into minimally invasive sternotomy and the standard sternotomy subgroups.

Patient selection for MIMS was based on the need for concomitant surgery, history of previous cardiac surgery, surgeon and patient preference. Initially, patients were randomly selected for LARI and paraseptal incision, but LARI soon became the preferred method of exposure both for conventional and minimally invasive mitral surgery.

Surgical Technique

A similar general anaesthetic care, perioperative monitoring and postoperative management were adopted in all the patients.

Minimally invasive sternotomy

The skin incision and sternotomy was performed as previously described [Nair 1998]. Briefly, a 10cm skin incision was made in the midline followed by a limited lower sternotomy from the xiphisternum upwards, to the second intercostal space. A tape was passed around the ascending aorta for the purpose of retraction. The ascending aorta and right atrium were cannulated for cardiopulmonary bypass. In group I patients, a dual stage cannula size 34/46Fr (Edward Lifesciences, Irvine, CA) was positioned in the right atrium with the tip in the inferior vena cava (IVC) and snared with a tape. Bicaval cannulation with single stage venous drainage cannulae sizes 32 and 36Fr (Baxter, Deutschland, GmbH) for the superior and inferior vena cavae respectively, was used in group II patients with snaring of both cavae.

Left atrial roof incision (LARI)

After achieving cardioplegic arrest, the aorta was retracted to the left to expose the left atrial (LA) roof. Dissection was carefully avoided around the superior vena cava (SVC). The exposed LA roof was incised transversely (fig.1) towards the SVC on the right, and the LA appendage on the left. The sino-arterial node (SAN) artery can be seen and avoided. With minimal retraction of the edges of the incision using stay-sutures or a hand-held retractor, the LA cavity and the mitral valve apparatus were excellently revealed (figs.2a & b). A cardiotomy suction positioned at the orifice of the left superior pulmonary vein maintained a dry operating field, enabling mitral valve replacement or repair in the usual manner. The left atrium was easily de-aired through part of the LARI before closure in two layers with prolene 3/0 suture.

Data analysis

Continuous variables are reported as the mean \pm standard deviation, and categorical variables as percentages.

RESULTS

In all, 95 patients were involved in the study. There were 55 (57.9%) females and 40 (42.1%) males with a mean age of 63 ± 12 yrs (29 to 88 yrs). The indications for surgical correction were mitral regurgitation (51.6%), mitral stenosis (16.8%), mixed valvular disease (24.2%) and endocarditis (prosthetic 4%, native 3.4%). Table 1 shows the preoperative characteristics in the study groups. Eighteen per cent of the mitral valve operations were redo procedures. Urgent or emergent correction was performed in 20% of cases. Minimally invasive technique was employed in 19%, and the mitral valve was exposed by LARI in 81 patients (85%). LARI was used in 83% and 87% of the minimally invasive and standard sternotomy patients respectively. The mitral valve was replaced in 82% and repaired in 18% of patients. Table 2 summarises the intraoperative details. The average cardiopulmonary bypass time, and cross clamp time for MVR did not differ significantly between the LARI and paraseptal groups. Concomitant surgical procedures were performed in 65.3% of patients, and include coronary artery bypass grafting (CABG) (28), aortic valve replacement (25) and repair (3), tricuspid valve replacement (2) and repair (5), and left atrial and ventricular volume reduction (5).

Mitral valve exposure

The exposure of the mitral valve and the left heart cavities with LARI was superior to the traditional paraseptal incision. The entire mitral valve apparatus was revealed in its anatomical and physiological disposition without distortion, to the surgeon and the assistant. The access was adequate for the implantation of valves larger than 27mm in size. With single right atrial cannulation (RA), there was less crowding of the working area, especially with the minimally invasive technique.

In-hospital morbidity and mortality

Two patients in the paraseptal group and 1 in the LARI group were re-opened for bleeding. The bleeding in these patients was not related to the method of valve exposure. No specific bleeding point was found in 2, but a side branch of the left internal thoracic artery was identified in 1 (paraseptal group).

Preoperative 12-lead electrocardiogram confirmed chronic atrial fibrillation (AF) in 10 patients (8 in LARI and 2 in paraseptal group). Four patients in the LARI group and none in paraseptal group regained sinus rhythm (SR) at discharge. Two patients in the paraseptal group developed new arrhythmia (1 complete heart block and 1 AF).

There was 1 death (group II), giving an overall mortality rate of 1%. He was a 72yr-old asthmatic in chronic AF preoperatively and required external pacing until the 4th postoperative day. He remained in slow AF and developed a chest infection for which he was treated with a course of ciprofloxacin. He was slow to mobilize and difficult to warfarinize. He had a bioprosthesis with an INR between 1.3 and 1.8 on a daily warfarin dose of 10mg. On the 10th postoperative day he collapsed and died, and post mortem confirmed pulmonary embolism.

The length of cardiopulmonary bypass, aortic cross clamp, intensive care stay, and hospital stay were similar in the groups.

DISCUSSION

The advantages of minimally invasive surgery are contingent on the fact that less extensive surgery-induced tissue trauma, and consequently less inflammatory response and pain, enables a speedy recovery with less complications. Up till now, the focus in MIMS has

been on reduced thoracic incisions, and many have been described [Navia 1996, Cosgrove 1998, Loumet 1998, Nair 1998, Rodriguez 1998, Svensson 1998, Gillinov 1999, Karagoz 1999, Ali 2000, El-Fiky 2000, Yung 2000]. The techniques of mitral valve exposure in these procedures have not differed from that used in conventional surgery, most of which do not conform with the philosophy of minimally invasive surgery. The concept of reduced tissue trauma in MIMS should be extended to involve cardiac incisions. Extensive and multiple incisions of the heart are not always innocuous and complication-free [Kim 1998]. We believe that the ideal cardiac incision, like the thoracic incision, should be less extensive, and associated with less cardiac trauma whilst providing optimal valve exposure. Unfortunately, it has not been possible to determine and quantify cardiac trauma due to cardiac incisions and snare injury, as distinct from that due to other aspects of the surgical procedure, of which myocardial protection, handling, concomitant cardiac procedures and perioperative cardiac events, are paramount.

LARI is a simplified modification of the superior approach, which eliminates technical complexities and potential sources of cardiac injury, and yet provides a good exposure and access for mitral valve surgery. The many advantages of the superior approach [Vijayanagar 1985, Hirst 1988] are retained by this cardiac incision. The exposure of the mitral valve with LARI is comparatively better, and pristine. Since there is no distortion of mitral valve apparatus, adequate assessment of the valve for repair or replacement is facilitated. In this study, mitral repair was performed in 17.9%, and most of this (14.7%) was done using LARI. The low rate of mitral valve repair in the study was because most of the valves were of rheumatic etiology (79%), and their gross pathology rendered them unsuitable for repair.

There is a good visualization of the interior of the left ventricle (LV) with LARI, and this was advantageous in performing left ventricular volume reduction by plicating the LV apex from within the LV cavity.

De-airing of the heart in MIMS with the paraseptal incision can be problematic. On the contrary, the position of LARI on the dome of the left atrium simplifies de-airing of the left side of the heart.

LARI provides an excellent view of the undistorted mitral valve apparatus to the surgeon and his trainee assistant, which is crucial for supervised skills training. Greene et al reported that the angular position of the stimulus results in a variation of the orientation and/or alignment of segments and points, and affect collinearity judgement [Greene 2000]. This is an inherent disadvantage of the traditional approach with regards to surgical training. With LARI, the trainee assistant can easily capture every surgical maneuver and thereby sustained teaching and demonstration throughout the procedure is possible. This is an important consideration in a teaching/training center.

The dual stage RA cannula was adequate for venous drainage, and improved access to the operating field, particularly in MIMS. Inadvertent incision into or tear of the right atrium with the paraseptal incision justifies the use of bicaval cannulation for mitral valve surgery, and the impairment of venous return associated with significant RA retraction required with this approach. However, this has become standard practice out of tradition. A single 2-stage RA cannula may have minimal cost, timesaving and cardiac trauma reduction advantages, but our choice for its use is because bicaval cannulation unnecessary with LARI, and can be associated with a snare injury in the area of the SAN.

Postoperative atrial arrhythmia has been a cause of concern for cardiac incisions involving the LA roof because of injury to the SAN artery. Therefore, we carefully avoided dissection around the SVC- RA junction and snaring of the SVC, to preclude direct injury to the SAN and its blood supply, and prevent postoperative edema in the area. Deliberate effort was made to preserve the SAN artery even though Masuda [Masuda 1996], Misawa [Misawa 1999], Shin [Shin 2001] and their associates have demonstrated that the electrophysiology of the heart is not adversely affected in the long term by incisions that divide the SAN artery. Although this study was not designed to compare alterations of cardiac rhythm associated with the technique of mitral valve exposure, we noticed that more patients regained sinus rhythm

with LARI compared to the conventional incision. Because of the small number involved, the significance of this finding is uncertain. Hirst et al reported no difference between the superior approach and conventional incision with regards to reversion to stable sinus rhythm, but they noted a diminished chance of gaining SR by patients in dysrhythmia preoperatively, with the superior approach. However in their study, no attempt was made to preserve the SAN artery, and dissection around the SVC-RA junction with snaring of the SVC was not avoided. Further investigation of the impact of different atrial incisions on the cardiac rhythm is warranted.

A small number of patients had MIMS (19%) in this study because most of the patients who required concomitant CABG, and redo mitral surgery were excluded. Our experience is growing, and more of our patients are now operated by minimally invasive techniques.

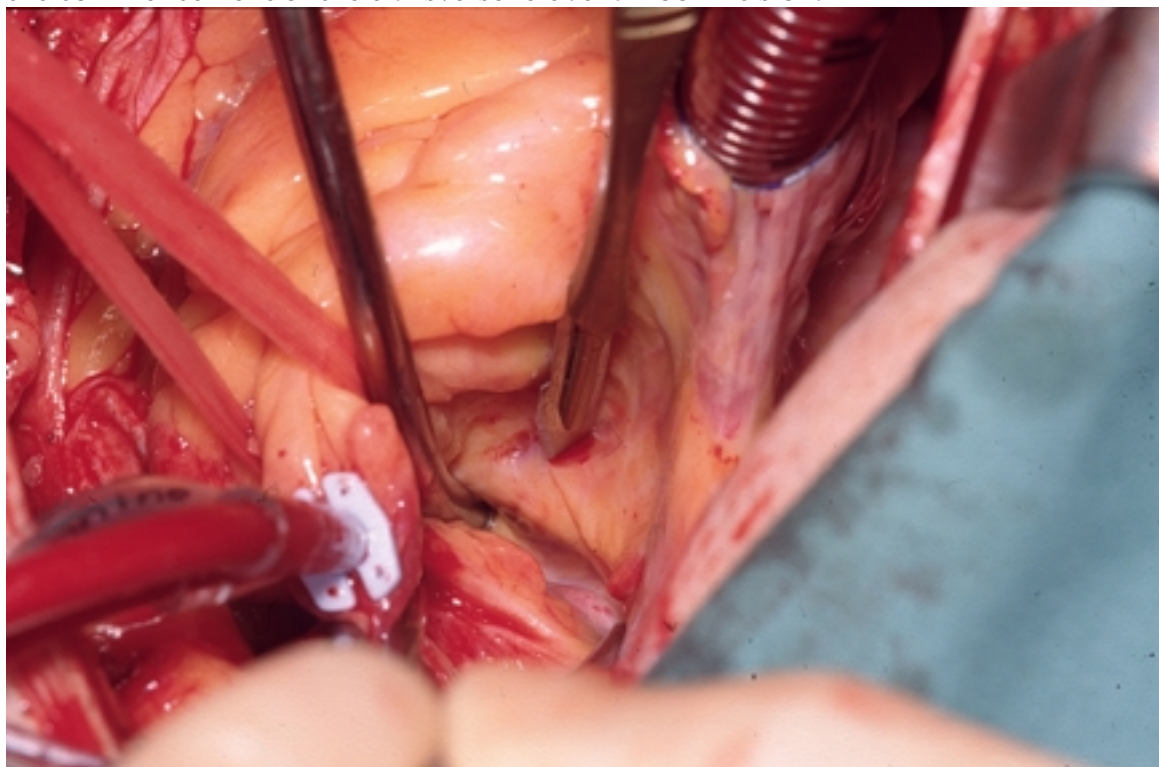
In conclusion, LARI is a simple, safe and effective method of mitral valve exposure. It requires a limited cardiac incision and minimal tissue distraction, which makes it ideal particularly for minimally invasive mitral valve surgery. It is an excellent approach for assessing the mitral valve for repair, and for supervised training. We now use this approach routinely for most of our mitral valve surgery.

REFERENCES

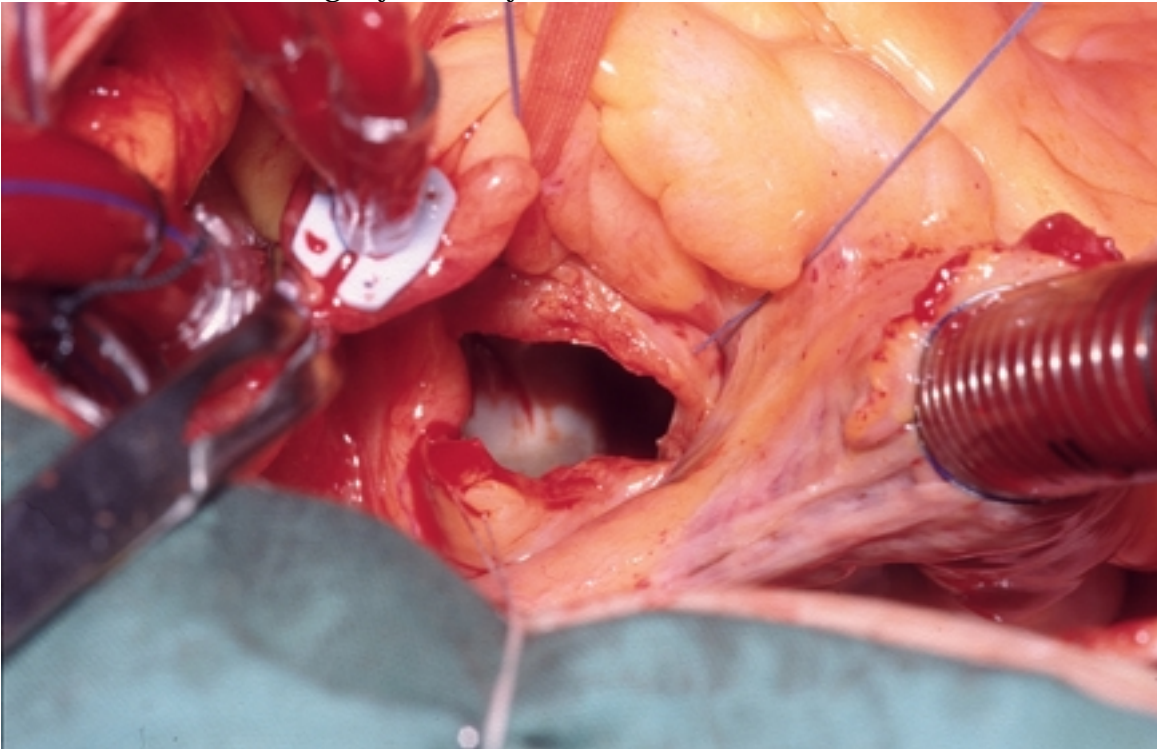
1. Ali IM, El-shanafi S, Kinley EC, Clark V. Subtotal median sternotomy for heart surgery. *Eur J Cardiothorac Surg* 17:255-8, 2000.
2. Barner HB. Combined superior and right lateral left atriotomy with division of the superior vena cava for exposure of the mitral valve. *Ann Thorac Surg* 40:365-7, 1985.
3. Barner HB. Combined superior and right lateral left atriotomy with division of the superior vena cava for exposure of the mitral valve: Update. *Ann Thorac Surg* 54:594, 1992.
4. Cosgrove DM 3rd, Sabik JF, Navia JL. Minimally invasive valve operations. *Ann Thorac Surg* 65:1535-9, 1998.
5. El-Fiky MM, El-Sayeh T, El-Beishry AS, Abdul Aziz M, Aboul Enein H, Waheid S, et al. Limited right anterolateral thoracotomy for mitral valve surgery. *Eur J Cardiothorac Surg* 17:710-3, 2000.
6. Gillinov AM, Cosgrove DM. Minimally invasive mitral valve surgery: mini-sternotomy with extended transeptal approach. *Semin Thorac Cardiovasc Surg* 11:206-11, 1999.
7. Greene E, Frawley W, Swimm R. Individual differences in collinearity judgement as a function of angular position. *Percept Psychophys* 62:1440-58, 2000.
8. Hirt SW, Frimpong-Boateng K, Borst HG. The superior approach to the mitral valve - is it worthwhile? *European J Cardithoracic surgery* 2:372-6, 1988.
9. Karagoz HY, Bayazit K, Battaloglu B, Kurtoglu M, Ozerdem G, Bakkaloglu B, et al. Minimally invasive mitral valve surgery: the subxiphoid approach. *Ann Thorac Surg* 67:1328-33, 1999.
10. Kim KB, Lee CH, Kim CH, Cha YJ. Effect of the Cox maze procedure on the secretion of atrial natriuretic peptide. *J Thorac Cardiovasc Surg* 115:139-47, 1998.
11. Kon ND, Tucker WY, Mills SA, Lavender SW, Cordell AR. Mitral valve operation via an extended transeptal approach. *Ann Thorac Surg* 55:1413-6, 1993.
12. Loumet DF, Carpentier A, Cho PW, Berrebi A, d'Attellis N, Austin CB, et al. Less invasive techniques for mitral valve surgery. *J Thorac Cardiovasc Surg* 115:772-9, 1998.
13. Machiraju VR, Lima CA, Culig MH, Bennett RD, Thakur NS. Exposure of the mitral valve by transecting the ascending aorta during aortic and mitral valve replacement. *Ann Thorac Surg* 69:646-7, 2000.
14. Masuda M, Tominaga R, Kawachi Y, Fukumura F, Morita S, Imoto Y, et al. Postoperative cardiac rhythms with superior-septal approach and lateral approach to the mitral valve. *Ann Thorac Surg* 62:1118-22, 1996
15. Meyer BW, Verska JJ, Lindesmith GG, Jones JC. Open repair of mitral valve lesions. The superior approach. *Ann Thorac Surg* 1:453-7, 1965.

16. Misawa Y, Fuse K, Kawahito K, Konishi H. Conduction disturbances after superior septal approach for mitral valve repair. *Ann Thorac Surg* 68:1262-4, 1999.
 17. Nair RU, Sharpe DAC. Limited lower sternotomy for minimally invasive mitral valve replacement. *Ann Thorac Surg* 65:273-4, 1998.
 18. Navia JL, Cosgrove DM. Minimally invasive mitral valve operations. *Ann Thorac Surg* 62:1542-4, 1996.
 19. Pezzella AT, Effler DB, Levy IE. Operative approaches to the left atrium and mitral valve apparatus. *Texas Heart inst J* 10:119-122, 1983.
 20. Roriguez JE, Cortina J, Perez de la Sota E, Maroto L, Ginestal F, Rofilanchas JJ. A new approach to cardiac valve replacement through a small midline incision and inverted L shape partial sternotomy. *Eur J Cardiothorac Surg* 14 Suppl 1:S115-6, 1998.
 21. Saksena DS, Tucker BL, Lindesmith GG, et al. The superior approach to the mitral valve. A review of clinical experience. *Ann Thorac surg* 12:146-153, 1971.
 22. Shin H, Yozu R, Higashi S, Kawdw S. Sinus node function after mitral valve surgery using the superior septal approach. *Ann Thorac Surg* 71:587-90, 2001
 23. Sirvydis V, Kavoliunas D, Uzdavinys G, Grebelis A, Nogiene G, Boristaite O, et al. Optimal approach for mitral valve surgery. *J Cardiovasc Surg(Torino)* 35:17-9, 1994.
 24. Smith CR. Septal-superior exposure of the mitral valve. The transplant approach. *J Thorac Cardiovasc Surg* 103:623-8, 1992.
 25. Svensson LG, D'Agostino RS. "J" incision minimal-access valve operations. *Ann Thorac Surg* 66:1110-2, 1998.
 26. Vijayanagar R, Bognolo DA, Eckstein PF, Jeffrey DL, Harrison E, Natarajan P, et al. Advantages of suprior approach for mitral valve surgery. *J Cardiovasc Surg* 26: 426-32, 1985.
 27. Yung MC, Wang JS, Lai ST. Minimally invasive mitral valve surgery via submammary hidden incision. *Chung Hua I Hsueh Tsa Chih (Taipei)* 63:322-8, 2000.
-

Figure 1. A photograph of the cannulated heart on cardiopulmonary bypass. It demonstrates the commencement of the transverse left atrial roof incision.



Figures 2a and 2b. Photographs showing the left atrial roof incision. In 2a, the edges of the incision are retracted slightly with stay sutures.



In 2b, a retractor improves the visualization of the mitral annulus after the anterior leaflet of the mitral valve is excised, and a cardiotomy suction to keep the operating field dry.

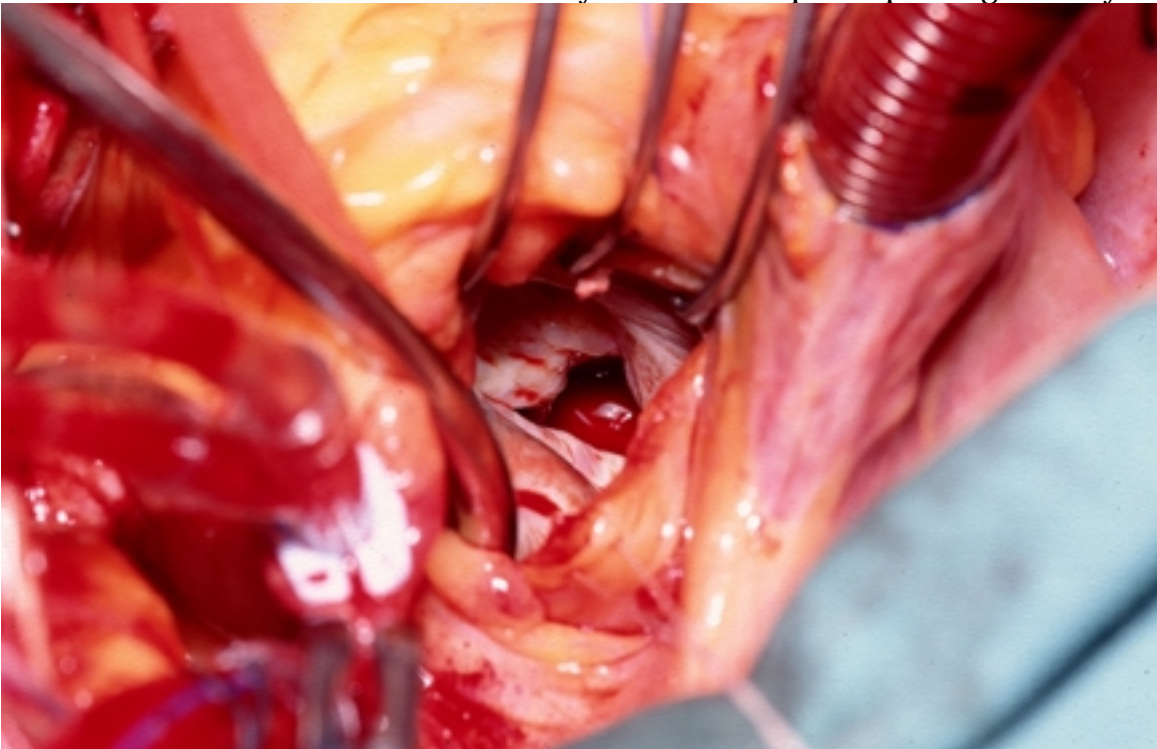


Table 1. Preoperative characteristics

Characteristics	Left Atrial Roof Incision (LARI) — Group 1		Conventional Paraseptal incision- Group II		Total (%)
	MIS	SS	MIS	SS	
Number (%)	15 (15.8)	66 (69.5)	3 (3.1)	11 (11.6)	95
Gender:					
Female	8	35	3	9	55(57.9)
Male	7	31	0	2	40(42.1)
Median age (range)	62.4 (40-78)	64.4 (29-88)	53 (51-56)	65 (32-77)	
Diagnosis:					
MS	3	7	1	5	16 (16.8)
MR	5	39	1	4	49 (51.6)
Mixed	7	14	1	1	23 (24.2)
Endocarditis	0	6	0	1	7 (7.4)
Heart rhythm					
SR	13	60	3	9	85 (89.5)
AF	2	6	0	2	10 (10.5)

Key

MIS = Minimally invasive sternotomy, SS = Standard sternotomy, SR = sinus rhythm, AF = atrial fibrillation, MS = Mitral stenosis, MR = Mitral regurgitation.

Table 2. Operative and postoperative details

Characteristics	Left Atrial Roof Incision (LARI) — Group 1		Conventional Paraseptal incision- Group II		Total (%)
	MIS	SS	MIS	SS	
Surgery type:					
Initial operation	13	53	2	10	78(82.1)
Redo operation	2	13	1	1	17(17.9)
Operation:					
MVR	15	52	3	8	78(82.1)
MVRepair	0	14	0	3	17(17.9)
Valve sizes:					
27mm	7	13	2	4	26
29mm	8	37	0	4	49
≥31mm	0	2	1	0	3
Concomitant surgery	9	44	1	8	62(65.3)
Mean MVR XC time	48±6mins	50 ±13 min	51mins	51 ± 5mins	
Mean CPB time	115 ± 37	109 ± 38	88 ± 13	102 ± 21	
Reopening for bleeding/Tamponade	1	0	0	2	3
Mean ICU stay (days)	1.2	2	1.5	1.8	
AF at discharge	0	2	1	3	5 (5.3)
Mean postoperative Length of stay	6.2	9.4	5.5	8	

Key

CPB = cardiopulmonary bypass, ICU = intensive care unit, MVR = mitral valve replacement, MVRepair = mitral valve repair, XC = cross clamp