

# Correction of Congenital Heart Defects and Mitral Valve Operations Using Limited Anterolateral Thoracotomy



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## ABSTRACT

**Purpose:** Median sternotomy, which generally is used as a standard access for atrial septal defect (ASD) and mitral valve operations, has a significant risk of postoperative instability/osteomyelitis of the sternum. Moreover, especially in young women, the resulting large scar is a poor cosmetic result that may have adverse psychological consequences. Our presentation suggests that these difficulties may be avoided by the use of a less invasive approach consisting of a limited anterolateral thoracotomy with standard cannulation.

**Material and methods:** From June 1997 until December 1999, 13 women, mean age  $31.9 \pm 9.2$  years, with atrial septum defect ( $n = 8$ ), sinus venosus defect with partial anomalous pulmonary venous connection ( $n = 1$ ), left atrial myxoma ( $n = 1$ ) or mitral valve regurgitation ( $n = 3$ ), were scheduled for less invasive operation. In all cases a double lumen tube was used for ventilation. After a submammary skin incision of about 10 cm a limited anterolateral thoracotomy was performed in the fifth right intercostal space. For cannulation of the ascending aorta a trochar cannula was used. Both caval veins were cannulated by angled vena cava catheters. Standard cardiopulmonary bypass was established using normothermia in all patients undergoing operations with correction of congenital heart defects and mild hypothermia ( $32^\circ\text{C}$ ) in the three patients undergoing mitral valve operation. Surgery was performed in cardioplegic arrest using Bretschneider's solution. All corrections of congenital heart defects were performed by Goretex<sup>®</sup> patches. Mitral valve reconstruc-

tion was carried out in two patients, and one patient underwent mitral valve replacement.

**Results:** No complications occurred in any of the 13 patients peri- or postoperatively. Total time of operation was  $211.9 \pm 36.0$  minutes, the perfusion time was  $77.0 \pm 25.8$  minutes, and the aortic cross-clamp time was  $51.8 \pm 21.9$  minutes. Mean stay in ICU was  $1.2 \pm 0.4$  days (total hospital stay:  $7.8 \pm 2.2$  days). Postoperative thoracic x-ray and cardiac echocardiography/dopplersonography revealed no pathological findings in any patients.

**Conclusion:** Atrial septal defect operations, including partial anomalous pulmonary venous connection, left atrial myxoma and mitral valve operations, can be performed safely and effectively using a limited anterolateral thoracotomy and standard cannulation technique with excellent cosmetic results.

## INTRODUCTION

Median sternotomy, which generally is used as a standard access for atrial septal defect, atrial myxoma resection, and mitral valve operations, has a significant risk of postoperative instability/osteomyelitis of the sternum. Moreover, especially in young women, the resulting large scar is a poor cosmetic result that may have adverse psychological consequences.

Different approaches have been used to reduce the operative trauma in such operations. Mini-sternotomy [Gundry 1998, Black 1998, Byrne 1999, Bauer 2000, Khan 1999], the transxiphoidal access [Van de Wal 1998, Barbero-Marcial 1998], the subxiphoid approach [Levinson 1998] and the limited right anterolateral thoracotomy [Dietl 1992, Grinda 1996, Honek 1996, Ying-long 1998, Wu 1998, Bauer 2000, Cremer 1999] have been reported as less invasive approaches in patients undergoing surgery for congenital heart defects. Furthermore, less invasive approaches with and without port access technique have

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Table 1. Demographic data of patients undergoing limited anterolateral thoracotomy for correction of congenital heart defects and mitral valve operations

Patient no.	Age [years]	Weight [kg]	Height [cm]	Diagnosis	Cardiac rhythm
1	36	63	165	ASD II	SR
2	33	58	158	ASD II	SR
3	36	62	158	ASD II	SR
4	30	54	168	MI III-IV°	SR
5	53	63	165	MI III-IV°	AF
6	31	70	176	ASD II	SR
7	17	47	152	ASD II	SR
8	26	72	168	ASD II	SR
9	23	51	170	ASD II	SR
10	42	64	165	MI IV°	SR
11	32	83	178	ASD II	SR
12	34	72	174	LA myxoma	SR
13	22	59	175	ASD II, SVD, PAPVC	SR

ASD=atrial septal defect, MI=mitral valve insufficiency, LA=left atrium, SVD=sinus venous defect, PAPVC=partial anomalous pulmonary venous connection, SR=sinus rhythm, AF=atrial fibrillation

been described for mitral valve operations [Carpentier 1996, Chitwood 1997, Falk 1998, Mohr 1998, Mishra 1999]. In this report, we describe our clinical experience with a limited right anterolateral approach in adult female patients with atrial septal defects, including one patient with partial anomalous pulmonary venous connection, mitral valve regurgitations, and one patient with left atrial myxoma. Our protocol incorporates the complete cannulation of the cardiopulmonary bypass via the limited anterolateral thoracotomy [Bauer 2000], thus avoiding additional skin incisions in the groin, neck, or elsewhere. Using this approach, it is possible to avoid vascular complications, lymphatic fistulas, and infections in this region.

**MATERIALS AND METHODS**

**Patients**

From June 1997 until December 1999, 13 female adult patients with mean age 31.9 ± 9.2 years (range 17 to 53 years) were operated upon using a less invasive surgical access (Table 1, ☉). The indication for operation was an atrial septal defect of secundum type (n=8), a sinus venous defect with partial anomalous pulmonary venous connection (n=1), a left atrial myxoma (n=1), and a mitral valve regurgitation (n=3). The patients were informed about the risks and the advantages of the operative procedure, and written informed consent was obtained in all cases.

**Anesthesia and Operative Technique**

In all patients, the skin incision along the submammarian crease was marked with a water-resistant felt pen pre-operatively with the patient in an upright position in

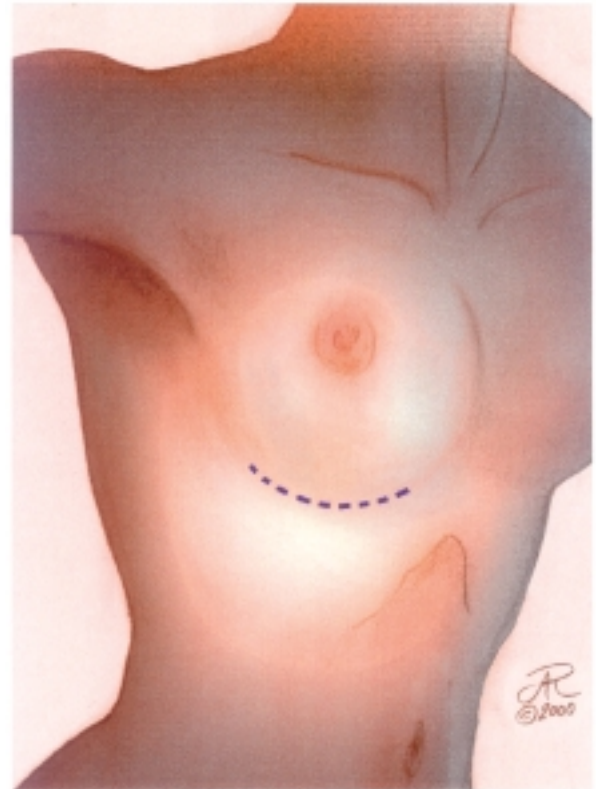


Figure 1. Skin incision in patients undergoing less invasive atrial septal defect operations or mitral valve procedures using a limited right anterolateral thoracotomy.

order to assure an optimal cosmetic result. General anesthesia was maintained with an intravenous infusion of propofol and sufentanil or remifentanil continuously and a single bolus injection of pancuronium bromide. In all cases intubation was accomplished with a double-lumen tube. The patient was placed in a supine position with the right flank as well as the shoulder elevated to about 30°, and the right arm above the head. After skin incision of about 10 cm in the submammarian crease (Figure 1, ☉), the pectoral muscle, including the breast, was dissected from the thoracic wall. The right thoracic cavity was entered through the fifth intercostal space, and the left lung was ventilated in order to facilitate unobstructed view to the operative field. The pericardium anterior to the phrenic nerve was opened longitudinally (see Movie 1, ☉). Exposure was facilitated by stay sutures. In all cases the complete connection to the heart-lung machine was carried out via limited anterolateral thoracotomy (Figure 2, ☉). For cannulation of the ascending aorta, an elongated one-piece arterial trochar cannula (Medtronic DLP, Grand Rapids, Michigan) was used, and both caval veins were cannulated by angled cannulae (Jostra, Hirrlingen, Germany) (see Movie 2, ☉). The view to the aortic cannulation site can be improved when fixation of the upper venous cannula is accomplished first and the right auricle is elevated from the ascending aorta by careful traction.

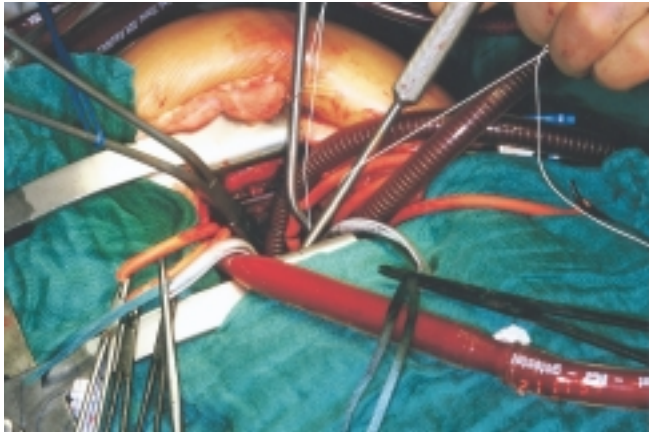


Figure 2. Intraoperative situs in a patient undergoing limited right anterolateral thoracotomy. The complete cannulation to the heart lung machine is performed through this less invasive surgical access.

Standard cardiopulmonary bypass was established using normothermia in all operations except mitral valve procedures, which were performed in mild hypothermia (Table 2, ☉). After aortic cross-clamping in all cases, cardioplegic arrest was induced by Bretschneider's solution and the right atrium was opened (see Movie 3, ☉). All atrial septal defects were closed with Goretex® patches and careful de-airing was performed (see Movie 4, ☉). The patient with sinus venosus defect with partial anomalous pulmonary venous connection was closed with a tunnel-shaped patch and the upper vena cava was enlarged with a pericardial patch. Mitral valve reconstruction was performed in two

patients using a quadrangular resection of the posterior mitral leaflet and an annuloplasty. Another patient underwent mitral valve replacement with a biological prosthesis. In one further patient, a left atrial myxoma was resected together with the atrial septum, and the resulting defect was closed with a Goretex® patch. All patients received atrial and ventricular pacing wires. After termination of the cardiopulmonary bypass, drains were inserted into the pericardium and the right pleural cavity. The pericardium was closed partially, followed by wound closure.

## RESULTS

All operations were performed successfully and no peri- or postoperative complications occurred in any patient. Mean time for surgery was  $211.9 \pm 36.0$  minutes, perfusion time was  $77.0 \pm 25.8$  minutes, and aortic cross-clamp time was  $51.8 \pm 21.9$  minutes. For further data, see Table 2 (☉) and Table 3 (☉). After declamping of the ascending aorta, seven out of 12 patients were defibrillated because of ventricular fibrillation. The mean total amount of secondary hemorrhaging was  $361 \pm 143$  ml. No patient required postoperative surgical revisitation as a consequence of pericardial effusion or secondary increased hemorrhaging. Seven patients undergoing atrial septal defect operations were extubated while in the OR, and the remaining six patients were extubated  $3.7 \pm 2.2$  hours following the surgery (Table 3, ☉). Mean stay in ICU was  $1.2 \pm 0.4$  days, and no neurological or neuropsychiatric complications occurred. Only one patient received a red blood cell transfusion of 250 ml. Postoperative pain was low in all patients with the exception of one 17-year-old woman who suffered from

Table 2. Intraoperative data of patients undergoing limited anterolateral thoracotomy for correction of congenital heart defects and mitral valve operations

Patient no.	Surgery [min]	CPB [min]	AoX [min]	Temp [°C]	Operative procedure	Intra-op defibrillation	Complications
1	205	70	49	37	Patch	No	No
2	210	63	39	37	Patch	No	No
3	225	78	51	37	Patch	Yes	No
4	240	82	46	35.9	MVC	Yes	No
5	260	127	101	33.1	MVR	Yes	No
6	190	59	33	37	Patch	Yes	No
7	205	55	32	37	Patch	No	No
8	175	62	42	37	Patch	Yes	No
9	165	60	40	37	Patch	No	No
10	290	132	96	30.8	MVC	No	No
11	190	62	50	37	Patch	No	No
12	175	58	39	37	Myxoma, Resection, Patch	Yes	No
13	225	93	55	37	Patch	Yes	No

CPB=cardiopulmonary bypass, AoX=aortic cross-clamp time, Temp=rectal temperature, Intra-op=intraoperative, MVC=mitral valve reconstruction, MVR=mitral valve replacement

Table 3. Postoperative data of patients undergoing limited anterolateral thoracotomy for correction of congenital heart defects and mitral valve operations

Patient no.	Extubation [OR/hours post-op]	Thoracic drainages [ml]	ICU [days]	Blood cells [ml]	Hemoglobin [mg/dl]	Hospital stay [days]	Follow-up [month]	Complications
1	OR	300	2	No	10.2	9	31	No
2	OR	180	1	No	12.9	9	29	No
3	OR	390	1	No	12.3	7	28	No
4	3	520	2	No	11.3	6	26	No
5	5	200	1	No	13.5	13	26	No
6	2	610	1	No	9.6	7	20	No
7	OR	290	1	No	9.6	5	19	No
8	OR	310	1	No	13.9	5	16	No
9	OR	190	1	No	12.8	7	16	No
10	7	490	2	250	10.5	8	9	No
11	4	250	1	No	11.1	10	5	No
12	1	450	1	No	8.4	7	2	No
13	OR	510	1	No	10.3	8	1	No

OR=operation room, post-op=postoperatively, ICU=intensive care unit

increased wound pain the first postoperative day. Wound healing was normal and the cosmetic result excellent. The mean postoperative follow-up was 17.3 ± 10.5 months (range of 1-31 months), and there was no mortality. The transthoracic echocardiographic investigation showed a

good ventricular function in all cases with no residual defect in the atrial septal defect patients, and no regurgitation or stenosis was observed in the mitral valve patients. All patients were highly satisfied with the cosmetic result of the operation (Figure 3, ©).



Figure 3. Cosmetic result three days after limited right anterolateral thoracotomy including skin incision in the submammary crease in a lying (a) and standing (b) patient.

## DISCUSSION

The median sternotomy is the standard surgical access for the correction of congenital heart disease or mitral valve operations. However, there are a number of potential problems associated with this approach, especially unsatisfactory wound healing of the sternum, including instability, which may result in osteomyelitis and mediastinitis. Moreover, the large scar from the frontal incision in the chest yields a poor cosmetic result that may have adverse psychological consequences, especially in young women.

Several authors describe their experiences with less invasive approaches for surgery to correct congenital defects [Dietl 1992, Grinda 1996, Black 1998, Gundry 1998, Van de Wal 1998, Ying-long 1998, Bauer 2000] or mitral valve operations [Carpentier 1996, Chitwood 1997, Falk 1998, Mohr 1998, Mishra 1999] that avoid the use of median sternotomy. It is reported that the length of incision, duration of endotracheal intubation, drainage volume postoperatively, length of hospital stay, and interval before return to normal activity were significantly shorter and lower in patients undergoing minimally invasive cardiac surgery than in patients treated by conventional surgery using a full sternotomy. [Komai 1996, Cohn 1997, Chang 1998, Mishra 1999].

We chose a limited anterolateral thoracotomy because skin incision in the submammary crease results in an excellent cosmetic outcome, and the operation can be performed under direct vision with standard instruments. Moreover, due to our protocol, the complete cannulation



to the heart-lung machine was performed exclusively through the limited anterolateral thoracotomy [Carpentier 1996, Bauer 2000]. Other authors indicate that the length of the skin incision in an anterior thoracotomy can be reduced significantly when using cannulation of femoral vessels and clamping of the ascending aorta via additional incisions [Chitwood 1997] or using an endoclip [Falk 1998, Mohr 1998, Mishra 1999]. However, these approaches require additional incisions or puncturing of the groin area for cannulation of the femoral vessels [Cremer 1999], which might result in vascular complications or wound healing problems. Moreover, due to the limited space provided by a smaller incision, special surgical instruments are necessary to perform the cardiac procedure, which demands a prolonged learning curve.

An essential point of our protocol is the cannulation of the ascending aorta, which is performed with an elongated, one-piece arterial trochar cannula. The use of this device enables us to cannulate safely the ascending aorta by distance. In order to control bleeding from the site of aortic cannulation, we use three tourniquet-armed sutures.

Due to the limited surgical access, air embolism can be a major problem of minimally invasive open heart surgery because manual heart massage is not possible. In order to prevent air embolism from the heart after declamping of the aorta, we filled the thoracic cavity with CO<sub>2</sub> during the entire open heart procedure. Furthermore, in all patients the cannula in the ascending aorta which had been used for administration of cardioplegic solution was used for de-airing immediately after releasing of the aortic clamp. By this procedure, significant air embolism was avoided, and all patients treated by this less invasive procedure readily regained consciousness. Seven patients were extubated while still on the operating table (Table 3, ⊙), and no neurological defects were observed in the postoperative period. Other authors report the use of transesophageal echocardiography in order to control residual air in the left chambers [Bauer 2000].

In our clinical experience, all patients undergoing a limited anterolateral right thoracotomy could be treated without complications. The operative view was good and no disadvantages of this method were observed. The duration of postoperative endotracheal intubation in the remaining six patients was relatively short [Chang 1998]. The cosmetic result was excellent and the recovery was rapid. However, total time of operation using this approach is longer in comparison to patients undergoing the conventional procedure using midline sternotomy [Chang 1998]. The reason for this probably is the longer learning curve and the smaller operating field, as well as the more demanding cannulation of the ascending aorta and caval veins.

## CONCLUSION

Atrial septal defect and mitral valve operations can be performed safely and effectively using a limited anterolateral right thoracotomy and complete cannulation for the

cardio-pulmonary bypass via this less invasive access. Using this approach, additional incisions in the groin or neck, with their potential complications, can be avoided while achieving excellent cosmetic results.

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