Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Medicine

journal homepage:www.elsevier.com/locate/apjtm

Document heading doi: 10.1016/S1995-7645(14)60105-X

Comparison of clinical outcomes and postoperative recovery between two open heart surgeries: minimally invasive right subaxillary vertical thoracomy and traditional median sternotomy

Chuan-Xian Hu[1], Juan Tan[1&], Sheng Chen[1], Hui Ding[1], Zhi-Wei Xu[2*]

[1]*Department of Cardiothoracic Surgery, Huai'an First People's Hospital Affiliated to Nanjing Medical University, Nanjing, Jiangsu, 223300, China*
[2]*Department of Cardiothoracic Surgery, Zhejiang Normal University, Jinhua, Zhejiang, 321004, China*

ARTICLE INFO

Article history:
Received 10 May 2014
Received in revised form 15 June 2014
Accepted 15 July 2014
Available online 20 August 2014

Keywords:
Minimally invasive surgery
Congenital heart diseases
Right subaxillary vertical thoracotomy
Traditional median sternotomy
Cardiopulmonary bypass

ABSTRACT

Objective: To compare the clinical outcomes of minimally invasive right subaxillary vertical thoracotomy and traditional median sternotomy through right atrium in treatment of common congenital heart diseases. **Methods:** Clinical data of 59 cases of common congenital heart diseases treated with minimally invasive right axillary vertical thoracotomy from May, 2011 to February, 2013 and 77 cases of same diseases with traditional median sternotomy in the past three years were retrospectively analyzed, including atrial septal defect, membranous ventricular septal defect and partial endocardial cushion defect. The results were compared from the two groups, including the time for operation and cardiopulmonary bypass, amount of blood transfusion, postoperative drainage, ventilation time, hospital stay, and prognosis. **Results:** No severe complications happened in both groups, like deaths or secondary surgery caused by bleeding. No significant differences were in CPB time and postoperative ventilator time between groups ($P>0.05$), while for all of the operative time, the length of incision, postoperative drainage and hospital stay, minimally invasive right axillary vertical thoracotomy was superior to median sternotomy, with statistically significant differences ($P<0.05$). In six-month followup after operation, no complications of residual deformity and pericardial effusion were found in both groups by doing echocardiography, but mild pectus carinatum was found in 8 patients in the traditional median sternotomy group (traditional group), whereas patients in another group were well recovered. **Conclusions:** Minimally invasive right subaxillary vertical thoracotomy for common congenital heart diseases is as safe as traditional median sternotomy, without the increasing incidence of postoperative complications. Additionally, compared with traditional median sternotomy, minimally invasive right subaxillary vertical thoracotomy is better in the aspects of hidden incision, appearance, and postoperative recovery.

1. Introduction

Traditional open heart surgery is median sternotomy, with big incision and bad appearance, and sometiimes resulting in sternal malunion or deformity in some patients. In recent years, with the development of equipments and techniques, the minimally invasive open heart surgery has become the focus direction in the future[1,2]. Currently, there are minimally invasivesurgery and non-robotically assisted totally thoracoscopic surgery[3,4]. Non-robotically assisted totally thoracoscopic surgery requires associated equipments and needs long-term learning curve, so it is difficult to promote the usage. The minimally invasive surgery needs no large-scale equipment, and the operation is relatively simple[5]. It mainly includes the right anterolateral incision and right subaxillary vertical incision, but it is still controversial for the security of minimally invasive open heart surgery[6]. From May, 2011 to February, 2013, the minimally invasive right subaxillary

*Corresponding author: Zhi-Wei Xu, Department of Cardiothoracic Surgery, Zhejiang Normal University, Jinhua, Zhejiang 321004, China.
E-mail: jcm025@126.com
Tel: 13605148430
Fax: 025-83207760
&The authors contributed equally to the study.

vertical thoracotomy was employed for treatment of 59 cases of common congenital heart diseases in our centerthat could be operated through right atrium, and compared with those patients taken the traditional median sternotomy. Different from reports in the literature, the cardiopulmonary bypass (CPB) was established through the right subaxillary vertical thoracotomy to avoid trauma caused by femoral artery and vein cannulation in our center.

2. Materials and Methods

2.1. Clinical data

A total of 59 patients in minimally invasive group were selected, of which 19 cases were simple secundum atrial septal defect (ASD), 8 cases were partial endocardial cushion defect (PECD), and 22 cases were membranous ventricular septal defect (VSD). All patients took right subaxillary vertical thoracotomy.

A total of 77 patients in traditional group were selected, all of which were the same type of patients that underwent traditional median sternotomy in past 3 years, including 28 cases of simple secundum ASD, 16 cases of PECD, 33 cases of membranous VSD. All patients were diagnosed by echocardiography and excluded from surgery taboo. Comparison of preoperative data of both groups was shown in Table 1.

2.2. Surgical methods

For patients in minimally invasive group, general anesthesia was achieved by using the double-lumen endotracheal intubation and intravenous injection, with left lateral decumbent position and 30 ° elevation of the left armpit. The flexional right upper limb was suspended above the head frame. Before surgery, the intercostal space was determined on anterioposterior chest radiograph reference to the horizontal line of the right atrium midpoint project to the chest wall. The right axillary midline vertical incision was made by reference to the intercostal space. If it was the atrial septal defect, the incision should be made in this intercostals space or that one above it (mostly the fourth or fifth intercostal space). If it was ventricular septal defect, it should be made in the below intercostals space (mostly the fifth or six intercostal space). The length of incision should be 6 - 8cm for children, and 10 - 12 cm for adult. The chest was vertically propped with two minimally invasive retractors. After the single-lung ventilation, a longitudinal incision was made at the front of phrenic nerve, with approximately 1.5cm distance, and the pericardium was suspended. CPB was established with ascending aorta, superior and inferior vena cava annulations through right subaxillary vertical thoracotomy. Secundum ASD was repaired with heart beating. Membranous VSD and PECD were repaired after placement of occlusion clamp through the right axillary incision and antegrade perfusion of cardioplegia solution through aortic root. Secundum ASD that is less than 8mm, and membranous VSD that is less than 5mm were directly sutured, and defects of large scale were repaired with glutaraldehyde-treated autologous pericardial patch. All 59 patients in the minimally invasive group were automatically cardiac resuscitation. Right chest tube was placed through the seventh intercostals in the posterior axillary line and closed the right axillary incision layer by layer. Patients were sent back to cardiac intensive care unit with endotracheal intubation after surgery.

In 77 cases in traditional group traditional median sternotomy was employed. The surgery procedure was the same with minimally invasive group.

2.3. Measured parameters

The time of operation and CPB, postoperative ventilation time, drainage, the length of incision and hospital stay were compared between minimally invasive group and traditional group. Followup was performed by telephone and outpatient.

2.4. Statistical analysis

All data were analyzed by SPSS 16.0. Measurement data were expressed as mean ±SD, and compared using independent samples t-test; count data were recorded as percentage, and compared using χ^2-test, $P<0.05$ was considered statistically significant.

3. Results

The patients in both groups were recovered uneventfully, without major complications, like secondary operation caused by bleeding and postoperative deaths. The surgery procedure of the minimally invasive group was completed as expected, without need of alteration into the median sternotomy in the half-way. No significant difference between 2 groups was found in CPB time and postoperative ventilation time ($P>0.05$), while for the operating time, postoperative drainage, length of incision and hospital stay,

Table 1
Comparison of preoperative data of minimally invasive group and traditional group(% or mean±sd).

Clinical data	Age (y)	Body weight (kg)	Female (%)	NYHA	Left ventricular ejection fraction (%)	Cardiothoracic ratio
Minimally invasive group	11.2±7.7	22.9±6.3	43.8	1.3±0.6	58.2±6.4	0.63±0.07
Traditional group	12.3±9.2	27.3±8.6	40.3	1.5±0.9	57.3±5.3	0.66±0.11
P value	0.12	0.03	--	0.09	0.08	0.09

Table 2
Comparison of postoperative data of minimally invasive group and traditional group (mean±sd).

Clinical data	Operating time (min)	CPB time (min)	Ventilation time (h)	Length of incision (cm)	Drainage (mL)	Postoperative hospital stay (d)
Minimally invasive group	141±22	58±19	6.8±2.1	6.3±1.1	72±21	4.2±0.07
Traditional group	162±27	52±24	7.1±3.3	9.6±2.5	155±31	8.3±0.11
P value	0.023	0.113	0.151	0.006	0.001	0.003

the results in the minimally invasive group were all less than those in the traditional group, with the statistical significant difference ($P<0.05$), as showed in Table 2.

Patients in both groups were followed up by telephone or outpatient for half a year with satisfactory resultsby UCG reexaminations, and no residual deformity was found. The cardiac function of all patients was class I. Different grades of scar were found in all patients subjected to traditional surgery, and mild pectuscarinatum was found in 8 of them in traditional group. No thoracic deformity was found in patients in minimally invasive group and all wounds were healed well with better appearance than that in the traditional group.

4. Discussion

Because of its good exposure, traditional median sternotomy was a classic pathway for cardiovascular surgery, which could meet the demand of a variety of cardiac surgeries[7]. However, it also caused long-term adverse effects on patients with large trauma, bleeding, long-term hospitalization, pectus carinatum in children and obvious scars after recovery. With the development of surgical techniques and minimally invasive devices, in recent years, a variety of minimally invasive surgeries appeared, such as right anterolateral thoracotomy, parasternal thoracotomy, inferior segment sternotomy and so on. Previous studies suggested in their study that minimally invasive right thoracotomy was a safe and effective alternatives to traditional median sternotomy for complex mitral valve surgeryin reducing operative mortality in high-risk patients[8,9].

In most medical centers, the right anterolateral minimally invasive incision was made into the third or fourth intercostal space. The incision needed to dissect the breast tissue, which would affect the growth and feeling of breast, especially in female patients. As to the right subaxillary vertical incision, it was located at subaxillary midline, away from the breast and chest muscle tissue, with access to the chest through the gap of the serratus anterior muscle, and only intercostal muscle needed to be cut. Because the right subaxillary vertical incision was with small surgical trauma, maintained the integrity of the thorax, and did not affect the growth of breast and muscle tissue, it was suitable for most heart surgeries through the right atrium[10]. Results found in previous studies showed that right subaxillary small incision for congenital heart defect can reduce the hurts to the breast, especially for female by increasing the radian away from the breast of the patients[11,12].

Lei *et al* stated in their study that there were no deaths and complications of arrhythmia and infection of incisional wound, no significant differences were in CPB time and postoperative ventilator time between groups ($P>0.05$), while for the length of incision, postoperative drainage and ICU stay, minimally invasive right axillary vertical thoracotomy was superior to median sternotomy, with statistically significant differences ($P<0.05$), which was consistent with the results of this study[13-16]. Considered that the operation was relatively simple for patients in both groups in our center, compared with traditional median sternotomy, the right subaxillary vertical thoracotomy did not increase the difficulty of surgery, so that there was no significant difference in CPB time. Because patients in both groups were all common congenital heart diseases with good preoperative cardiac function, tracheal intubation was removed rapidly after operation. So the ventilation time was also not statistically different. Although there was no significantly difference in CPB time between the two groups, operating time in minimally invasive group was significantly shorter than that of the traditional group, which indicated that it took less time to stop bleeding and open and close of chest in minimally invasive group than traditional group. Meanwhile, less amount of postoperative drainage,

shorter length of incision and hospital stay in minimally invasive group indicated that the postoperative recovery was significantly better than in the traditional group.

Different from the exposure of heart in traditional median sternotomy, right subaxillary vertical thoracotomy was better for the exposure ofascending aorta, but not of the inferior vena cava through the third intercostal space; whereas, it was better for the exposure of inferior vena cava through the forth intercostal space[17]. Our experience was that the incision should be made in accordance with the anterioposterior chest radiography. If the projective point of the horizontal line of the right atrium midpoint was at intercostal space, incision was made through this intercostal space. If not, incision should be made at an upper intercostal space in atrial septal defect, or at a lower one in ventricular septal defect. It was easy to expose the ascending aorta and inferior vena cava and convenient for surgical procedure by using this method. Serratus anterior muscle was blunt dissected and only the intercostal muscle should be cut off, without disruption of the integrity of the thorax, so that the surgery was with little trauma, better for postoperative recovery.

The right subaxillary vertical thoracotomy was deeper and less exposure for CPB. In most publications presently, CPB was established by the femoral artery and the jugular vein. It increased additional trauma, and particularly, it might raise the risk of neck hematoma in jugular vein catheterization. For this reason, we designed a device in which the inner core was added into the tube to make it harder in the aortic and vena cava cannulations. It was easy for deep operation. The device designed by us for inferior vena was good in plasticity and stiffness, and convenient for vena cava cannulation. With the devices, it was easy to establish CPB through right subaxillary vertical thoracotomy. Despite of difficulty for the exposure of operative position, it avoided the additional trauma in the femoral artery and vein. Meanwhile, it was not a problem for experienced surgeon with well knowledge of heart anatomy.

Minimally invasive right subaxillary vertical thoracotomy for common congenital heart diseases was reliable surgical technique which could reduce patients insult and surgical trauma caused by femoral artery and vein cannulation, giving good functional and cosmetic results to almost all patients[18-20]. Studies showed thatsurgery in children and adults with congenital heart diseases changed greatly during the last decade and improved surgical results in patients with simple congenital heart diseases and new interventional cardiology procedures stimulated the surgeons to employ minimally invasive techniques with the intention to reduce the patient's surgical insult and obtaining good functional and cosmetic results[21,22]. Poyrazoglu et al suggested in their study that no residual defects were found in the early postoperative period and after the end of the follow-up periods. All of the patients had functional capacity per NYHA and no deformation of breast growth were detected during 18 months of follow-up for the group I patients, who underwent right vertical axillary minithoracotomy[23]. And the similar situation in Wang's, Arslan's and Gil-Jaurena's studies[24-26]. In postoperative follow-up, we found that, for patients in traditional group with incision at the median sternum, the scar was obvious, which could be contributed to skin tension during breathing, easy to cause pectus carinatum for pediatric patients. There was a wire metal shadow found in chest film of the sternum, and it had certain influence for patients, physically or mentally. Whereas,right subaxillary vertical thoracotomy, is a minimally invasive surgery marked by hiddenincision, less tension, mostly subtlescar and free from the impact on female breast in anterolateral incision.

Thus, for common simple congenital heart diseases, it was safe and reliable by using the right subaxillary vertical thoracotomy to establish CPB, with small trauma, quick recovery, good appearance, early follow-up satisfaction, and good clinical results.

Conflict of interest statement

All the authors have no conflict of interest.

Acknowledgments

This article is supported by college medical journal clinical special funds (11321587).

References

[1] Hu SHSH. Challenges and opportunities of cardiosurgery in 21th century. *Chin J Cardiovascular Rev* 2005; **3**(3): 163-166.

[2] Vanelli P, Lemma M, Antona C. Right mini-thoracotomy for left maze with transesophageal echo guidance. *Interact CardioVasc Thorac Surg* 2010; **10**: 843-846.

[3] Ma ZS, Dong MF, Yin QY, Feng ZY, Wang LX. Totally thoracoscopic closure for atrial septal defect on perfused beating hearts. *Eur J Cardiothorac Surg* 2012; **41**: 1316-1319.

[4] Ota T, Patronik NA, Schwartzman D, Riviere CN, Zenati

MA. Minimally invasive epicardial injections using a novel semiautonomous robotic device. *Circulation* 2008; **118**: S115-S120.

[5] Iribarne A, Easterwood R, Chan EYH, Yang J, Soni L, Russo MJ, et al. The golden age of minimally invasive cardiothoracic surgery: current and future perspectives. *Future Cardiol* 2011; **7**(3): 333-346.

[6] Prêtre R. Editorial comment: Minimal invasive surgery in congenital heart defects: keeping sight of our priority. *Eur J Cardiothorac Surg* 2012; **42**: 980.

[7] Fukunaga N, Yuzaki M, Shomura Y, Fujiwara H, Nasu M, Okada Y. Clinical outcomes of open heart surgery in patients with atopic dermatitis. *Asian Cardiovascular Thoracic Ann* 2012; **20**: 137-140.

[8] Badhwar V, Anastacio MM, Wei LM. Video-assisted minimally invasive mitral valve surgery: transitioning from sternotomy to mini-thoracotomy. *Multimedia Manual Cardio-Thoracic Surg* 2013; **2013**: mmt016.

[9] Umakanthan R, Petracek MR, Leacche M, Kumar S, Solenkova NV, Kaiser CA, et al. Minimally invasive right lateral thoracotomy without aortic cross-clamping: an attractive alternative to repeat sternotomy for reoperative mitral valve surgery. *J Heart Valve Dis* 2010; **19**(2): 236.

[10]Li J, Liu Y, Yang F, Jiang G, Li C, Hu D, et al. Video-assisted thoracoscopic left cardiac sympathetic denervation: a reliable minimally invasive approach for congenital long-QT syndrome. *Ann Thorac Surg* 2008; **86**(6): 1955-1958.

[11]Wang SH, Zheng JW, Fu ZD. Outcomes and application of right subaxillary small incision for congenital heart defect in children. *Acta Acad Med Weifang* 2013; **35**(5): 352-354.

[12]Mishaly D, Ghosh P, Preisman S. Minimally invasive congenital cardiac surgery through right anterior minithoracotomy approach. *Annals Thoracic Surg* 2008; **85**(3): 831-835.

[13]Lei H, Yan ZY, Yan Y, Zhang QC. Comparison of right axillary straight incision and median sternotomy in mitral valve replacement. *Anhui Med J* 2013; **34**(9): 1287-1289.

[14]Poyrazoglu HH, Avsar MK, Demir Ş. Atrial septal defect closure: comparison of vertical axillary minithoracotomy and median sternotomy. *Korean J Thoracic Cardiovascular Surg* 2013; **46**(5): 340-345.

[15]Wang D, Wang Q, Yang X, Wu Q, Li Q. Mitral valve replacement through a minimal right vertical infra-axillary thoracotomy versus standard median sternotomy. *Ann Thoracic Surg* 2009; **87**(3): 704-708.

[16]Wang Q, Li Q, Zhang J, Wu Z, Zhou Q, Wang DJ. Ventricular septal defects closure using a minimal right vertical infraaxillary thoracotomy: seven-year experience in 274 patients. *Ann Thoracic Surg* 2010; **89**(2): 552-555.

[17]Pan S, Xing Q, Cao Q, Wang P, Duan S, Wu Q, et al. Perventricular device closure of doubly committed subarterial ventral septal defect through left anterior minithoracotomy on beating hearts. *Ann Thorac Surg* 2012; **94**(6): 2070-2075.

[18]Cingoz F, Tavlasoglu M, Sahin MA, Kurkluoglu M, Guler A, Günay C, et al. Minimally invasive pediatric surgery in uncomplicated congenital heart disease. *Asian Cardiovascular Thoracic Ann* 2013; **21**(4): 414-417.

[19]Lin PJ, Chang CH, Chu JJ, Liu HP, Tsai FC, Lin FC. Minimally invasive cardiac surgical techniques in the closure of ventricular septal defect: an alternative approach. *Ann Thoracic Surg* 1998; **65**(1): 165-169.

[20]Formigari R, Di Donato R M, Mazzera E, Carotti A, Rinelli G, Parisi F, et al. Minimally invasive or interventional repair of atrial septal defects in children: experience in 171 cases and comparison with conventional strategies. *J American Coll Cardiol* 2001; **37**(6): 1707-1712.

[21]Vida VL, Padalino MA, Motta R, Stellin G. Minimally invasive surgical options in pediatric heart surgery. *Expert Rev Cardiovasc Ther* 2011; **9**(6): 763-769.

[22]Vida VL, Tessari C, Fabozzo A, Padalino MA, Barzon E, Zucchetta F, et al. The evolution of the right anterolateral thoracotomy technique for correction of atrial septal defects: cosmetic and functional results in prepubescent patients. *Ann Thoracic Surg* 2013; **95**(1): 242-247.

[23]Poyrazoglu HH, Avsar MK, Demir Ş. Atrial septal defect closure: comparison of vertical axillary minithoracotomy and median sternotomy. *Korean J Thoracic Cardiovascular Surg* 2013; **46**(5): 340-345.

[24]Kadner A, Dodge-Khatami A, Dave H, Knirsch. W, Bettex D, Prêtre R. Closure of restrictive ventricular septal defects through a right axillary thoracotomy. The heart surgery forum. *Carden Jennings Publishing Co* 2006; **9**(6): E836-E839.

[25]Arslan G, Ugur M, Alp İ, Temizkan V. Is the right vertical axillary incision an alternative technique to the submammarian incision for the repair of simple congenital heart defects in female patients? *European J Cardio-Thoracic Surg* 2013; **44**(3): 584-585.

[26]Gil-Jaurena JM, Zabala JI, Conejo L, Cuenca V, Picazo B, Jiménez C, et al. Minimally invasive pediatric cardiac surgery. Atrial septal defect closure through axillary and submammary approaches. *Revista Española de Cardiología (English Edition)* 2011; **64**(3): 208-212.