# Evaluation of different minimally invasive techniques in the surgical treatment of atrial septal defect

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**Objective:** Minimally invasive cardiac surgery is becoming a safe and cosmetic alternative to standard median sternotomy (SMS). In the present retrospective study, we reviewed our results and experience with the totally thoracoscopic (TTS) and right vertical infra-axillary thoracotomy (RVIAT) techniques for atrial septal defect closure compared with SMS.

**Methods:** From December 2010 to February 2012, 198 patients underwent repair of atrial septal defect using the TTS technique (n = 66), RVIAT (n = 59), or SMS (n = 73). Cardiopulmonary bypass was achieved peripherally in the TTS group and directly in the RVIAT and SMS groups.

**Results:** The procedures were performed successfully in all 3 groups, and no in-hospital mortality occurred. No patient required conversion to SMS in the TTS group, although 2 patients did so in the RVIAT group. The cardiopulmonary bypass time was 87.26 ± 21 minutes in the TTS group, 41.81 ± 13.97 minutes in the RVIAT group, and 36.99 ± 10.84 minutes in the SMS group ($P < .01$). The crossclamp time was 32.86 ± 13.36, 22.54 ± 9.08, and 19.23 ± 6.92 minutes in the TTS, RVIAT, and SMS groups, respectively ($P < .01$). The total incision length in the SMS group (7.45 ± 1.54 cm) was longer than that in the other groups (TTS group, 5.21 ± 0.63 cm; RVIAT group, 6.48 ± 1.37 cm); the difference was statistically significant ($P < .01$).

**Conclusions:** The TTS technique and RVIAT can both be performed with favorable cosmetic and acceptable clinical results for closing atrial septal defects. They are promising alternatives to SMS and merit additional study. (J Thorac Cardiovasc Surg 2014;148:188-93)



Atrial septal defect (ASD) is one of the most common congenital heart diseases and constitutes 30% to 40% of all congenital heart diseases in adults.[1] Transcatheter closure of ASDs is standard practice, and excellent results have been reported, with low early and late complication rates.[2] However, primary surgical repair is still needed for large secundum defects with limited septal margins and complex ASDs, including ostium primum, sinus venosus ASDs, and fenestrated or aneurysmal interatrial septal.

With the assistance of advanced instrumentation and the rapid development of surgical techniques, the clinical results of cardiac surgery have dramatically improved during the past decade. Thus, the cosmetic and psychological implications of surgery have assumed increasing importance, and a variety of minimally invasive cardiac surgical techniques have been developed, including right thoracotomy,[3-7] port-access surgery,[8-10] and video-assisted methods.[11]

In our center, right vertical infra-axillary thoracotomy (RVIAT) has been used to repair congenital heart defects for several years to avoid standard median sternotomy (SMS) and its related discomfort. In addition, the totally thoracoscopic (TTS) technique has been performed for selected patients for the past 2 years. In the present retrospective study, we have reviewed our results and experience with the RVIAT and TTS techniques for the treatment of ASD compared with SMS.

## METHODS

The institutional review board of Zhengzhou University approved the present study, which was in compliance with Health Insurance Portability and Accountability Act regulations and the Declaration of Helsinki. The institutional review board waived the need for individual patient consent. The selection criteria for TTS or RVIAT ASD repair at our department were as follows: (1) age ≥ 10 years, with a body weight of ≥ 20 kg; (2) pulmonary arterial systolic pressure as measured by echocardiography of ≤60 mm Hg; (3) no history of lung disease or surgery on the right side of the chest; and (4) no other cardiovascular disease or chronic illness. Patients who were unable to meet all these selection criteria or who were unable to give informed consent were excluded from the present study. All patients underwent ASD closure by the same surgical team.

From January 2011 to December 2012, 198 patients underwent elective ASD closure. In accordance with patient preference and after discussion in our cardiology and surgical conference, surgical access was done using TTS (n = 66), RVIAT (n = 59), or SMS (n = 73). The 3 groups were well-matched for age, weight, pulmonary/systemic flow ratio, and defect size (Table 1).

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**Abbreviations and Acronyms**

ASD = atrial septal defect
CPB = cardiopulmonary bypass
ICU = intensive care unit
RVIAT = right vertical infra-axillary thoracotomy
SMS = standard median sternotomy
TTS = totally thoracoscopic

## Anesthesia

After induction of general anesthesia, a double-lumen endotracheal tube was placed to allow for single-lung ventilation in the TTS and RVIAT groups, and a single-lumen endotracheal tube was placed in the SMS group. The respiration rate was set at 18 to 30 breaths/min, and the arterial oxygen saturation rate was maintained at >97%.

## Operative Technique

**TTS group.** For TTS, the patients were placed in the supine position with the right side of the body elevated 15° to 20°. A transesophageal echocardiographic probe was inserted routinely to assess the place of the venous cannulation and surgical result and to detect possible intracardiac air. Cardiopulmonary bypass (CPB) was established by peripheral arterial and venous cannulation. After systemic heparinization, a double lumen catheter was inserted through the right femoral vein into the inferior and superior venae cavae. A 2-cm incision was used at the inguinal fold to expose the femoral vessels. After an activated clotting time > 400 s had been achieved, direct arterial cannulation was usually achieved through the femoral artery. On the right side of the chest, three 1- to 2-cm incisions were made in the fourth intercostal space on the right side of the sternum, in the sixth intercostal space on a midclavicular line, and in the fifth intercostal space on the right midaxillary line. These incisions allow the entry of tissue forceps or suture needles, scissors, and an endoscopic camera or thoracoscope (Figures 1 and 2).

Pericardiotomy was performed once the 3 ports were secured, and 3 or 4 sutures were placed to suspend the pericardium. Caval snares were placed in the superior and inferior vena cava to install total CPB. Carbon dioxide was conveyed to the operative field through the third incision. A long perfusion needle was introduced through the third incision (port 3) and inserted in the aorta through the purse-string suture with the help of the thoracoscope. When core body temperature had decreased to 32°C, an aortic crossclamp was introduced through the third incision and occluded the ascending aorta under direct thoracoscopic view. After cardiac asystolic arrest with anterograde cold cardioplegia, the right atriotomy was opened from a site parallel to the atrioventricular annulus by the forceps and scissors through incisions 2 and 3, respectively, and 4 sutures were placed on the incision to expose the intra-atrial structure. The ASD type, size, and relation to the atrial structures were carefully identified. The ASD was closed with 4-0 Prolene suture directly or with a Dacron patch according to the size of the defect. De-airing was done from the perfusion cannula and the ASD defect before knotting by lung inflation. The right atrium was sutured using 4-0 Prolene after the aortic clamp had been released and body warmed. Carbon dioxide was removed after closing right atrium. The cannula was removed after weaning from CPB. A chest tube was placed from incision 1 to drain effusion and air.

**RVIAT group.** In the RVIAT group, the patients were positioned with the right side elevated 60°, and the right arm was placed over the head in a natural position. The skin incision began at the third intercostal space and extended to the fifth intercostal space along the right mid-axillary line (Figure 3) to form a right vertical infra-axillary incision. The length of the incision was approximately 5 to 9 cm, but varied depending on the patient's physical characteristics and type of lesion. The thoracic cavity was entered through the fourth intercostal space. The lung was retracted posteriorly using wet sponges to expose the pericardium. The pericardium was opened 2 cm anterior to the phrenic nerve, superiorly to the pericardial reflection and inferiorly to the diaphragm, to provide enough exposure of the ascending aorta and inferior vena cava. After heparin sodium administration, the aorta was cannulated with the help of 2 long vascular clamps. One clamp was used to draw the cannulation site down and the other held the top of the aortic cannula to push it in place. Next, the superior and inferior venae cavae were cannulated. CPB with mild hypothermia (32°C) was instituted (Figure 4). An aortic perfusion needle was inserted in the aorta through the purse-string suture. Next, the aorta was crossclamped, and cold blood cardioplegic solution was used for myocardial protection.

After snaring the superior and inferior venae cavae, the right atrium was opened from a site parallel to the atrioventricular annulus, and 2 sutures were placed to expose the intra-atrial structure. The ASD was closed with direct 4-0 Prolene sutures. The autologous pericardium was used to repair larger ASDS with running Prolene sutures. The method of de-airing was the same as that for the TTS group. Once the CPB had ceased, the chest and pericardium were drained. The pericardium was closed, and all skin incisions were closed intracutaneously.

**SMS group.** In the SMS group, a standard midline sternotomy with a short skin incision was performed. Extracorporeal circulation was applied with venous outflow through catheters in both venae cavae, with arterial return through a catheter in the ascending aorta. Mild systemic hypothermia to 32°C was maintained. Myocardial protection was achieved with antegrade cold oxygenated blood cardioplegia and topical hypothermia. The exposure of the intra-atrial structure and the method of ASD closure were the same as described for the TTS group. The method of de-airing was also the same. Once CPB had ceased, the chest and pericardium were drained. The pericardium was closed, and all skin incisions were closed intracutaneously.

## Postoperative Management

Postoperatively, the patients were monitored in the intensive care unit (ICU). Bedside chest radiography was performed in the ICU to exclude complications in the lungs. Mechanical ventilation was withdrawn when patients' hemodynamics became stable.

## Statistical Analysis

The data were managed and analyzed using Statistical Package for Social Sciences, version 13.0 (SPSS, Chicago, Ill). All continuous variables are expressed as the mean ± standard deviation and were compared using 1-way analysis of variance. The categorical variables were analyzed using the chi-square test. All statistical tests are 2-tailed. $P < .05$ was considered statistically significant.

# RESULTS

## Demographic and Clinical Characteristics

The patient characteristics and procedure-related variables were similar. Of the 198 patients, 66 (42 girls and 24 boys; mean age, 29.68 ± 12.17 years) were in the TTS group, 59 (36 girls and 23 boys; mean age, 29.27 ± 14.23 years) were in the RVIAT group, and 73 (34 girls and 45 boys; mean age, 27.08 ± 12.32 years) were in the SMS group. More girls were in the TTS (63.6%) and RVIAT (60.02%) groups than in the SMS group (43.03%, $P = .02$). However, no significant difference was found between the TTS and RVIAT groups. No significant differences were present among the groups in the

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