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Original Article / Özgün Makale

Mini-thoracotomy versus median sternotomy for atrial septal defect closure: Should mini-thoracotomy be applied as a standard technique?

Atriyal septal defekt kapatılmasında mini-torakotomi ve medyan sternotominin karşılaştırılması: Mini-torakotomi standart teknik olmalı mı?

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ABSTRACT

Background: This study aims to compare outcomes of mini-thoracotomy versus median sternotomy for atrial septal defect closure.

Methods: Between January 2012 and May 2017, a total of 44 patients (8 males, 36 females; mean age 33.86 years; range, 14 to 63 years) who underwent atrial septal defect repair through mini-thoracotomy or median sternotomy in our clinic were retrospectively analyzed. Pre-, intra-, and postoperative data of the patients were recorded.

Results: There was no significant difference in the cardiopulmonary bypass and cross-clamp times between the groups, although the duration of operation was shorter in the mini-thoracotomy group (p=0.001). No significant difference was observed between the groups in terms of early mortality, neurological complications, and residual atrial septal defect. The mean mechanical ventilation time and length of intensive care unit and hospital stay were statistically significantly shorter, and the amount of bleeding was statistically significantly lower in the mini-thoracotomy group (p=0.001 for all).

Conclusion: Mini-thoracotomy should be kept in mind as a favorable alternative to sternotomy following a satisfactory learning curve period with less cost and higher patient benefit.

Keywords: Atrial septal defect, mini-thoracotomy, minimally invasive, sternotomy.

ÖZ

Amaç: Bu çalışmada atriyal septal defekt kapatılmasında mini-torakotomi ve medyan sternotominin sonuçları karşılaştırıldı.

Çalışma planı: Ocak 2012 - Mayıs 2017 yılları arasında kliniğimizde mini-torakotomi veya medyan sternotomi ile atriyal septal defekt tamiri yapılan toplam 44 hasta (8 erkek, 36 kadın; ort. yaş 33.86 yıl; dağılım, 14-63 yıl) retrospektif olarak incelendi. Hastaların ameliyat öncesi, sırası ve sonrasına ilişkin veriler kaydedildi.

Bulgular: Ameliyat süresi mini-torakotomi grubunda daha kısa olmakla birlikte, kardiyopulmoner baypas ve kros klemp süreleri açısından gruplar arasında anlamlı bir fark yoktu (p=0.001). Gruplar arasında erken mortalite, nörolojik komplikasyonlar ve rezidüel atriyal septal defekt açısından anlamlı bir fark izlenmedi. Mini-torakotomi grubunda ortalama mekanik ventilasyon süresi ve yoğun bakım ünitesi ve hastanede kalış süresi istatistiksel olarak anlamlı düzeyde daha kısa ve kanama miktarı istatistiksel olarak anlamlı düzeyde daha azdı (tümü için p=0.001).

Sonuç: Mini-torakotomi daha az maliyet ve daha fazla hasta yararı ile tatmin edici bir öğrenme eğrisi döneminden sonra sternotomiye uygun bir alternatif olarak akılda tutulmalıdır.

Anahtar sözcükler: Atriyal septal defekt; mini-torakotomi, minimal invaziv, sternotomi.

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Atrial septal defects (ASDs), particularly secundum ASD, is one of the most common form of congenital heart diseases. The estimated incidence of secundum ASD is 0.04/1,000 live births.[1] Median sternotomy (MS) is the gold standard approach for surgical ASD closure in both children and adults.[2] The ASD closure procedure is relatively simple, compared to other congenital heart diseases; however, a high number of patients are concerned about its cosmetic outcomes. Therefore, the number of minimally invasive cardiac surgery (MICS) procedures for ASD closure has been increasing every day.[3]

In our routine practice, right anterolateral mini-thoracotomy (RAT) for ASD closure has been used in adults for the past three years. In the present study, we aimed to compare clinical outcomes of RAT versus MS in adult patients undergoing ASD closure.

PATIENTS AND METHODS

Between January 2012 and May 2017, a total of 44 patients (8 males, 36 females; mean age 33.86 years; range, 14 to 63 years) who underwent ASD closure through RAT or MS by a single surgical team in Izmir Katip Celebi University Ataturk Training and Research Hospital were retrospectively analyzed. Patients who underwent concomitant procedures, such as valve procedures and coronary surgery, were excluded. Primum ASD cases were also excluded from the study. In addition, those who required urgent surgery for failure of percutaneous closure and underwent sternotomy were excluded. Pre-, intra-, and postoperative data of the patients were obtained from the hospital records and compared between the groups. A written informed consent was obtained from each patient. The study protocol was approved by the Noninvasive Ethics Committee of Izmir Katip Celebi University. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Operative technique

All operations were performed under general anesthesia. Isothermic blood cardioplegia was used in all patients. In patients requiring additional doses of cardioplegia during mini-thoractomy, we used a root cannula (MIAR™ Cannulae, Medtronic, MN, USA).

In the MS group, a standard median sternotomy was performed, and the usual aortic and bicaval cannulation were used. A vent cannula was inserted via the right superior pulmonary vein. Cardioplegia was infused in an antegrade fashion via an aortic root cannula, and the ascending aorta was cross-clamped. The right atrium was opened, and the ASD was closed primarily or with a patch, if necessary.

In the MICS-RAT group, the patients were positioned with their right side up by inserting towels under the right back. A small incision (~2 cm) was made in the inguinal region for the femoral artery and vein exploration. Two nylon tapes were turned around the femoral artery and vein separately. A purse string suture with 5/0 prolene was applied at the common femoral vein, and a venous cannula was inserted and the tip was positioned at the inferior vena cava level under the transesophageal echocardiography or angiography guidance. Another venous cannula was inserted via the right internal jugular vein and positioned at the superior vena cava level. Two venous cannulae were connected with a Y-connector. A purse string suture with 5/0 prolene was applied at the common femoral artery and an arterial cannula was inserted via the Seldinger technique (Figure 1). A small anterolateral thoracotomy (~5 cm) was made at the submammary line, and the pleural cavity was entered through the fourth intercostal space (Figure 2). The Carlens-type double-lumen tubes were used at all MICS-RAT procedures. The pericardium was opened and retracted using six sutures which passed through the chest wall via the suture catcher. The superior vena cava and inferior vena cava were snared down with a nylon tape and slider after cardiopulmonary bypass (CPB) was initiated. A vent cannula was inserted via the right superior pulmonary vein. Aortic cross-clamping (ACC) was achieved using a Chitwood DeBakey clamp (Scanlan International Inc., Saint Paul, Minnesota, USA) through another 0.5-cm incision at the second intercostal space.

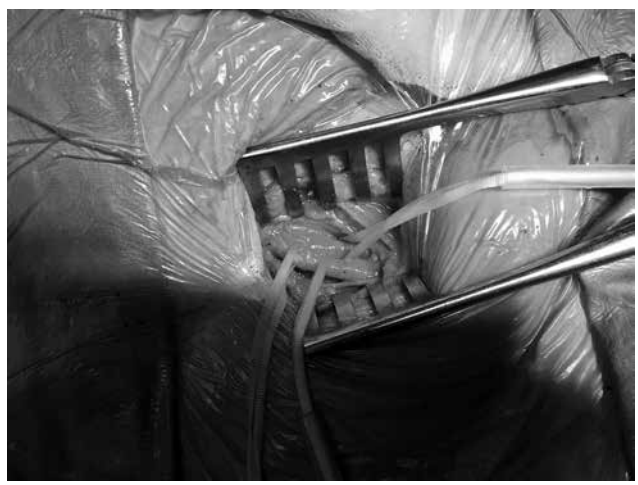

Figure 1. Femoral artery and vein exploration.

Figure 2. Jugular cannulation and incision area.

Cardioplegia was infused in an antegrade fashion via an aortic root cannula. The right atrium was opened, and the ASD was closed primarily or with a patch, if necessary (Figure 3). Throughout the procedure, carbon dioxide (CO_2) was infused into the thorax to reduce the risk of air embolism. As routinely, no thoracoscopy or thoracoscopic devices were used during ASD closure through MICS-RAT, although we used them for mitral procedures. The right atrium was closed, the ACC was released, and CPB weaning and decannulation procedures were performed using the standard techniques. Thoracotomy and femoral incision were closed with a particular concern for cosmetics (Figure 4).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean ± standard deviation (SD), while categorical variables were expressed in number and frequency. The distribution of the variables was measured using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used for the analysis of quantitative independent data. The chi-square test or Fisher's exact test was used to analyze qualitative independent data. A p value of <0.05 was considered statistically significant.

RESULTS

There were 29 patients in the MS group and 15 patients in the MICS-RAT group. None of the patients had tricuspid regurgitation or atrial fibrillation in any of the groups. There was no significant difference in the preoperative data between the groups (Table 1).

None of the patients required intraaortic balloon pump in any of the groups. The mean duration of surgery was significantly shorter in the MICS-RAT group, compared to the MS group (185.5±17.9 min vs. 221.9±47.0 min, respectively; p<0.001). However, there was no significant difference in the mean duration of CPB (67.1±16.7 min vs. 66.3±21.3 min, respectively; p=0.244) and ACC (35.5±18.4 min vs. 41.0±18.8 min, respectively; p=0.691) between the groups (Table 2).

In addition, there were no significant differences in the ratio of morbidities and mortalities between two groups. The mean amount of postoperative transfusion did not also differ between the groups (120.3±245.8 mL vs. 393.6±519.4 mL, respectively;

Figure 3. An intraoperative view of closure via patch.

Figure 4. A postoperative image of closure.

Table 1. Baseline demographic and clinical characteristics of patients

	MS group (n=29)			MICS-RAT group (n=15)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			33.4±11.3			33.3±11.9	0.975
Gender							0.822
Female	24	82.8		12	80		
Male	5	17.2		3	20		
Diabetes mellitus	5	17.2		1	6.7		0.333
Chronic obstructive pulmonary disease	2	6.9		1	6.7		1.000
Smoking	10	34.5		3	20		0.318
Chronic renal disease	1	3.4		0	0		1.000
Hypertension	7	24.1		2	13.3		0.400
EuroSCORE			1.1±0.8			1.1±0.8	0.916
Ejection fraction			60.2±2.5			60.2±3.0	0.261
Body surface area (kg/m^2)			1.7±0.2			1.7±0.2	0.853

MS: Median sternotomy; MICS-RAT: Minimally invasive cardiac surgery via right anterior thoracotomy; SD: Standard deviation.

Table 2. Intraoperative data

	MS group (n=29)			MICS-RAT group (n=15)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Intraaortic baloon pump	0	0		0	0		-
Cardiopulmonary bypass time			66.3±21.3			67.1±16.7	0.244
Aortic cross-clamp time			41.0±18.8			35.5±18.4	0.691
Total operation time			221.9±47.0			205.5±17.9	0.001*

MS: Median sternotomy; MICS-RAT: Minimally invasive cardiac surgery via right anterior thoracotomy; SD: Standard deviation; * p<0,05: Statistically significant (Pearson's chi square test.

Table 3. Postoperative data

	MS group (n=29)			MICS-RAT group (n=15)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Mechanical ventilation time (hours)			10.6±2.2			7.0±1.7	0.001*
Intensive care unit length of stay (day)			2.3±0.5			1.4±0.5	0.001*
Chest tube drainage (mL)			484.5±270.0			218.7±92.6	0.001*
Hospital length of stay (day)			6.3±1.1			3.7±0.5	0.001*
Residual defect	0	0		0	0		-
Reoperation for bleeding	1	3.4		0	0		1.000
Infused total blood products (mL)			393.6±519.4			120.3±245.8	0.138
Neurological complication	0	0		0	0		-
Renal failure	0	0		0	0		-
Respiratory failure	0	0		0	0		-
In hospital mortality	1	3.4		0	0		1.000

MS: Median sternotomy; MICS-RAT: Minimally invasive cardiac surgery via right anterior thoracotomy; SD: Standard deviation; * p<0,05: Statistically significant (Pearson's chi square test.

p=0.138). However, the mean mechanical ventilation time (7.0±1.7 h vs. 10.6±2.2 h, respectively; p=0.001) and length of intensive care unit (1.4±0.5 days vs. 2.3±0.5 days, respectively; p=0.001) and hospital stay (3.7±0.5 days vs. 6.3±1.1 days, respectively; p=0.001) were statistically significantly shorter in the MICS-RAT group. In addition, the mean amount of chest tube drainage was statistically significantly

lower in the MICS-RAT group (218.7±92.6 mL vs. 484.5±270.0 mL, respectively; p=0.001) (Table 3).

DISCUSSION

Atrial septal defect closure by conventional surgery provides excellent results with low mortality and morbidity rates.[4] The majority of patients scheduled for ASD closure are often younger, healthier, and more recently, preferring minimally invasive surgical options, as opposed to typical open heart surgery patients. In particular, in young and middle-aged women, the tendency toward these minimally invasive options is more pronounced. Although most percutaneous closure devices have good results, percutaneous closure devices are often indicated for relatively small secundum ASDs, but not for large ASDs, particularly in the presence of insufficient rim or sinus venosus type defects.[5] There is also a risk for cardiac complications such as percutaneous closure device migration, neurological events, systemic and pulmonary venous drainage obstruction, endocarditis, and post-procedural thromboembolic risk.[6] Therefore, we prefer surgical options other than patients who are eligible for percutaneous closure in our hospital.

Some authors have argued that excellent results of conventional surgery are more preliminary than the cosmetic benefit, although excellent results of minimally invasive approaches have been published in the literature.[7] Modified sternotomy techniques are also available options which result in significant scarring and do not reduce the risk of bleeding or complications of conventional sternotomy.[8] In our hospital, only the minimally invasive right anterior mini-thoracotomy is preferred in patients with sequential type ASD for the last three years. As shown in Table 1, there was no significant difference in the preoperative data of the patients between the two groups.

Atrial septal defect closure through median sternotomy is still associated with several disadvantages, despite being the most commonly used technique. Sternal dehiscence and wound infections are the most feared situations. Minimally invasive options seem to be more beneficial due to the lack of such complication risks and the lack of a long period of sternal healing.[9] The benefit of recovery and rehabilitation in the postoperative period is reflected in the duration of intensive care and hospital stay.[10] In our study, the duration of mechanical ventilation, amount of drainage, and length of intensive care unit and hospital stay were found to be statistically significantly shorter in the MICS-RAT group than in the MS group. However, there were no significant differences in bleeding revision, postoperative blood use, and pulmonary or renal dysfunction.

Bleeding, anatomical difficulties with ACC, severe pulmonary adhesions, and intraoperative aortic dissection have been reported in the literature.[11] In our series, there was no conversion to median sternotomy technique for any reason in the MICS-RAT group. Upon the failure of jugular venous cannulation in a planned MICS-RAT patient, venous cannulation of this patient was performed via standard femoral venous cannulation and a selective superior vena cava from thoracotomy incision.

Several complications of femoral cannulation for CPB and extracorporeal membrane oxygenation have been also reported, such as femoral artery injury, lower limb ischemia, wound infection, and lymphocele.[12] In our series, there were no complications such as peripheral ischemia, lymphorrhea, pseudoaneurysm, and wound infection in the MICS-RAT group in the femoral cannulation site.

In our series, similar results were obtained in terms of CPB and ACC time in both groups, and the total operation time was significantly shorter in the MICS-RAT group. We believe that the total incision area to be closed was shorter, the absence of sternal closure in the MICS-RAT group, and the adaptation of the team to the MICS-RAT technique after learning curve was effective in this end.

Nonetheless, there are some limitations to this study. Since we operate only adult patients in our clinic and we use the MICS-RAT technique routinely for the last two years, our sample size was relatively restricted. We also operated sinus venous and inferior cava type defects with median sternotomy, which also limits the sample size. Considering that we complete the learning curve, we plan to perform MICS-RAT technique to sinus venous type ASD patients.

In conclusion, mini-thoracotomy is a safe and useful alternative to median sternotomy following a satisfactory learning curve period with less cost and higher patient benefit. Patients who are treated with minimally invasive techniques are able to return to their daily living activities in a short time of period. Considering that the atrial septal defect operation is relatively simple and the young adult patient group with cosmetic concerns weighs heavily, we believe that it would be appropriate to perform such operations with minimally invasive techniques.

Declaration of conflicting interests

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