

Effects of the transcatheter closure of atrial septal defect on electrocardiographic and echocardiographic parameters six months after the closure

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Abstract

Although percutaneous transcatheter atrial septal defect (ASD) closure (TCC) has been performed on adults for a long time there is limited data about the effects of the procedure in the literature and the majority of studies have been performed on children. The study purposed to evaluate the impact of TCC on cardiac remodeling, electrical changes and exercise capacity in adults. Transthoracic echocardiography and electrocardiography were performed one day before and six months after TCC in 27 consecutive patients who underwent successful TCC. Twenty-seven age and sex matched healthy subjects were used as control group. Right ventricular (RV) diameter (had decreased from 44 ± 6.3 to 34 ± 3.9 ; $p<0.001$), right atrial (RA) diameter (had decreased from 38 ± 5.6 to 34 ± 4.7 ; $p<0.001$), systolic pulmonary artery pressure (sPAP) (had decreased from 38 ± 5.1 to 32 ± 4.3 ; $p<0.001$) and P dispersion (Pd) times (had decreased from 59 ± 9.9 to 45.2 ± 16.3 ; $p<0.001$) significantly decreased in patients with ASD after TCC. However, these parameters obtained after TCC were still higher compared with parameters of healthy controls. There were not significant differences regarding QT dispersion (QTd) times between ASD patients before and after TCC and healthy controls. New York Heart Association (NYHA) functional class of patients with ASD was significantly improved after TCC. The findings of the present study indicate that although TCC leads to significant improvements regarding right heart dimensions and sPAP and Pd values of ASD patients; residual deterioration still persists up to 6 months after the procedure.

Keywords: Atrial septal defect, Percutaneous atrial septal defect closure, p wave dispersion

Introduction

Atrial septal defect (ASD) is one of the most common congenital cardiac malformations in adults [1]. Although most patients with ASD remain asymptomatic until adulthood, early diagnosis and treatment is important because of potential complications, such as atrial fibrillation (AF), right-side heart failure, and pulmonary hypertension [2]. Percutaneous trans catheter closure (TCC) is a safe and effective procedure that is rapidly becoming standard treatment for secundum-type ASD [3]. Right ventricular (RV) volume-loading is reduced and systemic cardiac output is increased after TCC resulting in symptomatic improvement [4]. Although TCC has been performed on adults for a long time there is limited data about the effects of the procedure in the literature and the majority of studies have been performed on children. Moreover, most of the studies did not assess whether the adverse effects of ASD became normalized after the procedure.

In the present study we aimed to evaluate the impact of TCC on cardiac remodeling, electrographic parameters and

exercise capacity in adults. We also aimed to compare these parameters of ASD patients with the ones of healthy controls before and six months after TCC.

Material and Methods

Study Population

Twenty-seven consecutive adult patients with secundum-type ASD who underwent successful device closure and who were free of any exclusion criteria constituted our patient population. Twenty-seven healthy age and sex matched subjects were recruited for control group. Only individuals with normal sinus rhythms were eligible for inclusion. Patients were excluded if they were taking antiarrhythmic drugs, had electrolyte or acid-base disturbances at baseline laboratory work-up, had moderate or severe valvular heart disease and had coronary artery disease. Healthy controls were selected from among individuals admitted to the outpatient clinic for routine check-up that did not have any cardiac or non-cardiac disease, and who had normal physical examination and routine laboratory results.

The investigation conforms to the principles outlined in the Declaration of Helsinki. The study was approved by Inonu University Faculty of Medicine Research Ethics Committee. All participants gave written informed consent.

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Echocardiography and Procedure

Transthoracic echocardiography (TTE) and transoesophageal echocardiography (TEE) were performed using an IE33/Philips echocardiography machine (Philips Medical Systems [Philips Ultrasound], Bothell, WA, USA) and a 5.0 MHz biplanar transoesophageal probe in all patients in three different frames, recorded at the same phase of the cardiac cycle as previously described in detail [5]. The following heart parameters were measured in patients one day before and six months after TCC, and in the healthy controls: left ventricular ejection fraction (LVEF); left ventricular end-systolic diameter (LVESD); left atrium (LA) diameter; interventricular septum (IVS) diameter; left ventricular posterior wall (LVPW) diameter; right atrium (RA) diameter; right ventricle (RV) diameter; pulmonary artery systolic pressure (sPAP); and left ventricular end-diastolic diameter (LVEDD). The procedure was performed under general anesthesia using the Occlutech Figulla ASD Occluder (FSO) (Occlutech, Jena, Germany) with an anesthesiologist, as described previously [5,6]. The ASD size was measured using the balloon occlusive method under TEE monitoring in various positions. Oral aspirin and clopidogrel therapy were initiated one day before the TCC and continued for six months after the TCC.

In addition, the patients were clinically assessed according to New York Heart Association (NYHA) functional classification one day before and six months after TCC.

Electrocardiography

Standard 12-lead electrocardiography was obtained simultaneously using a recorder set at a speed of 50 mm/s and a calibration of 20mV/mm with the patient placed in a comfortable supine position. The electrocardiogram was recorded one day before and six months after the procedure. The P-wave was defined as the distance from the point of the first visible upward or downward departure from the baseline to the return to the baseline. The average P-wave of three consecutive beats from each lead was determined. If the P-wave was measurable in at least nine leads, the patient was kept for further analysis. Maximum P-wave duration (Pmax) was defined as the longest P-wave duration in all derivations and the minimum P-wave duration (Pmin) was defined as the shortest P-wave duration in all derivations. P-wave dispersion (Pd) was defined as the difference between the maximum and minimum P-wave durations from the 12 leads [7]. The QT interval was defined as the interval between the beginning of the QRS complex and the end of the T-wave. QT dispersion (QTd) was defined as the difference between the maximum and minimum of the QT intervals that could be measured in any of the 12 ECG leads. All of the ECG measurements were performed by two researchers who were unaware of the subject data.

Statistical Analyses

All statistical tests were performed with a commercially available statistical analysis program (SPSS 17.0 inc. Chicago, IL, USA). Continuous variables were expressed as mean $\pm$ standard deviation if they were normally distributed or as median (quartiles) when they were not normally distributed. Categorical variables were expressed in ratio. Distribution of data was assessed by using Shapiro-wilk test. Mann-Whitney U test was used to compare continuous variables while chi-square test was used for comparison of categorical variables. Mc Nemar test was used for comparison of NYHA functional class between before and after TCC group. Independent t-tests and paired t-tests were used for between-group comparisons. A p value less than 0.05 was considered statistically significant.

Results

Twenty-seven ASD patients (21 women, six men; mean age 34 ± 12) and 27 age-and-sex matched healthy controls (20 women, seven men; mean age 37 ± 9) were consecutively included in the study. There were no statistically significant differences in body mass index, sex, or age between the patients and the controls. The mean diameter of the ASD was 17 ± 7 mm (range 5–30 mm) and the mean QP/QS ratio was 1.5 ± 0.7 (range 1–3.3). Two (7.4%) of the patients with ASD had a history of a cerebrovascular event.

The RA diameter, the RV diameter, and sPAP were significantly higher in patients with ASD before and after TCC compared with controls. While the RA diameter, RV diameter, and sPAP significantly decreased in the patients with ASD after TCC, they were still significantly higher compared with controls (Table 1).

A comparison of the ECG parameters between the patients and the controls before and after TCC is shown in Table 2. P max, P min and Pd times were found to be significantly longer in the patients before TCC and after TCC compared with controls. Statistically significant reductions were observed for Pmax, Pmin, and Pd times after TCC; however, statistically significant differences between the patients and the controls continued to be observed for these parameters six months after TCC (Table 2). No statistically significant differences between the patients and the controls were observed for QT max, QT min, and QTd times before and after TCC (Table 2).

A significant improvement in the average NYHA functional class was observed in comparison with the baseline in patients with ASD six months after TCC (p 0.03) (Table-1).

Table 1. Comparison of echocardiography parameters and NYHA functional class of controls and patients

	Control group	Before closure	After closure
LV end diastolic diameter (mm)	46.5±2.9	44±3.4	44±3.5
LV end systolic diameter (mm)	28.2±2.8	26±3.4	26±3.3
LA diameter (mm)	32.4±2.9	34±4.2	34±3.9
LV ejection fraction (%)	65.1±3.8	64±4.2	64±4.8
Interventricular septum (mm)	9.7±0.9	9.3±0.9	9.3±0.9
Posterior wall (mm)	10.0±0.9	9.3±0.8	9.3±0.9
RV end diastolic (mm)	35.9±2.6 [†]	44±6.3 ^{††}	40.2±2.2 ^{†††}
RA diameter (mm)	27.1±3.4 [†]	38±5.6 ^{††}	34±4.7 ^{†††}
Systolic PAP (mmhg)	25.9±3.7 [†]	38±5.1 ^{††}	32±4.3 ^{†††}
NYHA n (%)			
1		4(14.8%)	10(37%) ^{†††}
2		23(85.2%)	17(63%) ^{†††}

Data presented as mean ± SD

LV: Left ventricle, LA: Left atrium, RV: Right ventricle, RA: Right atrium. [†]P < 0.001 between control group and before closure; ^{††}P < 0.001 between before and after closure; ^{†††}P < 0.001 between after closure and control group. Independent and paired t-tests were used

^{††††}P: 0.03 between before and after closure group Mc Nemar test was used.

Table 2. Comparison of electrocardiography parameters of controls and patients

	Control group	Before closure	After closure
Heart Rate (bpm)	75.2±9.1	76.7±7.5	74.7±7.8
P maximum (ms)	62.9±15.3 [†]	101.9±12.4 ^{††}	90.1±13.4 ^{†††}
P minimum (ms)	38.5±12.8 [†]	42.8±10.7 ^{††}	42.4±8.3 ^{†††}
P dispersion (ms)	24.4±12.3 [†]	59±9.9 ^{††}	45.2±16.3 ^{†††}
QT maximum (ms)	359±28.9	363±30.8	362.2±38.8
QT minimum (ms)	327.2±26.2	324.6±7.1	329.1±34
QT dispersion (ms)	32.2±12.2	38.8±12.3	33.2±16.9

Data presented as mean ± SD Bpm: Beats per minute

[†]P < 0.001 between control group and before closure; ^{††}P < 0.001 between before and after closure; ^{†††}P < 0.001 between after closure and control group. Independent and paired t-tests were used.

Discussion

The main finding of the present study is that TCC leads to significant improvements regarding right heart dimensions and sPAP and Pd values of ASD patients; however, residual deterioration still persisted up to 6 months after the procedure. There were no significant differences regarding parameters reflecting left heart functions between patients with ASD and healthy controls. Likewise, there were no significant differences regarding left atrial and left ventricular dimensions and LVEF values of patients before and after the procedure.

It is well known that long-standing RV volume overload due to left-to-right shunt in the course of ASD leads to some morbidities, such as right-side heart failure, supraventricular arrhythmia, and ischemic events [2,8]. Patients with ASD have increased RA and RV diameters and increased SPAP compared with healthy individuals, and this was also observed in the present study. The fundamental objectives of ASD treatment are to eliminate left-to-right shunt, reverse geometric change due to volume overload, and prevent ischemic events. Trans catheter ASD closure can achieve these purposes by remodeling the right side of hearts, improving functional capacity, and reducing pulmonary artery pressure [9]. Monfredi et al [10] reported immediate sustained benefits on multiple

echocardiographic parameters reflecting right heart functions and dimensions in patients with ASD after TCC. Although the RV and RA diameters and SPAP significantly decreased after TCC, these parameters were still significantly higher compared with controls 6 months after the procedure in our study. Similar to our findings, previous studies have demonstrated that although dilation of the right side of the heart may be reversed for up to five years following TCC, residual RA and RV enlargement may still persist after successful procedure [11,12].

P-wave dispersion is a useful and noninvasive predictor of AF and supraventricular arrhythmias [13]. It is known that Pd is prolonged in patients with ASD. AF/flutter is the most important problem in adult patients with ASD. The reasons for the increased incidence of arrhythmias and AF/flutter may be explained by RA stretch and dilation due to left-to-right shunt in these patients [7,14]. In the present study, we observed a significant reduction in Pd six months after TCC, but post-procedure Pd of patients with ASD was still prolonged compared with Pd of healthy controls. Similar to our findings, Fang et al [13]. reported a reduction in Pd after TCC; they also found Pd was still prolonged despite the closure of ASD. These observations might be explained by the fact that, despite the correction of ASD, residual right enlargement persisted in some patients and many years are needed for complete reverse

remodeling of the right side of the heart [14,15]. Previous studies have reported that QTd increases various types of cardiovascular diseases, such as myocardial infarction, heart failure, and cardiomyopathy, and it can predict cardiac events and arrhythmias [16]. Santoro et al [17]. showed that QTd decreased in pediatric and adult patients with secundum-type ASD one month after TCC. Similarly, Kaya et al [9]. found that QTd decreased in pediatric and adult patients two years after TCC. However, neither of these studies used control group. In our study, QTd was found to be increased in patients with ASD compared with controls before TCC, however the significance failed to reach statistical significance at a borderline value ($p=0.06$). It may be suggested that the significance might have been statistically significant if more patients had been enrolled into study. In contrast to Santoro et al. and Kaya et al., we did not find a significant QTd decrease after TCC. The cause of discrepancy is not clear, however, heterogeneity regarding the demographic characteristics of the study populations and follow-up periods might have contributed to inconsistent results.

Clinical improvement in exercise capacity of patients with ASD after TCC has also been shown in previous studies in accordance with our findings. However, NYHA functional class was still 2 for 17 (63%) patients despite the successful closure six months after TCC in our study. Giardini et al [12]. evaluated exercise capacity using a cardiopulmonary exercise test before TCC and six- and >36 months after closure. They reported improvement in exercise capacity at six months after closure; moreover, exercise capacity became normal for the majority of patients (79%) three years after closure.

The major limitation of the present study is small sample size and short follow-up period. We did not monitor the incidence of AF/flutter and ischemic stroke, which is the main cause of morbidity and mortality in patients with ASD. In addition, we only evaluated RV and LV function using two dimensional echocardiography; we did not use other advanced echocardiographic techniques, such as speckle tracking and three-dimensional echocardiography.

In conclusion, the findings of the present study indicate that although TCC leads to significant improvements regarding right heart dimensions and sPAP and Pd values of ASD patients; residual deterioration still persist up to 6 months after the procedure.

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