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Original Article

Comparison of the Tricuspid Valve Function with or without Tricuspid Valve Detachment in Closure of Ventricular Septal Defect VSD Closure with Tricuspid Valve Detachment

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ABSTRACT

Objective: Ventricular septal defect (VSD) is defined as a defect in the interventricular septum. It is the second most prevalent congenital heart disease following bicuspid aortic valve and makes up 5% of congenital heart diseases. Although most VSDs tend to close on their own in the first year of life, larger defects should be percutaneously or surgically closed to prevent right ventricular strain and right ventricular failure. Considering the frequency of the procedure, a safe and effective closure without tricuspid valve and atrioventricular node injury is vital.

Methods: We retrospectively included 165 patients with a diagnosis of VSD who underwent surgical closure. Depending on the excised leaflet of the tricuspid valve, the patients were divided into two groups: 86 patients (Group 1) had their anterior leaflet excised, while 79 patients (Group 2) had their posterior leaflet excised. The diagnosis was based on the results of preoperative catheter angiography and echocardiography. Echocardiography was repeated on the 1st week, 1st month, and 6-12th month to evaluate postoperative residual VSD and postoperative tricuspid regurgitation.

Results: The aortic cross-clamp time, cardiopulmonary bypass time, duration of intubation, length of stay in intensive care unit and hospital, postoperative residual VSD, postoperative tricuspid regurgitation, and postoperative morbidity and mortality were evaluated in patients in Groups 1 and 2. Tricuspid regurgitation or dysfunction was not detected in any group. Furthermore, no other parameters differed between two groups.

Conclusion: Our study has shown that elaborate tricuspid leaflet incision for adequate visualization allows a safe and effective closure of VSD.

Keywords: Ventricular septal defect, tricuspid valve, tricuspid regurgitation

INTRODUCTION

Ventricular septal defect (VSD) is the most common congenital heart defect after bicuspid aortic valve, and it is seen at 2-6 per 1,000 live births.[1] VSDs are likely to close spontaneously in the first year of life. However, since larger defects will cause excessive volume burden to the lungs and right heart failure, treatment of these defects is often surgical.[2]

The main point in VSD surgery is the safe and complete closure of the defect without damaging the tricuspid valve and atrioventricular node. Therefore, sufficient surgical field of vision is required to ensure a successful closure.[3] Retraction of the tricuspid valve may be sufficient, but the retraction procedure alone is insufficient for a clear assessment of the boundaries and relationships of some defects, resulting in a lower chance of surgical success.[4] Excessive retractions of the tricuspid valve for maintaining surgical vision can cause injury to the leaflets and/or cordal structures.[5] In order to avoid injury, reveal the true limits of the defect, and ensure successful closure, incision of the tricuspid valve leaflets in the radial and circumferential style is preferred.[6–9]

In this study, we aimed to compare the results of tricuspid valve functions at the post-operative period in patients with the diagnosis of isolated VSD, who have or have not undergone tricuspid valve leaflet detachment procedure by radial and circumferential incision in our clinic between 2007 and 2015.

METHODS

In the Department of Cardiovascular Surgery of Gaziantep University Faculty of Medicine Şahinbey Practice and Research Hospital, 165 patients diagnosed with VSD and surgically closed VSD were retrospectively examined between the years of 2007 and 2015. In patients operated in Group 1, VSD was

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Table 1. Preoperative Catheter, Preoperative Echocardiographic Values and Anatomical Location of VSD

	Group 1	Group 2	*P*
PAB (mmHg) (ÇN: terimlerin İngilizce versiyonları gelecek PAP gibi)	30 ± 2.08	29 ± 2.18	>.05
QP/QS	3.7 ± 1.98	3.9 ± 1.68	>.05
EF (%)	65.7 ± 2.08	63.1 ± 1.5	>.05
FK (%)	45.2 ± 1.65	43.0 ± 1.36	>.05
LVH (mL)	22.6 ± 4	21.6 ± 1.77	>.05
LVEDD (mm)	31.3 ± 1.2	30.2 ± 1.3	>.05
LVESD (mm)	12.9 ± 1.18	15.3 ± 1.08	>.05
Perimembranous outlet VSD	76	65	>.05
Perimembranous inlet VSD	4	5	>.05
Muscular outlet VSD	3	2	>.05
Muscular trabecular VSD	2	1	>.05
Subarterial VSD	1	6	>.05

operated by separating tricuspid valve leaflets, and in Group 2, VSD was directly closed. All patients in Groups 1 and 2 were operated by the same surgical team. Intensive care and inpatient follow-up of the patients were also performed by the same surgical team. Ethics committee approval was received for this study from the ethics committee of Gaziantep University Faculty of Medicine Sahinbey Practice and Research Hospital (18.05.2015-2015/167).

Surgical Technique

All patients were operated under general anesthesia. The patient's skin was encased by sterile covering after surgical cleaning and prepared for the operation. Median sternotomy was performed. Following bicaval and aortic cannulation, a cross-clamp was placed and cardiac arrest was achieved using crystalloid cardioplegia. Moderate hypothermia (32-34°C) was achieved in all patients. VSD was closed by right atriotomy in 158 patients by pulmonary artery way in three patients and by transaortic way in four patients. VSDs were closed using Dacron patch material or autologous pericardial patch material fixed with gluteraldehyde. When closing VSDs, 5/0 or 6/0 prolene suturing and continuous suture technique were used in all patients. In patients where the tricuspid anterior-septal leaflet was cut prior to VSD closure, the circumferential incision was repaired using the continuous suturing method, and the radial septal incision was repaired using the interrupted suture technique with 6/0 prolene sutures. In order to understand the tricuspid leak after the procedure, pulmonary artery occlusion right ventricle was filled quickly with SF by using a 50 cc syringe, and it was evaluated whether there is any leak or not. The right atrium was closed with two rows of prolene sutures using a continuous suture technique, and the aortic cross clamp was removed. After warming up and air removal procedures, the patient was separated from cardiopulmonary-bypass. After controlling bleeding, pacemaker wires and chest drainage tubes were placed, and the operation was terminated by closing the layers according to the anatomy.

Main Points

- Ventricular septal defect is the most common congenital heart defect after bicuspid aortic valve, and it is seen at 2-6 per 1000 live births.
- In our study, no statistically significant difference was found between the two groups in terms of tricuspid regurgitation.
- The results of the surgical applications performed by separating the anterior and the septal leaflet either circumferentially or radially are close to perfection.

The Statistical Package for the Social Sciences (SPSS Inc.; Chicago, IL, USA) program was used for statistical calculations. For parametric variables, two independent group comparisons, student t test, and nonparametric variables Mann–Whitney U test were performed. Results with $P < .05$ were interpreted as statistically significant. In cases where both variables are categorical, Chi-square, Fisher's exact, or Mantel–Hansel chi-square tests were performed, and again $P < .05$ was interpreted as statistically significant.

RESULTS

Preoperative echocardiographic examination revealed no significant aortic insufficiency in both the groups. Preoperative echocardiography revealed no tricuspid insufficiency in Group 1, and five patients with moderate tricuspid insufficiency in Group 2. There was no statistical difference when both the groups were evaluated in terms of preoperative echocardiographic features. Also, when preoperative catheter findings of both the groups were compared, no statistically significant difference was found (Table 1). When we look at the location of

Table 2. Cardio-Pulmonary By-pass Time, Aortic Cross Clamp Time, Extubation Time of the Patients According to the Groups, Intensive Care Time, Chest Tube Length of Stay, Post-surgery Hospitalization Time, and Post-Operative Echocardiography Values of the Patients

	Group 1 (mean ± SD)	Group 2 (mean ± SD)	*P*
CPB (minute)	74.7 ± 11.2	72.3 ± 12.3	>.05
ACC (minute)	52.3 ± 9.7	44.5 ± 12.1	>.05
Intubation (hour)	7.9 ± 3.6	8.2 ± 2.94	<.05
Intensive care times (day)	1.8 ± 0.23	1.7 ± 0.48	>.05
Chest tubes length of stay (day)	1.4 ± 0.27	1.9 ± 0.14	>.05
Discharge time (day)	5.75 ± 1.87	6.58 ± 0.77	>.05
Postoperative ECO EF (%)	60.8 ± 8.71	64.76 ± 8.23	>.05
FK (%)	29.7 ± 6.3	30.1 ± 5.8	>.05
LVH (mL)	18.2 ± 10.7	17.5 ± 8.59	>.05
LVEDD (mm)	24.3 ± 6.13	22.8 ± 5.7	>.05
LVESD (mm)	16.7 ± 3.3	14.6 ± 4.81	>.05

VSD, there was no statistically significant difference between the two groups (Table 1).

No statistically significant difference was found between the patients in both the groups in terms of cardiopulmonary bypass and aortic cross-clamp times (Table 2).

When the average extubation time, length of stay in the ICU, duration of the chest drainage tubes, and length of hospital stay were compared, there was no statistically significant difference between the two groups (Table 2).

When both the groups were compared in terms of A-V full block, there was no statistically significant difference between the two groups ($P > .05$). In both the groups, deep wound infection and mediastinitis were not observed in the post-operative period. There was no early mortality in either group.

There was no statistically significant difference in the echocardiographic examinations performed in the first post-operative period, when both th were compared (Table 2). In both the groups, no aneurysm formation on the patch placed on VSD that is narrowing the ventricular outflow tract was observed.

The mean follow-up time of the patients was 23 ± 7.19 months in Group 1 and 21.3 ± 5.64 months in Group 2. When the groups were compared in terms of residual ventricular septal defect, there was no statistically significant difference between the two groups, and residual ventricular septal defects were hemodynamically insignificant.

In final post-operative echocardiographic examinations, mild tricuspid regurgitation was detected in three patients in Group 1 and five patients in Group 2. There were no patients with severe insufficiency. No statistically significant difference was found between the two groups in terms of tricuspid regurgitation. At the follow-up period, infective endocarditis was not detected clinically and echocardiographically in both the groups.

DISCUSSION

Considering that VSD is the second most common disease among congenital heart defects is seen with other congenital heart defects, or is a component of some congenital malformations, it can be said that its incidence is gradually increasing. While the incidence is so high, it is important to close the defect safely and completely without any damage to the tricuspid valve or A-V node.

Most VSDs tend to close spontaneously in the first year of life, and this rate draws a curve that decreases with age from the first months. Other than spontaneous closure, invasive closure is preferred in VSD treatment. Although some of the VSDs have been successfully closed with transcatheter or hybrid approaches thanks to the advances in invasive cardiology in recent years, many centers still prefer transcatheter methods in muscular defects or in closing post-operative residual defects, especially due to the high A-V full block and aortic valve injury rates that appear after VSD closure, and surgical treatment is still the most commonly used method of VSD closure.

Patch material is often used when closing VSD, and very small defects can also be closed primary. The most commonly used patch materials during VSD closure are synthetic materials. Dacron material is used most frequently among synthetic materials, and polytetrafluoroethylene (PTFE) used secondly.

As the closure of residual VSDs is delayed in the post-operative period, patients are at risk for infective endocarditis and

continued pulmonary overload. At the same time, due to excessive pulling motion to increase the surgical field of vision during the closure of VSD, tricuspid insufficiency, right atrial dilatation, atrial arrhythmias, and right heart failure may occur due to tricuspid valve and chorda damage. It is very important to observe the exact defect boundaries and neighborhoods during the VSD closure to avoid the occurrence of residual defect, tricuspid valve, and A-V node damage.

In 1962, Hudspeth et al.[7] described the incision or partial detachment of the tricuspid valve to provide sufficient visibility during VSD closure. In this publication of the authors consisting of eight patients, the tricuspid valve was removed from the annulus with a circumferential incision, thereby demonstrating an increased visibility.

Gaynor et al.[6] separated the tricuspid valve from the annulus by making a circumferential incision along the tricuspid anterior and septal leaflet and reported that after this procedure, tricuspid insufficiency, rhythm problems, and residual defect have not been occurred. They also stated that there was no statistically significant difference in terms of cardiopulmonary bypass time, aortic cross-clamp time, and post-operative hospital stay. They also emphasized that in the group in which the tricuspid valve was removed, the rate of reoperation was lower than in the other group, and the tricuspid regurgitation (TR) rate was minimal in the group where the tricuspid valve was removed, but in the other group, six patients had moderate tricuspid regurgitation. In the literature, there are similar results from different centers.[10–13] In their study, Kapoor et al. described a technique in which they performed a chordal detachment from the septum and performed a cordal reimplantation after closing the defect; as a result, they detected residual VSD in only one patient and did not provide any information about TR. However, there are no long-term results regarding this technique, and we think that severe tricuspid valve deficiency will occur in the case of detachment after cordal reimplantation of the septum.[11]

Bol-Rapp et al. applied tricuspid detachment to 39 of 149 patients and showed that the cross-clamp time was slightly longer than the other group. In addition, reoperation was performed due to residual VSD in a patient who did not underwent detachment procedure.[10]

In the 215 case series with isolated VSD, Scully et al.[12] reported that they performed retraction to see the defect limits clearly in the majority of patients, but if they could not see this limit clearly, separating the septal and/or anterior leaflet from the annulus is a very useful technique to see the defect limits.

Russell et al. claim that VSD closure with detachment has very successful results, with very low residual VSD, heart block, or tricuspid regurgitation.[13]

In the 600-patient case series published by Zhao et al., they applied tricuspid valve detachment to 122 patients.[14] They stated that there was no difference between the two groups in terms of total bypass time and aortic cross-clamp time, and in their study, it has been observed that while there were three patients with heart block, 10 patients with residual VSD, and 12 patients with first degree TR in group without detachment procedure, there was only insignificant TR in nine patients in the detachment group.

In the current publications, approximately 25-50% of surgeons make a tricuspid valve incision.[14] In our opinion, the most important concern in this regard is the tricuspid regurgitation that may occur in the post-operative period. Therefore, which patient should have detachment procedure depends on the location of the defect, the valve and chorda structure, and other intracardiac anatomical variations, and most importantly the surgeon's experience.

In our series, there is no statistically significant difference between the group in which the detachment process is applied and the other group in terms of results, and these results are parallel with the literature.

There are numbers of publications related to septal leaflet detachment; in the series of 33 patients who underwent the anterior leaflet separation procedure published by Maile et al., only one patient who they continued to follow had a residual defect, one patient had complete block, and two patients had right bundle branch block.[15]

All these studies are nonrandomized and retrospective. Therefore, patients do not have long-term follow-up echoes.

CONCLUSION

In VSD closure operation, which is the most common pediatric cardiac surgery operation, the important thing is to make the correct surgical timing. Consensus should be provided between the pediatric cardiologist and surgeons for both catheter closure and timing of surgical closure. The results of the surgical applications performed by separating the anterior and the septal leaflet either circumferentially or radially are close to perfection, and as stated earlier, the determining factors in success of these procedures are the well-known intracardiac anatomy and the correct evaluation of the echo and catheter findings, and successful results will continue in line with the increased surgical experience. In our retrospective and nonrandomized study, the data that we obtained could contribute to the circumferential and radial tricuspid valve detachment surgery method. We believe that it can be more meaningful and useful after results of further prospective and randomized studies.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gaziantep University Faculty of Medicine Şahinbey Practice and Research Hospital (18.05.2015-2015/167).

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