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Comparison of Continuous and Interrupted Suturing Techniques in Ventricular Septal Defect Closure

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ABSTRACT

Background: Our goal is to evaluate postoperative outcomes of continuous versus interrupted suturing techniques in ventricular septal defect (VSD) closure surgery.

Methods: The study included 286 patients with isolated VSD who underwent VSD closure surgery between June 2010 and April 2017. VSD closure was performed by using the interrupted suturing technique in group 1 (n = 74, 25.9%) and the continuous suturing technique in group 2 (n = 212, 74.1%). The groups were compared in terms of mortality and rates of clinical morbidities such as infection and complete atrioventricular (AV) block.

Results: Early mortality occurred in 3 cases in group 1 (4.0%) and 5 cases in group 2 (2.3%). There was no late mortality in either group. One patient from both groups required extracorporeal membrane oxygenation (ECMO) at postoperative 48 hours. Five patients in group 1 (6.8%) and 11 patients in group 2 (5.2%) developed complete AV block postoperatively and received permanent pacemaker implants.

Conclusion: Complication rates were similar between the patient groups operated on by using continuous and interrupted suturing techniques in our study, suggesting that neither technique is superior for VSD closure surgery.

INTRODUCTION

Ventricular septal defect (VSD) is the most common congenital heart disease, with an incidence of approximately 0.34-2.68 in 1000 live births [Hoffman 2004; Bahtiyar 2008]. It represents 20%-30% of cardiac anomalies [Grabitz 1988]. The defect closes spontaneously within the first month of life in 80% of patients [Bol Raap 2007]. VSD may be isolated, or concurrent with other cardiovascular anomalies.

The first successful surgical repair of VSD was reported in 1957 [Stirling 1957]. Surgery is the definitive treatment, and the mortality rate has now been reduced to less than 2% as a result of accurate diagnostic methods, improved surgical techniques, myocardial protection during surgery, and improved postoperative care in the intensive care unit (ICU) [Tucker 2007; Anderson 2013].

Currently, the most commonly used surgical method is VSD closure via the transatrial approach, in which the defect is reached through the tricuspid valve by following a right atriotomy. The interventricular septum may be closed either by primary repair or by use of an autologous pericardium patch [Caimmi 2010]. However, primary closure of VSD by directly suturing the defect without using a patch is an obsolete practice.

The use of interrupted versus continuous suturing techniques when applying the patch is considered a matter of surgeon preference. However, potential differences in postoperative outcomes of the 2 techniques would be grounds for standardizing the practice among surgeons. In the present study, we sought to compare the mid-term postoperative mortality and morbidity outcomes of VSD closure surgery performed with continuous and interrupted sutures in our clinic.

METHODS

Patients with congenital VSD who underwent closure surgery in our center between June 2010 and April 2017 were identified by using the hospital database.

VSD pathologies were grouped as perimembranous inlet, perimembranous outlet, perimembranous trabecular, muscular, and doubly committed, according to the modified classification described by Anderson et al [Tynan 2002]. The techniques used for VSD closure were interrupted suture technique (group 1) and continuous suture technique (group 2).

Medical records were retrospectively reviewed for all patients. Variables collected included age, weight, cardiac diagnosis, primary cardiac surgical procedure, and other demographic data. In addition, we also noted operative and postoperative data such as the type of surgery performed, overall surgery duration, cardiopulmonary bypass (CPB) and cross-clamp times, lengths of ICU and hospital stays, and any surgery-related complications such as arrhythmia, residual VSD, sepsis, or low cardiac output.

Patients with complex cardiac anomalies (transposition of great arteries, atrioventricular septal defect, etc.), those with history of previous pulmonary banding due to multiple VSD or tetralogy of Fallot, and those with previous VSD closure surgery were excluded from the study.

Surgical Technique

In all cases, arterial cannulation was performed through the ascending aorta, and venous cannulation was performed by

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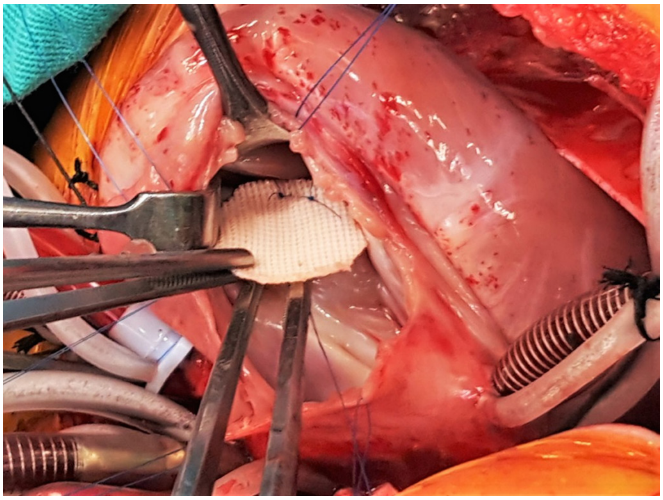

Figure 1. Interventricular septal defect closure was performed by using interrupted sutures.

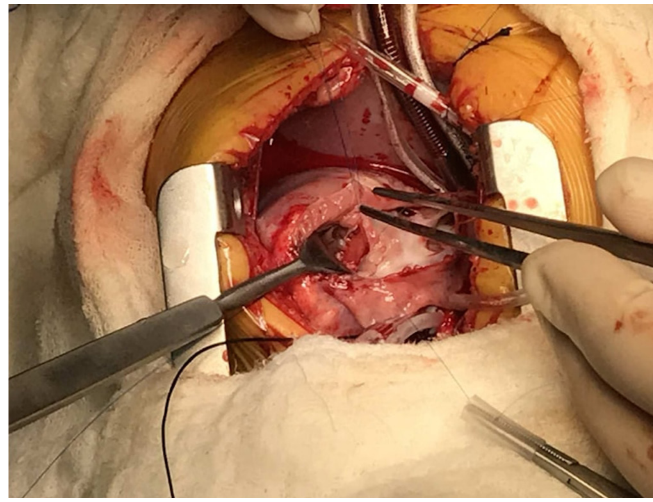

Figure 2. Interventricular septal defect was performed by using continuous sutures. The part of the VSD neighboring the septal leaflet of the tricuspid valve was repaired by using continuous sutures.

placing 2 cannulae through the superior–inferior vena cava after standard median sternotomy. The aorta was clamped under hypothermic CPB, and the operation was performed with total bypass following diastolic cardiac arrest. Myocardial protection was achieved with methods including intermittent antegrade isothermic blood cardioplegia, intermittent antegrade +4°C blood cardioplegia, and Custodiol® HTK Solution, (Essential Pharmaceuticals, LLC, Durham, NC, USA). The left atrium was vented through the patent foramen ovale (PFO) in 167 patients (58.4%) and through a right upper pulmonary vein in 119 patients (41.6%) for the purpose of decompression. The total circulatory arrest was not required in any of the cases. The primary method to access the VSD was through right atriotomy. In 3 patients, the VSD could not be adequately visualized despite retraction of the tricuspid valve, so access to the VSD was achieved by separating the septal leaflet of the tricuspid valve from the annulus. After defect closure, the septal leaflet was sutured back to the annulus by using 6-0 polypropylene material. None of the cases required a transaortic or transpulmonary approach or a right ventriculotomy. The cases were grouped according to the surgical suturing technique. Autologous pericardium was the preferred patch material for defect closure, with synthetic patches (Dacron) used in patients with insufficient autologous material.

The closure of the VSD was performed with interrupted sutures in group 1 (Figure 1), and with continuous sutures in group 2 (Figure 2). No pledgets were used in either technique. The suture technique was chosen according to surgeon preference. In 2 cases from group 2, the segments of the VSD neighboring the septal leaflet of the tricuspid valve were repaired by using interrupted sutures with pericardium pledgets because of septal leaflet tissue deficiency (Figure 3), whereas continuous sutures were used in the rest of the patients (Figure 2).

In 140 cases, PFO accompanying the VSD was repaired primarily. Atrial septal defect (ASD) accompanying VSD was repaired primarily in 58 cases and closed with pericardial patch in 16 cases. Before closure of the right atriotomy, the tricuspid valve was tested by filling the right ventricle with saline. None of the patients required any intervention to the tricuspid valve. The presence of aortic valve or tricuspid regurgitation and residual VSD was evaluated with either transesophageal echocardiography (TEE) for patients weighing more than 5 kilograms, and with transepicardial echocardiography for patients weighing less than 5 kilograms to prevent esophageal damage by the TEE probe. After termination of CPB, none of the cases required additional interventions. Transthoracic echocardiography performed prior to the operation revealed patent ductus arteriosus (PDA) with persistent flow in 8 patients. The PDA was ligated in these patients after initiating CPB and before clamping the aorta.

Follow-up

All the patients attended outpatient follow-up visits at postoperative 1, 3, and 6 months, then at 6-month intervals for 2 years, then yearly for a maximum of 6.3 years. Each follow-up visit included clinical examination, electrocardiogram, and echocardiogram.

Statistics

Statistical analyses were performed with IBM SPSS Statistics for Windows, Version 20.0 (released 2011; IBM Corp., Armonk, NY, USA) software. Descriptive statistics were expressed as mean ± standard deviation for continuous variables, and as percentage and count for categorical variables. Normality of the data distributions were assessed by using the Kolmogorov-Smirnov test, and based on this result, group means were compared with either the Student t test or the Mann-Whitney U test. Comparisons of categorical variables were made with chi-square and Fisher exact tests. $P < .05$ was accepted as statistically significant.

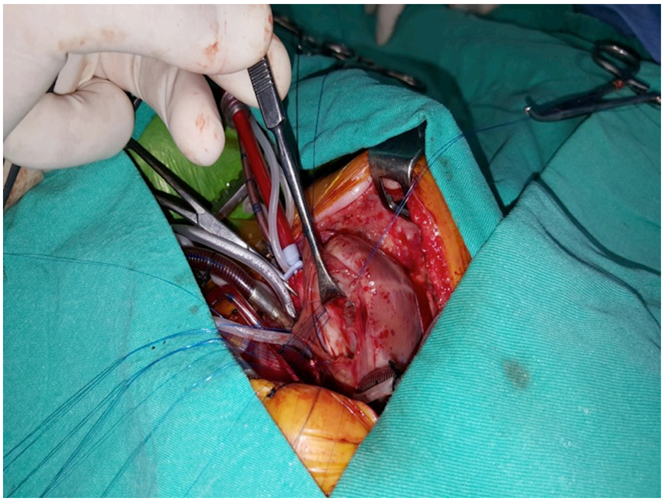

Figure 3. Interventricular septal defect was performed using continuous sutures. In 2 cases from Group 2, the segments of the VSD neighboring the septal leaflet of the tricuspid valve were repaired using interrupted sutures with pericardium pledgets because of septal leaflet tissue deficiency.

Table 1. Demographic Data of the Patients*

Variables	Group 1 (n = 74)	Group 2 (n = 212)	*P*
Age, mo, median (maximum-minimum)	3 (0.1-36)	4 (0.2-40)	NS
Age, n (%)			
<6 months	14 (4.9)	34 (11.9)	NS
6-18 months	45 (15.8)	166 (58.0)	NS
18-36 months	14 (4.9)	11 (3.8)	NS
>36 months	1 (0.3)	1 (0.3)	NS
Weight, kg, median (maximum-minimum)	8 (2-45)	7.1 (3-50)	NS
Sex, n (%)			
Male	47 (16.4)	114 (39.9)	NS
Female	27 (9.4)	98 (34.3)	NS
Genetic syndrome, n (%)			
Trisomy 21	12 (4.2)	35 (12.2)	NS
Trisomy 18	1 (0.4)	2 (0.9)	NS
No	61 (21.3)	175 (61.1)	NS
VSD type, n (%)			
Perimembranous inlet	32 (11.1)	89 (31.1)	NS
Perimembranous outlet	22 (7.7)	75 (26.2)	NS
Perimembranous trabecular	11 (3.8)	21 (7.3)	NS
Muscular	5 (1.7)	16 (5.6)	NS
Doubly committed	4 (1.4)	11 (3.8)	NS

*NS Nonsignificant.

RESULTS

A total of 286 patients met the study inclusion criteria. VSD closure was performed by using interrupted sutures in 74 patients (25.9%; group 1) and continuous sutures in 212 patients (74.1%; group 2). There were 161 (56.3%) male and 125 (43.7%) female cases, and the median age was 10 months (range, 3 months–8 years). Seventy-nine patients (27.6%) were younger than 6 months. VSD types detected were perimembranous inlet (121 patients, 42.3%), perimembranous outlet (97 patients, 31.1%), perimembranous trabecular (32 patients, 11%), muscular (21 patients, 7.3%), and doubly committed (15 patients, 5.2%). The demographic characteristics of the patients as well as their complaints upon admission and preoperative clinical findings are shown in Table 1. There were no significant differences between the groups in all parameters.

Concomitant cardiac pathologies diagnosed with VSD included ASD in 74 patients (25.9% overall; 31 [10.8%] in group 1, 43 [15.1%] in group 2) and PDA in 8 patients (2.8% overall; 4 patients [1.4%] each in groups 1 and 2).

Operative characteristics including lengths of ICU and hospital stays, mean follow-up time, CPB and aortic clamp times, and patch materials used are presented in Table 2. There were no significant differences between the groups in any of these parameters. In group 1, one patient died in the hospital on postoperative day 7 because of sepsis. Together with 2 deaths during outpatient follow-up, the total mortality rate in group 1 was 4.0% (n = 3). Five patients in group 2 died, one in hospital because of low cardiac output at postoperative 24 hours and 4 during outpatient follow-up, resulting in a mortality rate of 2.3%. There was no statistically significant difference in mortality between the 2 groups (*P* = .43).

Five patients in group 1 (6.7%) and 11 patients in group 2 (5.1%) developed complete AV block that required a permanent pacemaker (*P* = .569). Intraoperative echocardiographic monitoring following CPB termination revealed residual VSD with a 2-dimensional diameter of 3 mm or less in 6 patients from group 1 (8.1%) and 27 patients in group 2 (12.7%) (*P* = .466). Clinical problems were not anticipated from these defects, so no additional intervention was performed. Two patients from group 1 (2.7%) and one patient from group 2 (0.4%) who did not have significant residual VSD in perioperative or early postoperative assessments developed VSD with a diameter of 5 mm or greater during follow-up. These patients underwent reoperation in which the defects were repaired by using the same method but also by replacing the old patches (*P* = .165). During inpatient follow-up, 2 patients from group 1 (2.7%) and 3 patients from group 2 (1.4%) developed wound site infections (*P* = .607). These patients were treated by applying wound care with wet dressing. None of the patients required vacuum-assisted closure (VAC) therapy. After showing improvement in infection parameters, the wound sites were closed surgically in all cases. Of the 3 patients whose VSD was repaired by separation of septal leaflet, only one was found to have residual mild tricuspid regurgitation in predischarge examination. According to the New York Heart Association classification, 95.1%

Table 2. Operative Characteristics

Variable	Group 1*	Group 2*	P
Bypass time, min	85.2 ± 20.0	94.7 ± 33.8	.800
Aortic cross-clamp time, min	57.0 ± 15.3	61.6 ± 23.7	.356
Pericardium patch/Dacron patch	58/16	179/33	.282
ICU time, h	58.3 ± 33.4	53.4 ± 23.9	.568
Hospital stay, d	9.8 ± 5.9	9.4 ± 10.0	.604
Reoperation	2 (2.7)	1 (0.4)	.165
Wound infection	2 (2.7)	3 (1.4)	.607
Transient heart block	4 (5.4)	27 (12.7)	.081
Permanent heart block (pacemaker placed)	5 (6.7)	11 (5.1)	.569
Extracorporeal membrane oxygenation (ECMO)	1 (1.3)	1 (0.4)	.137
Death	3 (4.0)	5 (2.3)	.431

*Data are given as mean ± SD, n/n, or n (%).

of the patients had Class I functional capacity, and 4.9% of the cases had Class II functional capacity during follow-up. None of the patients in the pediatric age group showed growth retardation.

During follow-up, aneurysmal changes in the pericardial patch with no hemodynamic disorder was diagnosed in 4 patients from group 2 by echocardiographic studies.

DISCUSSION

This study compared the outcomes of VSD closure using interrupted versus continuous suturing techniques performed in a new cardiac center in terms of mortality, permanent complete AV block, infection, and similar clinical morbidities. The 2 methods yielded statistically comparable rates of VSD closure and complications. Our study is one of the few in the literature to focus on this topic.

The treatment modality utilized to repair VSD can influence late postoperative morbidity and mortality. The most frequently preferred approaches are the transatrial and right ventriculotomy. Because clinical-experience knowledge has progressed, the transatrial approach can be performed more conveniently without the need for right ventriculotomy, which can lead to adverse effects in the long term [Erdil 2000; Mercan 2001]. Although the majority of surgical VSD closures are performed via the transatrial route, it may be necessary to separate the tricuspid septal leaflet from the annulus to provide adequate visualization during surgery in perimembranous (inlet, outlet, and trabecular) defects [Tatebe 1995; Gaynor 2001]. In 3 of our patients (1.1%), we gained access to the VSD by separating the septal leaflet of the tricuspid valve because VSD closure was not possible via the transatrial route. The major disadvantage of this method is that valvular functions may be impaired after the septal leaflet is reimplanted in its previous position, leading to tricuspid regurgitation. Although some surgeons argue that VSD can be closed safely with this method without causing tricuspid regurgitation or AV block, we believe that it is safer to avoid this technique and that adequate retraction of the septal leaflet should be sufficient for closure of VSD [Pridjian 1993; Gaynor 2001].

In patients with doubly committed VSD who also have aortic regurgitation, VSD closure alone may not be sufficient. Aortic regurgitation may progress over time and require reoperation in the future [Sim 1999]. For this reason, it is beneficial to evaluate the aortic valve intraoperatively.

Atrioventricular block is very rarely reported in recent case series [Anderson 2013]. This can be attributed to advances in surgical techniques over the years and to attention to localize and avoid damage to the conduction pathway. In the present study, we did not find a statistically significant difference between the suturing techniques in rates of AV block ($P = .569$).

There is currently no ideal patch material for VSD closure. Autologous pericardium has become the preferred material for VSD closure, though there have been reports of patients with aneurysmal dilation [Atik 2009]. In 3 patients in the present study, we observed no problems in initial postoperative echocardiographic examination, but detected leakage from the patch edge in later examinations after the patients exhibited elevated levels of biochemical markers of infection, and these patients were reoperated on. However, there was no statistically significant difference between the 2 groups regarding infection caused by the surgical technique ($P = .165$). Furthermore, although autologous pericardium was the primary patch material in ourstudy, Dacron patches were used in case of autologous material deficiency (group 1, n = 16, 21.6%; group 2, n = 33, 15.6%; $P = .282$). As there was no statistical difference between the 2 groups in terms of patch material used, we did not consider it necessary to exclude the patients who received Dacron patches.

Surgical treatment of VSD can be performed with lower morbidity and mortality as more experience is gained [Anderson 2013]. In our series, morbidity and mortality rate went down as experience increased, which is illustrated by the fact that no mortality or complete AV block occurred in the last 53 cases.

Study Limitation

Some limitations of this study are that it was retrospective and unicentric, and was conducted in a relatively new pediatric cardiac center. Furthermore, the surgeries were performed by 2 different surgical teams.

CONCLUSION

In conclusion, the present study indicates that interrupted and continuous VSD closure techniques are both effective and safe methods that yield similar morbidity and mortality rates. This suggests that the optimal surgical method for VSD closure cannot be defined in terms of a particular patch material or suturing technique and that surgeons should employ the technique they are most experienced and comfortable with.

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The authors have nothing to disclose and declare no conflicts of interest. The study was approved by an institutional review board. No informed consent has been collected since it is a retrospective study.

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