

Interventricular Septal Hematoma Following Surgical Correction of Ventricular Septal Defect in Infants: A Single-Center Experience

Ling-Shan Yu, MM,^{1,2,3,4} Wen-Hao Lin, MM,^{1,2,3,4} Shi-Hao Lin, MM,^{1,2,3,4} Jing Wang, MD,^{1,2,3,4}
Hua Cao, MD,^{1,2,3,4} Zeng-Chun Wang, MD,^{1,2,3,4} Qiang Chen, MD^{1,2,3,4}

¹Department of Cardiac Surgery, Fujian Branch of Shanghai Children's Medical Center, Fuzhou, China; ²Fujian Children's Hospital, Fuzhou, China; ³College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, China; ⁴Fujian Key Laboratory of Women and Children's Critical Diseases Research, Fujian Maternity and Child Health Hospital, Fuzhou, China

ABSTRACT

Objective: To review and analyze the cases of interventricular septal hematoma (IVSH) following surgical correction of the ventricular septal defect (VSD) in infants in our center.

Methods: Retrospective analysis was performed on five infants with IVSH after surgical correction of VSD in our center from January 2020 to January 2022. The general preoperative information and intraoperative and postoperative results were collected and analyzed.

Results: All five infants with VSD were repaired under cardiopulmonary bypass and occurred IVSH. The cardiac arrest occurred in one patient five hours after return to the intensive care unit (ICU). The patient's hemodynamics were difficult to maintain after cardiopulmonary resuscitation, and the patient died. Two other patients had arrhythmia and unstable hemodynamics during the perioperative period, the hematoma puncture was performed, and the patients' symptoms lessened. Perioperative and postoperative echocardiography showed that the hematoma gradually was shrunk, and the hemodynamics became stable. The hemodynamics were stable in the remaining two infants during the perioperative period. No specific medical intervention was required other than clinical observation in these two patients. Finally, the four infants successfully were discharged with good clinical results.

Conclusion: IVSH is a rare complication of surgical repair of VSD. Prevention and early detection of IVSH during operation in infants with VSD are essential.

INTRODUCTION

Interventricular septal hematoma (IVSH) is defined as dissection between the spiral planes of the septum, and it occurs after myocardial infarction, cardiac trauma, or various cardiac interventions [Jensen 2007]. IVSH is a rare complication of surgical correction of the ventricular septal defect (VSD) in infants, which may be related to the endocardium and interventricular septal vessel damage along with the ventricular septal patch. Drago et al. first reported a 4-month-old infant with an IVSH following surgical repair of VSD in 2005 [Drago 2005]. Subsequent cases of IVSH have been reported, with varying time and clinical manifestations ranging from occasional postoperative routine echocardiography findings to severe low cardiac output [Haranal 2019; Bailey 2017]. This study retrospectively analyzed the cases of IVSH after surgical correction of VSD in infants in our center from January 2020 to January 2022, discussed the diagnosis and treatment process, and provided experience sharing for the treatment of similar clinical cases.

MATERIALS AND METHODS

The present study was approved by our center's ethics committee and adhered to the Declaration of Helsinki. Besides, written informed consent was obtained from the patients' parents.

Due to the lack of equipment and experience before 2020, intraoperative transesophageal echocardiography (TEE) monitoring was not routinely performed, and patients with IVSH were not detected in time or effectively managed. Therefore, the patients included in this study were focused on the period, when our center began to conduct intraoperative TEE monitoring from January 2020 to January 2022.

All infantile patients with VSD were undergoing surgical repair under cardiopulmonary bypass (CPB). A 5 cm median sternal incision was used and systemic heparinization intravenously was administered using 3mg/kg heparin. Routine CPB was established, then the cardiac arrest fluid was perfused, following ascending aorta clamp. The right atrium was cut, and the size and location of the VSD were explored through the tricuspid valve. The autologous pericardial patch was trimmed, according to the size and shape of the VSD. Then,

Received February 20, 2022; received in revised form May 2, 2022; accepted May 2, 2022.

Correspondence: Qiang Chen, MD, Department of Cardiac Surgery, Fujian Branch of Shanghai Children's Medical Center, Fuzhou, China; Fujian Children's Hospital, Fuzhou, China; College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, China; Fujian Key Laboratory of Women and Children's Critical Diseases Research, Fujian Maternity and Child Health Hospital, Fuzhou, China (e-mail: chenqiang2228@163.com).

continuous suture with 6-0 prolene suture was used to repair the VSD. The right atrial incision was closed. The ascending aorta was opened, and the heart beat again. Cardiac structure and function were assessed by TEE.

Between January 2020 and January 2022, there were 352 infantile patients with VSD who underwent surgical closure in our center, and there were five cases of IVSH (1.4%). This retrospective analysis was performed on these five infants with IVSH. (Figure 1) (Figure 2) The general preoperative information, operation situation, intraoperative and postoperative echocardiography monitoring results, postoperative hemodynamics, intervention measures, and outcomes were analyzed. No other cardiac malformations occurred in these patients, except atrial septal defect or patent foramen ovale.

Once the patient had unstable hemodynamic parameters after CPB, and TEE indicated a larger IVSH, we recommended IVSH puncture for the patient. The puncture method we used was similar to the transthoracic device closure of VSD that was used in our previous report [Chen 2018]. A purse was made on the free wall of the right ventricle after the puncture site was confirmed by TEE guidance. Under continuous TEE guidance, we used a gauge needle to puncture the free wall of the right ventricle, then advanced it into the hematoma. The inner core of the needle was withdrawn, and a syringe was attached to the needle for suction.

RESULTS

The mean age of these five infantile patients was 2.0 ± 1.0 months, the weight was 4.2 ± 0.9 kg, ejection fraction (EF) was $63.2 \pm 2.2\%$, and size of VSD was 6.8 ± 1.2 mm. The mean operative time was 177.4 ± 14.9 minutes, CPB duration was 68.6 ± 10.5 minutes, aortic cross-clamp duration was 46.2 ± 4.1 minutes, and hematoma size was 14.5 ± 1.8 mm.

Cardiac arrest occurred in one patient five hours after return to the intensive care unit (ICU). The echocardiography indicated an IVSH of 16 mm in this patient, and early intraoperative hemodynamics were stable without further treatment. The patient's hemodynamics were difficult to maintain after cardiopulmonary resuscitation, and the patient died. No TEE was performed in the ICU. Two other cases showed marked hemodynamic instability and arrhythmias, and TEE showed obvious IVSH during the preparation (15.3 mm and 15.5 mm, respectively). Because of the unstable hemodynamics, the hematoma puncture was performed through the free wall of the right ventricle. After the puncture, TEE indicated the hematoma was smaller than before in these two patients, and the hemodynamics gradually stabilized and heart rhythm gradually stabilized. Both patients then were transferred to the ICU and continued treatment and recovery went well. Postoperative echocardiography showed a gradual decrease in the hematoma. The remaining two patients with IVSH had stable hemodynamics and heart rates. The diameter of IVSH was 11.5 mm and 14.1 mm in these two patients, respectively. Routine postoperative treatment and close medical observation were followed, and both patients successfully recovered. Early postoperative echocardiography showed a gradual



Figure 1. Transesophageal postoperative 4-chamber image



Figure 2. Transthoracic postoperative 4-chamber image

decrease in the hematoma. After three months of postoperative follow up, transthoracic echocardiography showed varying degrees of absorption and reduction of hematoma in all four infants who were successfully discharged, and their heart functions were normal.

DISCUSSION

IVSH is a rare postoperative complication of surgical repair of CHD in infantile patients. The cause is still a matter of some debate. It is speculated that the ventricular septal perforator artery is injured during the interventricular septal patch suture, causing subendocardial bleeding. Due to the need for CPB during surgery, heparinized anticoagulation is performed, leading to the continuous development of hematoma and ventricular septal dilation. Thus, the ventricular cavity is limited, and obstruction of the outflow tract occurs, which further leads to hemodynamic instability [Zhu 2013; Vargas-Barrón 2009; Burkhart 2020]. In this study, we collected the cases of IVSH occurring in our center during the

observed period. The mean age of the patients was 2.0 ± 1.0 months, and weight was 4.2 ± 0.9 kg. It was speculated that young infants with low body weight might be at increased risk of ventricular septal perforator artery injury, due to limited surgical field, which was also questioned in Jegatheeswaran's study [Jegatheeswaran 2020]. However, due to the small sample size, it was not sure whether it was a high-risk factor. We also had no direct anatomical evidence that the injury of the ventricular septal perforator artery was the cause of the IVSH because the exact position of the artery was not anatomically revealed during the operation. So, we could only offer suggestions, such as shallow stitches in the corresponding area of the ventricular septum.

In this study, five infants all were monitored by intraoperative TEE, and all were found to have IVSH. Two patients had difficulty maintaining hemodynamics after CPB stopped, and TEE indicated the diagnosis of IVSH. The trans-right ventricular puncture was performed in these two patients. Perioperative echocardiography showed the hematoma was smaller than before, and the hemodynamics were stable. One of the untreated patients subsequently went into cardiac arrest, although his intraoperative hemodynamics were stable. Unfortunately, there was a lack of postoperative ultrasound data, and we speculated that the hematoma was further enlarged to the extent that it affected hemodynamics and cardiac electrical rhythm. We considered the efficacy of ventricular septal puncture in these patients with IVSH to be debatable. Although there was some improvement in our two cases, the hematoma did not immediately shrink significantly, which might be caused by the decompression effect of the puncture. There still was no consensus on the treatment of hematoma. Two other patients with hematoma also recovered without special treatment. This suggested that the size of the hematoma might be the main factor affecting prognosis.

Intraoperative TEE monitoring has become an essential part of cardiac surgery, which is a crucial tool to evaluate the surgical effect of congenital heart disease (CHD) [Bettex 2005]. Although TEE may cause some trauma or compression to the trachea or large blood vessels, it generally is recommended that routine placement of TEE for monitoring of infants with CHD, which helps assess the condition and early detection of related complications [Padalino 2007; Eyileten 2013]. From our study, it could be seen that TEE provided powerful help for the immediate diagnosis of IVSH during the operation and evaluation of the condition of infants with hemodynamic instability.

Padalino et al. did a retrospective analysis of IVSH in infants undergoing VSD repair and confirmed that intraoperative echocardiographic evaluation had significantly reduced the impact of this potentially fatal complication on the clinical course of our patients [Padalino 2007]. The measured diameter of the hematoma might be critical in deciding treatment and determining prognosis. In our two patients with hematoma diameters larger than 15mm, we adopted ventricular septal puncture and achieved certain results. At this point, the TEE could be used as a tool for puncture guidance, just as we reported the guiding process of transthoracic device closure of VSD. It also was useful for us to do therapy. The cardiac function and anatomical results assessed by TEE also were

important indicators that we used to evaluate how to further manage the hematoma.

Myocardial hematoma formation might cause hemodynamic instability or conduction abnormalities, leading to serious complications, including cardiac arrest, outflow tract obstruction, and tamponade [Mart 2011]. At present, the main treatment methods include conservative treatment, inter-ventricular septum puncture, and drainage, interventricular septum incision, and drainage or extracorporeal membrane oxygenation (ECMO) [Jegatheeswaran 2020; Padalino 2007; Suteu 2016]. Jegatheeswaran et al. reported 12 cases of IVSH after VSD repair in a single center, and five cases were treated with extracorporeal ECMO support until the hematoma disappeared, with satisfactory results [Jegatheeswaran 2020]. ECMO also might be a practical support for hemodynamically unstable patients. However, specific anticoagulant regimens might be required for such patients. The study by Vargas-Barron et al. reported an 80% mortality rate for surgical treatment compared with 100% for conservative treatment of IVSH [Vargas-Barrón 2009]. Zhu and his team retrospectively analyzed the cases of IVSH after cardiac surgery in infants in recent years. They concluded that the results of IVSH in infants, especially the conservative treatment results, were encouraging compared with adults [Zhu 2013]. After reviewing the relevant data, we concluded that complete avoidance of this complication was not possible, our medical record review could not provide a definitive treatment opinion, and the best treatment plan was controversial. In infants, most of the ventricular free wall function is well, compensating for the limited movement of the ventricular septum. When there is no obvious compression in the left and right ventricles and obstruction in the outflow tract and hemodynamics are stable, conservative treatment should be recommended. IVSH after cardiac surgery in infants is rare, and the number of cases is small. Surgeons should be aware of this complication.

Limitation: There were still some deficiencies in this study. First, this was a retrospective study. The small number of cases involved and certain biases in the study process might have affected the results. However, we believed these results still had specific guiding significance for clinical practice. It needs to be further confirmed by future multi-center and large-sample clinical studies.

CONCLUSION

IVSH is a rare complication of surgical repair of VSD in infants. Intraoperative TEE monitoring is useful in both the diagnosis and treatment of this complication. Although this complication is unavoidable, prevention and early detection of IVSH during the operation in infants with VSD is essential.

ACKNOWLEDGEMENT

We highly acknowledge the contribution of all the participating doctors from our center. We hope humans eventually defeat COVID-19.

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