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Clinical Research

Does Early Drain Removal Affect Postoperative Pericardial Effusion after Congenital Cardiac Surgery?

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Background: Patients undergoing cardiac surgery require postoperative chest drainage. However, the drain is difficult to keep in place in children with congenital heart disease. Since 2015, at Kyungpook National University Hospital, the chest tube is removed on postoperative day 1 in patients who have undergone simple congenital cardiac surgery (i.e., closure of an atrial or ventricular septal defect). In this study, we evaluated the relationship between the duration of drain placement and the likelihood of pericardial effusion after congenital cardiac surgery.
Methods: The medical records of patients who underwent closure of an atrial or ventricular septal defect at our hospital between January 2014 and December 2016 were reviewed. In total, 162 patients who received follow-up echocardiography and had information available on postoperative pericardial effusion after the repair procedure were enrolled.
Results: Echocardiography was performed at a median of 5 days (range, 4 to 6 days) postoperatively before discharge from the hospital. Pericardial effusion occurred in 21 patients (13.0%), of whom only 3 (1.9%) had moderate or greater pericardial effusion, regardless of the drain duration. All patients improved during outpatient follow-up without invasive management. No patient had severe complications because of pericardial effusion. The duration of drain placement did not affect the incidence of postoperative pericardial effusion (p=0.069). Operative survival was 100%.
Conclusion: Based on our study, we recommend removing the drain as soon as its role is complete, generally on postoperative day 1, because early removal does not increase the incidence of pericardial effusion in patients undergoing simple congenital cardiac surgery.

Keywords: Atrial heart septal defects, Congenital heart disease, Drainage, Pericardial effusion, Ventricular heart septal defects

Introduction

Patients who undergo cardiac surgery routinely have 1, 2, or more chest tubes placed postoperatively to monitor postoperative bleeding or to drain pericardial effusion, which may cause hemodynamic instability because of cardiac tamponade and/or pleural effusion [1]. Surgeons hesitate to remove chest tubes too early because of these potential postoperative complications and the possible need for an additional invasive procedure (e.g., pericardiocentesis or closed thoracostomy). However, an unnecessarily prolonged period of chest tube drainage is painful, immobilizes the patient, causes mechanical irritation to the heart and pericardium, and can be a source of infection [2-4].

Chest tube drainage is particularly problematic in children with congenital heart disease, who lack the understanding and patience needed to bear the discomfort of the chest drain. Furthermore, pediatric patients are likely to struggle, which causes air to be sucked back into the mediastinum. In 2015, our congenital cardiac surgery team started removing the chest tube on the first postoperative day in patients undergoing simple congenital cardiac sur-

Table 1. Patients' characteristics (n=162)

Characteristic	Value
Age (mo)	3 (1–19)
Sex	
Female	78 (48.1)
Male	84 (51.9)
Weight (kg)	5.5 (3.8–10.5)
Body surface area (m^2)	0.3 (0.2–0.5)
Postoperative hospital stay (day)	7 (5–9)

Values are presented as median (interquartile range) or number (%).

Table 2. Intraoperative outcomes in 162 patients (n=162)

Characteristic	Value
Clamp time (min)	40.5 (31.0–53.0)
Pump time (min)	64.5 (50.0–83.0)
ASD closure	32 (19.8)
MV repair	8
TV repair	11
Ventricular septal defect closure	130 (80.2)
ASD closure	102
MV repair	22
TV repair	27

Values are presented as median (interquartile range), number (%), or number.
ASD, atrial septal defect; MV, mitral valve; TV, tricuspid valve.

gery, such as closure of an atrial septal defect (ASD) or ventricular septal defect (VSD).

The aim of this study was to evaluate the relationship between the duration of drain placement and the likelihood of pericardial effusion after simple congenital cardiac surgery.

Methods

Patients

The study was approved by the Institutional Review Board of Kyungpook National University Hospital (IRB approval no., 2018-11-031). The requirement for informed consent was waived because of the retrospective nature of the study and the anonymity of the data. We reviewed the clinical records, echocardiograms, operative findings, and surgical outcomes in 162 patients who underwent corrective surgery for ASD or VSD at Kyungpook National University Hospital between January 2014 and December 2016. The indications for surgery were failure to thrive, congestive heart failure, and other standard indications for closure of ASD or VSD.

Drain management

A single round 16F silicone thoracic catheter (500 mm in length; Sewoon Medical Co. Ltd., Cheonan, Korea) was placed in the retrosternum in all patients. The chest drain was connected to a disposable dry suction control chamber (OASIS Dry Suction Water Seal Chest Drain; Maquet, Rastatt, Germany) with 20 cmH_2O of suction. No additional manipulation (milking, stripping, or withdrawing) of the catheter was performed during the drainage period. Before 2015, the drain was kept in place for at least 24 hours postoperatively and removed when there was a decreasing trend of effusion. Starting in 2015, the drain was removed if the patient had no postoperative bleeding and stable vital signs regardless of the amount of drainage.

Echocardiography

Echocardiography was routinely performed by pediatric cardiologists in all cases preoperatively and repeated at least once before discharge from the hospital or at the first outpatient clinic follow-up visit in the early postoperative period. The presence and amount of pericardial effusion was assessed by 2-dimensional echocardiography in the parasternal short axis, long axis, apical 4-chamber, and subcostal views. Pericardial effusion was graded according to the maximum separation between the pericardium and epicardium: less than 5 mm was considered mild, 6 to 15 mm as moderate, and more than 16 mm as severe [5].

Statistical analysis

Continuous variables are expressed as the median and interquartile range for non-normally distributed data; differences between these variables were assessed by the Mann-Whitney U-test. Categorical variables are expressed as the number and percentage; differences between these variables were evaluated using the chi-square test. Differences were considered to be statistically significant when the p-value was less than 0.05. All statistical analyses were performed using IBM SPSS ver. 23.0 for Windows (IBM Corp., Armonk, NY, USA).

Results

Patient characteristics

Patients' demographic characteristics are shown in Table 1. At the time of surgery, patients' median age was 3 months

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(range, 1 to 19 months), and their median body weight and surface area were 5.5 kg (range, 3.8 to 10.5 kg) and 0.3 m^2 (range, 0.2 to 0.5 m^2), respectively. The median postoperative hospital stay was 7 days (range, 5 to 9 days).

The intraoperative outcomes are presented in Table 2. The median clamp and pump times were 40.5 minutes (range, 31.0 to 53.0 minutes) and 64.5 minutes (range, 50.0 to 83.0 minutes), respectively. Thirty-two patients underwent ASD closure with or without mitral or tricuspid valve repair, and 130 underwent VSD closure with or without mitral or tricuspid valve repair or ASD closure.

No operative complications occurred. There was no operative mortality or any deaths during the hospital stay or follow-up period. The distribution of the patients according to the duration of drain placement and year of surgery is shown in Fig. 1.

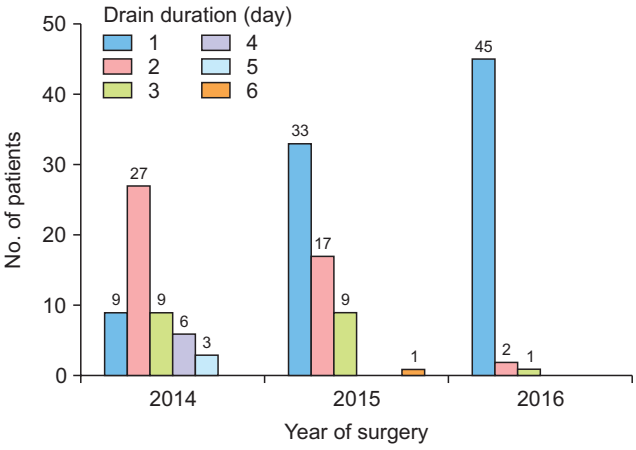

Fig. 1. Distribution of patients according to drain duration and year of surgery.

Evolution of pericardial effusion

The evolution of pericardial effusion in all 162 patients, from the postoperative echocardiogram to the second outpatient follow-up echocardiogram, is demonstrated in Fig. 2. The postoperative echocardiogram was obtained at a median of 5 days (range, 4 to 6 days) after removal of the chest tube, and the second outpatient follow-up echocardiogram was obtained at a median of 12 months (range, 11 to 16 months) postoperatively.

The postoperative echocardiograms showed pericardial effusion in 19 patients and no pericardial effusion in 143 patients. The amount of pericardial effusion was mild in 18 cases and moderate in 1. In 18 cases, the pericardial effusion had resolved by the time of the first outpatient follow-up echocardiogram, and it eventually resolved in the remaining case (Fig. 2A). Two of the 143 patients who did not have pericardial effusion before discharge showed moderate effusion echocardiograms obtained at the time of their first outpatient clinic visit (Fig. 2B).

Effect of drain duration on postoperative pericardial effusion

We compared patients' characteristics and operative outcomes according to whether the chest tube was removed on postoperative day 1 or later than postoperative day 1, as shown in Table 3. No significant difference was found in any of the patients' characteristics or outcomes according to whether the chest tube was removed on the first postop-

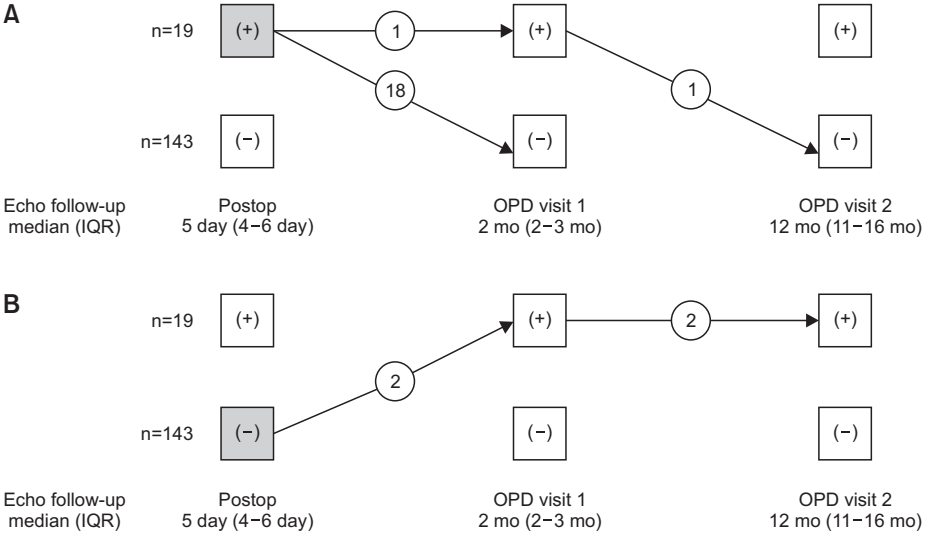

Fig. 2. Frequency of pericardial effusion in 162 patients after congenital cardiac surgery. (A) Follow- up of 19 patients who had pericardial effusion before discharge from the hospital. (B) Follow-up of 143 patients who did not have pericardial effusion before discharge from the hospital. Echo, echocardiography; IQR, interquartile range; Postop, postoperative; OPD outpatient department.

Table 3. Comparison of patients' characteristics and operative outcomes according to the timing of chest tube removal

Variable	Tube removed on POD ≤1 (n=87)	Tube removed on POD ≥2 (n=75)	p-value
Age (mo)	3 (1–21)	2 (1–15)	0.721
Weight (kg)	6.0 (3.9–11.0)	5.4 (3.9–10.4)	0.687
Body surface area (m^2)	0.3 (0.2–0.5)	0.3 (0.2–0.5)	0.807
Clamp time (min)	40.0 (27.5–50.0)	44.0 (34.5–58.0)	0.021
Pump time (min)	60.0 (47.0–75.0)	72.0 (59.0–95.0)	0.003
Total drainage (mL/kg)	6.0 (4.4–8.7)	12.6 (9.3–16.4)	<0.001
Drainage in final 6 hr (mL/kg)	1.2 (0.7–1.6)	0.6 (0.3–1.1)	<0.001
Postoperative hospital stay (day)	7 (5–8)	8 (6–10)	0.059
Pericardial effusion	15 (17.2)	6 (8%)	0.069
Before discharge	14	5	
Mild	13	5	
Moderate or greater	1	0	
After discharge[a]	1	1	

Values are presented as median (interquartile range), number (%), or number.
POD, postoperative day.
[a]All patients had moderate or greater pericardial effusion.

erative day (Table 3).

Predictably, however, significant differences were found in the total amount of fluid drained (p<0.001) and the amount drained during the final 6 hours of drain placement (p<0.001). The total volume of drainage fluid was inevitably lower in the group with early tube removal than in the group with delayed tube removal, because the total drainage volume is smaller if the duration of drain placement is shorter and larger if the duration is longer. Considering the need to wait for effusion to decrease, the volume drained in the 6 hours before removal of the tube in the group with delayed removal was necessarily significantly lower than that in the group with early tube removal.

However, contrary to our expectations, significant between-group differences were found in clamp time (p=0.021) and pump time (p=0.003). There are 2 possible reasons for these significant differences. First, even though the number of patients in these 2 groups was similar, their relative distribution changed between 2014 and 2016 (Fig. 3). Second, operator proficiency and coordination of the congenital cardiac surgery team may have improved between 2014 and 2016, resulting in a significant effect on clamp and pump times (Table 4). The retrospective nature of this study meant that these factors could not be controlled; if the groups' composition had been similar in terms of when the procedures were performed, there might have been no significant differences in clamp time or pump time.

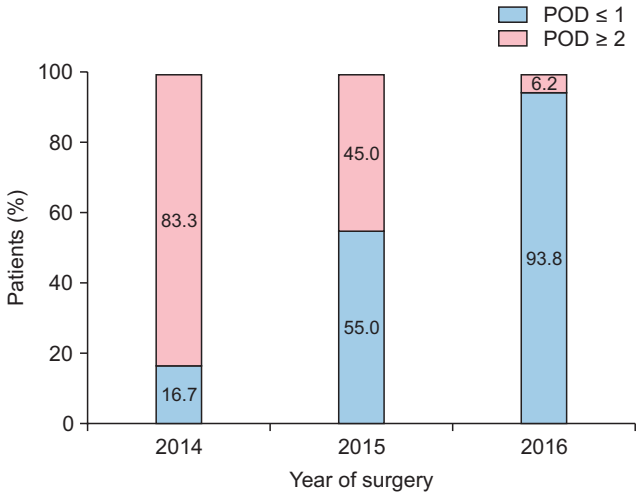

Fig. 3. Distribution of the groups according to the timing of drain removal between 2014 and 2016. POD, postoperative day.

Discussion

In this study, we evaluated the incidence of pericardial effusion after simple congenital cardiac surgery, (i.e., ASD or VSD closure). Pericardial effusion occurred in 21 (13.0%) of 162 patients; only 3 patients (1.9%) had moderate or greater pericardial effusion on follow-up echocardiography after surgery regardless of the drain duration. Pericardial effusion eventually improved in all patients during follow-up in the outpatient clinic with no need for further invasive management.

Pericardial effusion was detected on immediate postoperative echocardiography in 19 patients (11.7%) and had

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Table 4. Changes in clamp and pump times between 2014 and 2016

Variable	Year			p-value
	2014 (n=54)	2015 (n=60)	2016 (n=48)	
Clamp time (min)	44.0 (33.0–58.0)	44.0 (37.0–57.0)	35.0 (24.5–45.5)	0.009
Pump time (min)	71.0 (59.0–92.0)	67.0 (56.5–86.0)	55.0 (44.0–75.0)	0.010

Values are presented as median (interquartile range).

improved in all cases by the second outpatient follow-up visit without any invasive management or re-admission (Fig. 2A). Two patients in whom there was no pericardial effusion before discharge were noted to have moderate or greater pericardial effusion at their first visits to the outpatient clinic (Fig. 2B). These 2 patients were readmitted for further management. However, neither of these patients had clinical symptoms or signs of infection; therefore, they did not require invasive pericardiocentesis and were discharged on oral medication with regular short-term follow-up at the outpatient clinic.

The reported incidence of pericardial effusion after cardiac surgery ranges from 1.5% to 84% depending on the type of surgery performed and the study design. Even when the incidence of pericardial effusion is high, hemodynamic instability with cardiac tamponade is rare, reportedly occurring in 0.8% to 1.3% of all patients who undergo cardiac surgery [1,2,4,6,7]. Adrichem et al. [8] reviewed 1,031 patients at 3 academic hospitals to identify the risk factors for clinically relevant pericardial effusion after pediatric cardiac surgery and found that 301 (24.3%) developed postoperative pericardial effusion, which was considered clinically relevant in 136 (11.0%) patients. Furthermore, in a review of the frequency of post-pericardiotomy syndrome after closure of an ASD in 97 pediatric patients, Heching et al. [9] found pericardial effusion on pre-discharge echocardiography in 36 cases (37.1%).

Unfortunately, the pathophysiological mechanism of postoperative pericardial effusion is still unclear. Nonetheless, various explanations have been proposed, including impaired lymphatic drainage, pericardial inflammation, an immune response, drain-related conditions, and anticoagulation therapy [4,8]. The incidence of postoperative pericardial effusion on pre-discharge echocardiograms was lower (13%) in our study than in previous reports, and only 3 (1.9%) of our patients had moderate or greater (i.e., clinically relevant) pericardial effusion. We assume that our surgeons did their utmost to minimize the risk of pericardial effusion by avoiding unnecessary manipulation, preventing leakage of lymph fluid by preserving the thymus unless it interfered with the surgical view, electrocauterizing the resected pericardium, removing the epicardial pacing wires before closure of the sternum if sinus rhythm was recovered in the operative field, thoroughly checking for bleeding, and ensuring strict control of postoperative volume status in the intensive care unit, especially in the first 12 hours after surgery.

In conclusion, pericardial effusion occurred in 21 (13.0%) of 162 patients who underwent simple congenital cardiac surgery. The pericardial effusion was considered moderate or greater in only 3 patients (1.9%). Removal of the drain on the first postoperative day did not increase the risk of pericardial effusion after surgery. No patient developed severe complications as a result of pericardial effusion. Our findings indicate that there was no relationship between the duration of drain placement and the incidence of pericardial effusion after simple congenital cardiac surgery.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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