Outcomes after Biventricular Repair Using a Conduit between the Right Ventricle and Pulmonary Artery in Infancy

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Background: This study investigated the outcomes of biventricular repair using right ventricle to pulmonary artery (RV-PA) conduit placement in patients aged <1 year.
Methods: Patients aged <1 year who underwent biventricular repair using an RV-PA conduit between 2011 and 2020 were included in this study. The outcomes of interest were death from any cause, conduit reintervention, and conduit dysfunction (peak velocity of ≥3.5 m/sec or moderate or severe regurgitation).
Results: In total, 141 patients were enrolled. The median age at initial conduit implantation was 6 months. The median conduit diameter z-score was 1.3. The overall 5-year survival rate was 89.6%. In the multivariable analysis, younger age (p=0.006) and longer cardiopulmonary bypass time (p=0.001) were risk factors for overall mortality. During follow-up, 61 patients required conduit reintervention, and conduit dysfunction occurred in 68 patients. The 5-year freedom from conduit reintervention and dysfunction rates were 52.9% and 45.9%, respectively. In the multivariable analysis, a smaller conduit z-score (p<0.001) was a shared risk factor for both conduit reintervention and dysfunction. Analysis of variance demonstrated a nonlinear relationship between the conduit z-score and conduit reintervention or dysfunction. The hazard ratio was lowest in patients with a conduit z-score of 1.3 for reintervention and a conduit z-score of 1.4 for dysfunction.
Conclusion: RV-PA conduit placement can be safely performed in infants. A significant number of patients required conduit reintervention and had conduit dysfunction. A slightly oversized conduit with a z-score of 1.3 may reduce the risk of conduit reintervention or dysfunction.

Keywords: Right ventricle to pulmonary artery conduit, Infancy, Conduit reintervention, Conduit dysfunction, Conduit diameter z-score

Introduction

In patients who require complete repair of various congenital cardiac defects associated with a discontinuous right ventricular outflow tract (RVOT) or the Ross operation for congenital aortic valve diseases, establishing continuity between the right ventricle (RV) and the pulmonary artery (PA) entails the placement of an RV-PA conduit.

Various conduits, such as homografts, porcine-valved Dacron conduits (Hancock; Medtronic Inc., Minneapolis, MN, USA), bovine jugular vein-valved conduits (Contegra; Medtronic Inc.), and polytetrafluoroethylene tubes (PTFE; W.L. Gore & Associates Inc., Newark, DE, USA) with or without a PTFE membrane valve, have been used for establishing RV-PA continuity; however, homografts, which were the traditionally preferred option, are no longer widely available in most countries [1-3]. Although surgery using an RV-PA conduit has excellent survival outcomes, the conduit failure and reintervention rates are still high [3-5]. According to previous studies, younger age is associated with higher rates of reintervention or conduit failure, and most patients who undergo RV-PA connection with a conduit in infancy require conduit reintervention during their lifetime [3,6,7]. This may be attributable to the patient's outgrowth, conduit degeneration and subsequent calcification, external compression by the sternum, distal anastomosis

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site obstruction, and the use of an oversized conduit [4,6].

The majority of prior RV-PA conduit studies included patients of varying ages and employed homografts, which are currently difficult to obtain. As a result, we focused on younger patients for whom selecting the conduit type and size is difficult, as well as patients who had RV-PA conduit placement since 2011 (i.e., during a period when homografts were infrequently used). Therefore, this study aimed to investigate the outcomes of RV-PA conduit placement for biventricular repair in patients aged <1 year.

Methods

Patient selection and data collection

This study was approved by the institutional review board of Asan Medical Center (approval number: 2023-1557-0001; approval date: July 21, 2023), and the requirement for informed consent was waived given the retrospective study design.

Patients aged <1 year who underwent biventricular repair using an RV-PA conduit between January 2011 and September 2020 were included in this study. Patients who underwent RV-PA connection using a homograft were excluded. Baseline characteristics, morphological characteristics, operative details, and perioperative outcomes were collected by reviewing electronic medical records. Follow-up data were obtained from outpatient visit records and telephone contact.

Definitions

The outcomes of interest were death from any cause or transplantation, conduit reintervention or reoperation, and conduit dysfunction. The date of death, first reintervention, and first documentation of conduit dysfunction were the study endpoints. Early mortality was defined as any death that occurred either within 30 days after the initial operation or before hospital discharge.

Conduit reintervention was defined as any catheter-based or surgical reintervention performed on the conduit during follow-up. Catheter-based interventions included balloon dilatation or stenting of the conduit.

Serial echocardiographic examinations following RV-PA conduit implantation were reviewed to evaluate conduit function. To evaluate size mismatch, the conduit size was converted to a z-score using a standard formula. Conduit dysfunction was defined as a peak conduit velocity ≥3.5m/sec or moderate or severe regurgitation [8].

Surgical techniques

After a midline incision was made and median sternotomy was performed, cardiopulmonary bypass (CPB) was established by aortobicaval cannulation. Immediately after CPB initiation, systemic-to-PA shunts or persistent arterial ducts were occluded. Under moderate hypothermic CPB and cardioplegic arrest, intracardiac procedures such as closure of ventricular or atrial septal defects and right ventricular incision for the RV-PA connection were performed. During rewarming after the release of the aortic cross-clamp (ACC), the distal end of the RV-PA conduit was first anastomosed to the PA, after which the proximal end was beveled and connected to the longitudinal incision on the RV. The conduit was chosen at the surgeon's discretion. If necessary, narrow segments of the PA were augmented using various patch materials. Intraoperative transesophageal echocardiography was routinely performed to evaluate procedural success after the patient was weaned from CPB.

Statistical analysis

The normality of the data distribution was tested using the Shapiro-Wilk test. Categorical variables were described as absolute numbers with percentages, and continuous variables were described as medians with interquartile ranges. The probabilities of survival, freedom from conduit reintervention, and freedom from conduit dysfunction were estimated using the Kaplan-Meier method. The intergroup equality of survival curves was assessed with the log-rank test. Factors associated with death or transplantation, conduit reintervention, and conduit dysfunction were identified using a logistic regression model and Cox proportional hazard models. Analysis of variance (ANOVA) was used to examine the significance of nonlinear relationships, and restricted cubic splines were used to analyze variables with a nonlinear relationship with the outcome. The analysis results for these variables were reported using partial effect plots. Variables with a p-value of <0.05 in the univariable analysis were further assessed in the multivariable analysis. Statistical analysis was performed using R software ver. 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patients' characteristics

A total of 141 patients between January 2011 and Sep-

tember 2020 were included. Table 1 summarizes the baseline characteristics of the patients. The median age and body weight at initial conduit implantation were 6 months (interquartile range, 1–8 months) and 6.5 kg (interquartile range, 3.8–7.6 kg), respectively. Of these patients, 25 (17.7%) were neonates, and 16 (11.3%) weighed <3 kg. Moreover, 26 infants (18.4%) were born prematurely. Chromosomal abnormalities were found in 25 patients (17.7%). The primary diagnosis was categorized into 5 groups. Pulmonary atresia with ventricular septal defect was the most common category, accounting for 58.1% (n=82) of cases.

Operative details

Table 2 describes the operative details of the patients. Previous palliative cardiac surgery had been performed in 95 patients, and the most common palliative surgery was a modified Blalock-Taussig shunt (n=65, 46%). The types of conduits for RV-PA connection were Contegra in 82 pa-

tients (54.2%), homemade PTFE membrane-valved PTFE conduit in 34 patients (24.1%), valveless PTFE conduit in 19 patients (13.5%), and Hancock in 6 patients (4.3%). The median diameter of the implanted RV-PA conduits was 12 mm (interquartile range, 12–14 mm), and the median z-score of the conduit diameter was 1.3 (interquartile range, 0.8–1.8). Concomitant pulmonary arterioplasty was performed in 92 patients (65.2%) at initial conduit implantation. The differences in characteristics according to conduit type are described in Table 3.

Survival

Eight early deaths (5.6%) occurred, and the causes of ear-

Table 1. Baseline characteristics of the patients

Characteristic	Value
Total no. of patients	141
Age at operation (mo)	6 (1–8)
Neonate at operation (<28 day)	25 (17.7)
Weight at operation (kg)	6.5 (3.8–7.6)
Low weight at operation (<3.0 kg)	16 (11.3)
Gender	
Male	62 (44.0)
Female	79 (56.0)
Premature	26 (18.4)
Chromosomal anomalies	25 (17.7)
DiGeorge syndrome/22q11.2 microdeletion	9 (6.3)
Down syndrome	3 (2.1)
CHARGE syndrome[a]	2 (1.4)
VACTERL syndrome[b]	1 (0.7)
Others	10 (7.0)
Primary cardiac diagnosis	
Pulmonary atresia with VSD	82 (58.1)
Truncus arteriosus	18 (12.7)
DORV/ToF	16 (11.3)
ToF/absent pulmonary valve syndrome	10 (7.0)
Others	15 (10.6)

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

VSD, ventricular septal defect; DORV, double outlet right ventricle; ToF, tetralogy of Fallot.

[a]CHARGE is an abbreviation for several of the features common in the disorder: coloboma, heart defects, atresia choanae (also known as choanal atresia), growth retardation, genital abnormalities, and ear abnormalities. [b]VACTERL syndrome is based on an acronym for the affected organs and systems: V (vertebral anomalies), A (anal atresia), C (cardiovascular abnormalities), TE (tracheoesophageal fistula), R (renal anomalies), and L (limb defects).

Table 2. Operative details

Variable	Value
Previous palliative cardiac surgery	
Modified Blalock-Taussig shunt	65
Central shunt	14
Pulmonary artery banding	9
Pulmonary artery angioplasty	8
MAPCA unifocalization	8
Modified norwood operation	4
Closure patent ductus arteriosus	3
Valvuloplasty	3
Truncal separation	1
Others	2
No. of previous cardiac surgery	
0	46 (32.6)
1	77 (54.6)
2	14 (9.9)
≥3	4 (2.8)
Type of conduit	
Bovine jugular vein (Contegra) conduit	82 (54.2)
Valved PTFE conduit	34 (24.1)
Valveless PTFE	19 (13.5)
Porcine-valved Dacron (Hancock) conduit	6 (4.3)
Conduit diameter (mm)	12 (12–14)
8	9 (6.3)
10	13 (9.2)
12	61 (43.2)
14	55 (39.0)
16	3 (2.1)
Conduit/weight ratio	1.99 (1.7–2.8)
Conduit diameter, z-score	1.34 (0.8–1.8)
Concomitant pulmonary artery angioplasty	92 (65.2)
Cardiopulmonary bypass time (min)	151 (123–203)
Aortic cross-clamp time (min)	54 (40–88)

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

MAPCA, major aortopulmonary collateral arteries; PTFE, polytetrafluoroethylene.

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Table 3. Preoperative and operative characteristics according to the type of conduits

Characteristic	All	Contegra	Valved PTFE	Valveless PTFE	Hancock	p-value
Total no. of patients	141	82	34	19	6	
Age at operation (mo)	6 (1 to 8)	6 (4 to 8)	5 (1 to 9)	1 (0 to 5)	11 (7 to 12)	<0.001
Weight at operation (kg)	6.5 (3.8 to 7.6)	6.7 (5.3 to 7.7)	6 (3.7 to 7.7)	3.2 (2.8 to 6.1)	7.7 (7.0 to 8.6)	<0.001
Male gender	62 (44.0)	36 (85.0)	13 (38.0)	8 (42.0)	5 (83.0)	0.235
Premature	26 (18.4)	17 (20.4)	5 (14.7)	3 (15.7)	1 (16.6)	0.873
Chromosomal anomalies	25 (17.7)	10 (12.1)	11 (32.3)	2 (10.5)	2 (33.3)	0.039
Primary cardiac diagnosis						0.002
Pulmonary atresia with VSD	82 (58.1)	52 (63.4)	17 (50.0)	7 (36.8)	6 (100.0)	
Truncus arteriosus	18 (12.7)	9 (10.9)	3 (8.8)	6 (31.5)	-	
DORV/ToF	16 (11.3)	11 (13.4)	4 (11.7)	-	-	
ToF/Absent pulmonary valve syndrome	10 (7.0)	4 (4.8)	6 (17.6)	1 (5.2)	-	
Others	15 (10.6)	6 (7.3)	4 (11.7)	5 (26.3)	-	
Conduit diameter (mm)	12 (12 to 14)	12 (12 to 14)	12 (12 to 14)	10 (8 to 10)	14 (14 to 14)	<0.001
8	9 (6.3)	-	-	9 (47.3)	-	
10	13 (9.2)	-	7 (20.5)	6 (31.5)	-	
12	61 (43.2)	43 (52.5)	16 (47.0)	2 (10.5)	-	
14	55 (39.0)	38 (46.3)	10 (29.4)	2 (10.5)	5 (83.3)	
16	3 (2.1)	1 (1.2)	1 (2.9)	-	1 (16.6)	
Conduit diameter, z-score	1.34 (0.8 to 1.8)	1.47 (0.9 to 2.0)	1.00 (0.8 to 1.7)	0.08 (-0.2 to 0.8)	1.27 (1.0 to 1.6)	<0.001
Cardiopulmonary bypass time (min)	151 (123 to 203)	143 (119 to 175)	176 (147 to 209)	204 (149 to 246)	153 (141 to 172)	0.007
Aortic cross-clamp time (min)	54 (40 to 88)	48 (37 to 73)	61 (48 to 90)	95 (76 to 110)	45 (42 to 57)	0.001

Values are presented as number, median (interquartile range), or number (%).
PTFE, polytetrafluoroethylene; VSD, ventricular septal defect; DORV, double outlet right ventricle; ToF, tetralogy of Fallot.

ly death were low cardiac output syndrome in 4 patients, respiratory failure in 2 patients, and sepsis in 2 patients. The median follow-up duration from initial conduit implantation was 4.4 years (interquartile range, 2.4–6.2 years). Six late deaths (4.2%) occurred, and the causes of late death included respiratory failure in 1 patient, sepsis in 1 patient, gastrointestinal disease in 1 patient, and unknown in 3 patients who died outside the hospital. The overall survival rates were 91.5% and 89.6% at 1 and 5 years, respectively (Fig. 1). In the univariable analysis, younger age, lower body weight, no previous palliative surgery, and longer CPB or ACC time were associated with overall mortality. In the multivariable analysis, younger age (p=0.006) and longer CPB time (p=0.001) were identified as risk factors for overall mortality (Table 4).

Conduit reintervention

During follow-up, 61 patients required conduit reintervention, including surgical reintervention in 44 patients and catheter-based reintervention in 17 patients, at a median of 29 months after initial conduit implantation. The indications for conduit reintervention included stenosis in 30 patients (49.1%), regurgitation in 8 patients (13.1%), com-
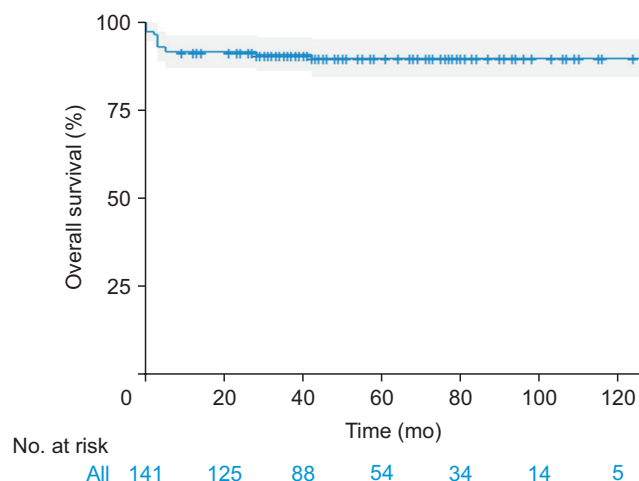

Fig. 1. Overall survival after right ventricle to pulmonary artery conduit insertion. The shaded area represents 95% confidence interval.

No. at risk
All	141	125	88	54	34	14	5

bined stenosis and regurgitation in 15 patients (24.5%), infective endocarditis in 2 patients (3.2%), and others in 6 patients (9.8%). The freedom from conduit reintervention rates were 90% and 52.9% at 1 and 5 years, respectively (Fig. 2A). In the univariable analysis, younger age, lower body weight, no previous cardiac surgery, a smaller con-

Table 4. Factors associated with overall mortality (n=14)

| Variable	Univariable analysis		Multivariable analysis	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Age at operation (mo)	0.76 (0.64–0.91)	0.003	0.78 (0.65–0.93)	0.006
Weight at operation (kg)	0.63 (0.46–0.85)	0.002		
Prematurity	2.52 (0.84–7.52)	0.097		
Previous palliative cardiac surgery	0.34 (0.11–0.99)	0.048	0.95 (0.22–4.13)	0.953
Chromosomal abnormality	0.75 (0.16–3.39)	0.718		
Conduit diameter, z-score	1.53 (0.76–3.08)	0.232		
Concomitant pulmonary arterioplasty	0.36 (0.12–1.05)	0.063		
Type of conduit	1.01 (0.60–1.68)	0.968		
Primary cardiac diagnosis	1.36 (0.98–1.88)	0.063		
Cardiopulmonary bypass time	1.01 (1.01–1.01)	0.001	1.01 (1.00–1.01)	0.001
Aortic cross-clamp time	1.01 (1.00–1.03)	0.001		

HR, hazard ratio; CI, confidence interval.
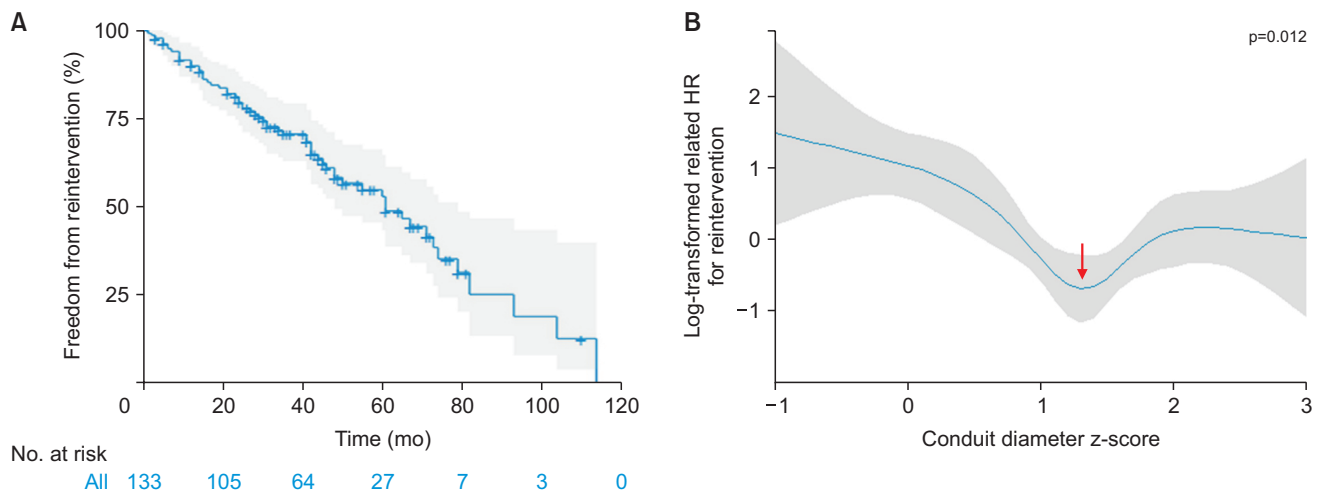
Fig. 2. Conduit reintervention following right ventricle to pulmonary artery (RV-PA) conduit insertion. (A) Kaplan-Meier curve for freedom from conduit reintervention and (B) a partial effect plot for the RV-PA conduit diameter z-score and the log-transformed related hazard ratio (HR) for conduit reintervention. The shaded area represents the 95% confidence interval. The arrow indicates the conduit diameter z-score (1.3) with the lowest risk of conduit reintervention.

duit diameter z-score, and the use of a valved or valveless PTFE conduit were associated with conduit reintervention. In the multivariable analysis, a smaller conduit diameter z-score (p=0.003) was identified as a risk factor for conduit reintervention (Table 5). ANOVA demonstrated that the conduit diameter z-score had a significant nonlinear relationship with conduit reintervention (p=0.012). To account for this nonlinearity, restricted cubic splines were used to model the relationship, and this showed that the lowest risk was at a conduit diameter z-score of 1.3 (Fig. 2B).

Conduit dysfunction

During follow-up, conduit dysfunction occurred in 68 patients at a median interval of 21 months. The causes of conduit dysfunction included stenosis in 29 patients (42.6%), regurgitation in 22 patients (32.3%), combined stenosis and regurgitation in 15 patients (22%), and infective endocarditis in 2 patients (2.9%). The freedom from conduit dysfunction rates were 84% and 45.9% at 1 and 5 years, respectively (Fig. 3A). In the univariable analysis, younger age, lower body weight, no previous cardiac surgery, smaller conduit diameter z-score, type of conduit (valveless conduit), and longer ACC time were associated with conduit dysfunction. In the multivariable analysis, younger age, smaller conduit diameter z-score, and longer ACC time were identified as independent risk factors for conduit dysfunction (Table 6). According to ANOVA, the conduit diameter z-score showed a significant nonlinear relationship with conduit dysfunction (p=0.043). To ac-

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Table 5. Factors associated with conduit reintervention (n=61)

Variable	Univariable analysis		Multivariable analysis	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Age at operation (mo)	0.87 (0.81–0.93)	<0.001	0.92 (0.82–1.03)	0.175
Weight at operation (kg)	0.76 (0.67–0.87)	<0.001		
Prematurity	0.63 (0.28–1.38)	0.252		
Previous palliative cardiac surgery	0.30 (0.18–0.52)	0.001	0.44 (0.18–1.06)	0.068
Chromosomal abnormality	0.71 (0.36–1.42)	0.341		
Conduit diameter, z-score	0.59 (0.42–0.84)	0.003	0.57 (0.40–0.83)	0.003
Concomitant pulmonary arterioplasty	0.73 (0.42–1.25)	0.253		
Type of conduit	0.78 (0.61–0.98)	0.038	1.05 (0.82–1.03)	0.742
Contegra conduit	Reference			
Valved PTFE conduit	2.33 (1.28–4.24)	0.005		
Valveless PTFE	2.43 (1.13–5.19)	0.021		
Hancock valved conduit	1.10 (0.37–3.30)	0.857		
Primary cardiac diagnosis	1.21 (0.93–1.34)	0.225		
Cardiopulmonary bypass time	1.00 (0.99–1.00)	0.330		
Aortic cross-clamp time	1.00 (0.99–1.01)	0.308		

HR, hazard ratio; CI, confidence interval; PTFE, polytetrafluoroethylene.
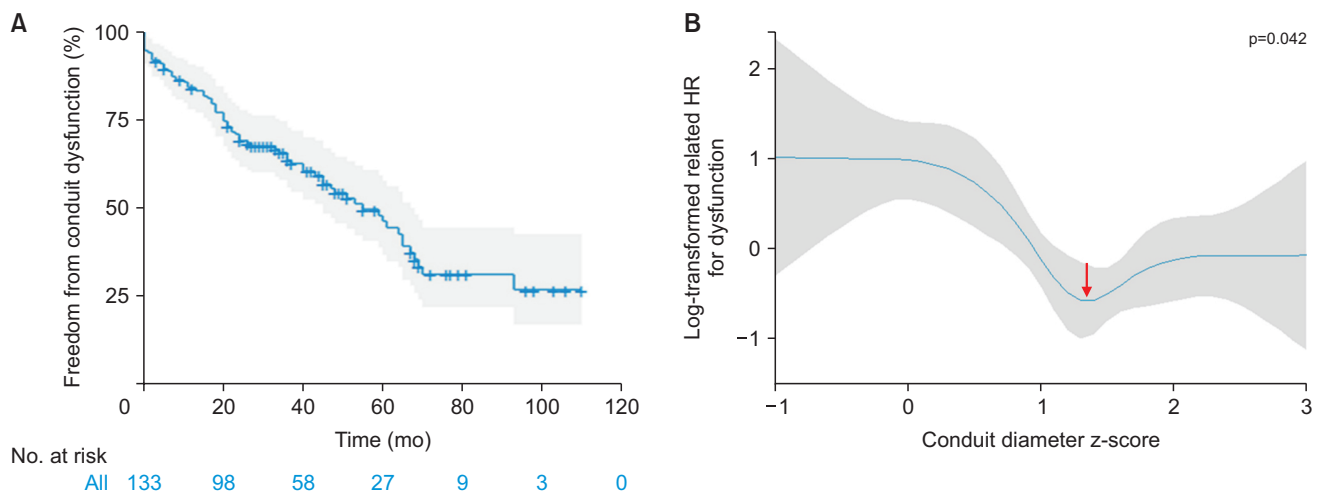

Fig. 3. Conduit dysfunction following right ventricle to pulmonary artery (RV-PA) conduit insertion. (A) Kaplan-Meier curve for freedom from conduit dysfunction, and (B) a partial effect plot for RV-PA conduit diameter z-score and the log-transformed related hazard ratio (HR) for conduit dysfunction. The shaded area represents the 95% confidence interval. The arrow indicates the conduit diameter z-score (1.4) with the lowest risk of conduit dysfunction.

count for this nonlinearity, restricted cubic splines were used to model the relationship, and this showed that the lowest risk was at a conduit diameter z-score of 1.4 (Fig. 3B).

Discussion

The use of an RV-PA conduit to establish continuity between the ventricle and pulmonary circulation is essential for achieving complete repair of various congenital cardiac defects associated with a discontinuity between the RV and

the PA.

Corrective surgery, including RVOT reconstruction using an RV-PA conduit, is a safe procedure with a low risk of death. The findings of this study also support this conclusion, although overall mortality was not negligible. Younger age and longer CPB time were identified as risk factors for death. A possible explanation is that younger patients requiring repair had more severe disease; therefore, poor preoperative conditions might have affected their surgical outcomes. In addition, a longer CPB time might have been associated with mortality because it indi-

Table 6. Factors associated with conduit dysfunction (n=68)

Variable	Univariable analysis		Multivariable analysis	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Age at operation (mo)	0.89 (0.83–0.95)	0.001	0.86 (0.78–0.95)	0.003
Weight at operation (kg)	0.83 (0.73–0.93)	0.003		
Prematurity	0.49 (0.22–1.07)	0.076		
Previous palliative cardiac surgery	0.49 (0.30–0.81)	0.005	1.15 (0.56–2.36)	0.699
Chromosomal abnormality	0.74 (0.38–1.42)	0.374		
Conduit diameter, z-score	0.58 (0.42–0.81)	<0.001	0.67 (0.48–0.95)	0.024
Concomitant pulmonary arterioplasty	0.62 (0.37–1.03)	0.068		
Type of conduit	1.35 (1.07–1.70)	0.010	1.29 (0.95–1.75)	0.094
Contegra conduit	Reference			
Valved PTFE conduit	1.18 (0.65–2.14)	0.574		
Valveless PTFE	5.98 (3.22–11.10)	<0.001		
Hancock valved conduit	0.81 (0.24–2.68)	0.736		
Primary cardiac diagnosis	1.11 (0.93–1.32)	0.166		
Cardiopulmonary bypass time	1.00 (0.99–1.00)	0.709		
Aortic cross-clamp time	1.01 (1.00–1.02)	0.003	1.01 (1.00–1.02)	0.009

HR, hazard ratio; CI, confidence interval; PTFE, polytetrafluoroethylene.

cates higher disease complexity and a poorer heart condition before surgery.

Although previous studies have reported significant improvements in the survival of RVOT reconstruction using an RV-PA conduit, the rate of conduit reintervention remains high [2]. Caldarone et al. [7] reported a strong relationship between conduit failure and age at the time of implantation, and Willetts et al. [1] reported that weight was the most significant factor associated with conduit failure. Similarly, younger age was identified as an independent risk factor for conduit dysfunction in our study. Because the available conduit size is limited in small babies regardless of the conduit type, placing an adequate-sized conduit within the limited space is difficult; consequently, external compression, which may cause conduit failure, is more likely to occur [9,10]. Furthermore, age-related immune mechanisms that affect conduits are more prevalent in younger patients, and the likelihood of requiring reintervention increases over time because of rapid degeneration and calcification [4,6,11]. Saxena et al. [3] also reported that most patients required conduit replacement before 5 years of age. Thus, the selection of the conduit type or size in small patients such as neonates and infants is challenging, which is why we exclusively enrolled and evaluated patients aged <1 year in this study.

An interesting finding in our study was that a longer ACC time was a risk factor for conduit dysfunction. Given that most patients who require longer ACC may be younger, the same explanation about the association between younger age and conduit dysfunction may be applicable to that between conduit dysfunction and longer ACC time.

Although an appropriate conduit size is critical for the longevity of the implanted RV-PA conduit in young children [12,13], earlier studies have made inconsistent recommendations regarding the conduit size. Poynter et al. [14] noted that an oversized conduit could be advantageous for durability when considering somatic growth in patients aged <2 years. Conversely, Askovich et al. [15] demonstrated that an oversized conduit with a z-score ≥2.7 may reduce the durability of the conduit. An oversized conduit may lead to external compression of the conduit because of the limited space and subsequent pulmonary valve distortion and distal PA distortion attributable to accelerating pulmonary valve insufficiency and failure [7,15,16].

In the present study, the conduit diameter z-score was identified as a shared risk factor for both conduit reintervention and conduit dysfunction, and the results indicated that a higher conduit diameter z-score was associated with lower risk. Furthermore, the lowest risk was observed at a conduit diameter z-score of 1.3 for conduit reintervention and a conduit diameter z-score of 1.4 for conduit dysfunction, which suggests that a too-large or too-small conduit diameter could be disadvantageous for the patients. Karamlou et al. [12] reported that a conduit diameter z-score of 1–3 was associated with improved outcomes in patients aged <2 years at initial implantation. Recently, Kim et al. [17] suggested that an oversized conduit may have poor longevity, and even without a valve, smaller conduits may be better for small babies.

Allografts have been predominantly used to establish

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RV-PA connections for over 50 years and have long been believed to be the most durable option. However, many countries and centers, including ours, are experiencing extreme graft shortages. Therefore, since 2011, alternative conduits such as homemade PTFE membrane-valved or non-valved PTFE conduits, Contegra, and Hancock have been exclusively used at our center.

Since its introduction in 1999, Contegra has been predominantly used in many countries because of its advantages, such as being easy to handle and having a wide range of sizes for selection; furthermore, the durability of Contegra was comparable to that of homograft [6,10], and may even be better than that of homografts [16]. However, Mery et al. [13] reported that Contegra, particularly in younger patients, was associated with a higher incidence of distal conduit stenosis and early conduit insufficiency. Homemade PTFE valved conduits began to be used in earnest by Japanese groups and are a good alternative to RV-PA conduits, with a low risk of reoperation or reintervention [11,18-21]. Our center adopted a homemade tricuspid PTFE-valved conduit that was made using the technique introduced by Kim et al. [22] in 2013. Hancock conduits have been used for a long time and have shown comparable outcomes to those of other RV-PA conduits in previous studies [6,23]. In the present study, no conduit was clearly superior to others in terms of longevity. Hopefully, future research will suggest suitable conduits for each patient with different characteristics based on the advantages and disadvantages of each conduit type.

Limitation

This study has inherent limitations because of its retrospective design. Throughout the study period, the predominantly used conduits changed based on their availability and surgeons' preferences, without definitive criteria. This variation precludes a fair comparison and hinders the ability to draw meaningful conclusions. Although the number of events was sufficient to conduct a multivariable analysis, readers should cautiously interpret the results because of the small number of patients and events.

Conclusion

The results of this study reveal that RV-PA conduit placement in infants can be performed safely. A significant number of patients required conduit reintervention and had conduit dysfunction. A slightly oversized conduit with a z-score of 1.3 might reduce the risk of conduit reintervention or dysfunction.

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Conflict of interest

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

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