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Palliative Cardiac Surgery for Trisomy 13 and Trisomy 18 Improves Heart Failure and Facilitates Transition to Home Care

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Research Article

Keywords: Trisomy 18, Trisomy 13, Congenital heart disease, Palliative cardiac surgery, Home care transition

Posted Date: November 17th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11617660/v1

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Additional Declarations: No competing interests reported.

Palliative Cardiac Surgery for Trisomy 13 and Trisomy 18 Improves Heart Failure and Facilitates Transition to Home Care

Article Type: Original Article

Running Head: Palliative Cardiac Surgery in T13 and T18

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Word Count (Abstract): 381 words

Word Count (Main Text): 2669 words

Total Number of Figures: 1

Total Number of Tables: 2 (Table 1, Table 2A–C;)

Abstract

Background: Congenital heart disease (CHD) occurs in 80%–90% of infants with trisomy 13 (T13) and trisomy 18 (T18). Although surgical intervention remains controversial due to limited life expectancy, palliative cardiac surgery may improve heart failure symptoms and facilitate transition to home care. This study aimed to evaluate the clinical profiles, surgical outcomes, and discharge rates of infants with T13 and T18 who underwent cardiac surgery.

Methods: We retrospectively reviewed 22 consecutive patients with T13 or T18 and CHD who underwent initial cardiac surgical intervention between April 2013 and March 2024 at our institution.

Results: The cohort comprised 22 patients (T18: n = 19; T13: n = 3). Primary intracardiac diagnoses were ventricular septal defect (VSD) in 12 cases, double outlet right ventricle (DORV) in 6 cases, patent ductus arteriosus (PDA) in 3 cases, coarctation of the aorta (CoA) complex in 1 case, and interrupted aortic arch (IAA) in 1 case. All initial surgical interventions were performed off-pump. At surgery, the median age was 25 [interquartile range (IQR) 16–30] days, body weight was 1.59 [1.35–1.75] kg, and median height was 41.0 [38.6–44.3] cm. Median gestational age at birth was 37 [34–38] weeks, and 14 patients had a prenatal diagnosis. Associated comorbidities included gastrointestinal anomalies in 7 cases, neurological conditions in 3 cases, and respiratory disorders in 2 cases. Serial measurements of serum B-type natriuretic peptide (BNP) levels demonstrated a statistically significant reduction postoperatively (preoperative: 736.5 [441.2–3316] pg/mL vs. postoperative: 164.7 [133.2–335.6] pg/mL; $p < 0.05$). Postoperative complications occurred in 5 patients (23%), including phrenic nerve palsy (n = 2), chylothorax (n = 2), and arrhythmia (n = 1). Overall, 18 patients (82%) were successfully discharged home (home oxygen therapy: n = 5 [23%];

tracheostomy: n = 2 [9%]). Two patients (9%) subsequently achieved definitive biventricular repair. Total overall mortality was 36% (n = 8), with a 90-day mortality rate of 4% (n = 1) and an in-hospital mortality rate of 14% (n = 3).

Conclusion: Palliative cardiac surgery in selected infants with T13 and T18 effectively alleviates heart failure and facilitates transition to home care. Surgical strategies should be tailored to individual family values and clinical conditions through multidisciplinary shared decision-making.

Keywords: Trisomy 18; Trisomy 13; Congenital heart disease; Palliative cardiac surgery; Home care transition

List of Abbreviations

ASD: Atrial septal defect

BNP: B-type natriuretic peptide

CHD: Congenital heart disease

CoA: Coarctation of the aorta

DORV: Double outlet right ventricle

IAA: Interrupted aortic arch

IQR: Interquartile range

PAB: Pulmonary artery banding

PDA: Patent ductus arteriosus

VSD: Ventricular septal defect

PFO: Patent foramen ovale

SSS: Sick sinus syndrome

Introduction

Trisomy 18 (Edwards syndrome) and trisomy 13 (Patau syndrome) are common chromosomal abnormalities associated with severe developmental delay, multiple congenital malformations, and high infant mortality. Congenital heart disease (CHD) is present in 80% to 90% of affected infants, with ventricular septal defect (VSD), patent ductus arteriosus (PDA), atrial septal defect (ASD), and double outlet right ventricle (DORV) being common manifestations.

Historically, conservative or non-interventional management was the standard approach due to dismal life expectancy. However, recent clinical reports suggest that cardiac surgical intervention can significantly relieve heart failure symptoms, improve early survival, and assist in transitioning infants from prolonged intensive care stays to home care with their families [1–3]. Despite these emerging benefits, surgical management of CHD in patients with T13 and T18 remains a subject of active debate [3–5].

At our center, we employ a multidisciplinary strategy involving neonatologists, pediatric cardiologists, cardiovascular surgeons, and clinical psychologists to engage families in comprehensive counseling. Surgical intervention is considered a viable option when the primary objective is to improve quality of life and achieve transition to home care. This study evaluated our single-center experience with cardiac surgical intervention in patients with T13 and T18.

Materials and Methods

Study Population and Design

We performed a single-center, retrospective chart review of all consecutive infants with T13 or T18 who underwent initial cardiac surgery between April 2013 and March 2024. Diagnosis of T13 or T18 was confirmed by standard cytogenetic analysis (G-banding) or chromosomal

microarray. Clinical variables collected included gestational age, birth weight, sex, cardiac and extra-cardiac malformations, preoperative intubation, surgical procedure and approach, laboratory values, postoperative complications, length of hospital stay, rate of home discharge, and survival outcomes.

Institutional Decision-Making Policy

When T13 or T18 is suspected prenatally, multidisciplinary meetings involving obstetrics, neonatology, pediatric cardiology, and clinical psychology are held to counsel the family and formulate a perinatal management strategy. Postnatally, accurate diagnostic information and therapeutic options are discussed thoroughly with the parents. If surgical intervention is desired by the family, joint conferences with neonatologists, pediatric cardiologists, and cardiac surgeons are conducted. In favorable cases, staged therapeutic plans aimed toward ultimate radical repair are considered.

Statistical Analysis

All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were expressed as median [interquartile range (IQR)] for continuous variables and as counts and percentages (%) for categorical variables. Differences between paired preoperative and postoperative continuous values were analyzed using the Wilcoxon signed-rank test. A p-value of < 0.05 was considered statistically significant.

Results

Patient Demographics and Baseline Characteristics

A total of 22 patients were included in this study (T18: n = 19; T13: n = 3, including two mosaic cases [2% and 40% mosaicism]). The cohort comprised 18 females and 4 males. The median gestational age at birth was 37 [IQR: 34–38] weeks. Median age was 25 [16–30] days, body weight was 1.59 [1.35–1.75] kg, and height was 41.0 [38.6–44.3] cm. Associated extra-cardiac anomalies were identified in several patients, including omphalocele (n = 2), tracheoesophageal fistula / esophageal atresia (n = 2), malrotation (n = 1), hiatus hernia (n = 1), gastric volvulus (n = 1), and cerebellar hypoplasia (n = 1). Preoperative endotracheal intubation was required in 16 patients (73%), with a duration ranging from 1 to 88 days prior to surgery. Detailed baseline clinical characteristics, operative procedures, and perioperative factors are summarized in Table 1.

Surgical Details and Hemodynamic Response

Surgical approaches were lateral thoracotomy in 15 patients (68%) and median sternotomy in 7 patients (32%). Primary operative procedures performed were:

• PAB: n = 7 (32%)

• Combined PAB and PDA ligation: n = 5 (23%)

• PDA ligation: n = 3 (14%)

• Bilateral PAB: n = 2 (9%)

• PAB with pacemaker implantation (PMI): n = 1 (5%)

• Other combined procedures: n = 4 (18%)

Serial measurements of serum B-type natriuretic peptide (BNP) levels (n = 20; 2 patients excluded due to missing postoperative measurements) demonstrated a statistically significant reduction postoperatively. Preoperative mean serum BNP level was 736.5 [441.2–3316] pg/mL, which sharply declined to164.7 [133.2–335.6] pg/mL postoperatively (Figure 1; $p < 0.05$). The boxplot distribution highlights a marked decrease in both the median value and

interquartile range postoperatively, reflecting successful relief of pulmonary hyperperfusion and cardiac volume overload following palliative interventions.

Postoperative Complications and Clinical Outcomes

Postoperative outcomes, complications, mortality, and surgical stage progression are summarized in Table 2. Median follow-up period is 63 [32–114] months.

• Postoperative Complications: Occurred in 5 patients (23%), including phrenic nerve palsy requiring diaphragm plication (n = 2, 9%), chylothorax / chylopericardium (n = 2, 9%), and arrhythmia (n = 1, 5%) (Table 2A).

• Mortality: Total overall mortality during the follow-up period was 36% (n = 8). The 90-day mortality rate was 4% (n = 1), in-hospital mortality was 14% (n = 3), and post-discharge mortality was 18% (n = 4). The median age at death was 13.5 [7-33] months (Table 2B).

• Transition to Home Care: Overall, 18 patients (82%) achieved successful transition to home care. Among them, 5 (23%) required home oxygen therapy and 2 (9%) underwent tracheostomy prior to discharge (Table 2C). Median hospital stay period was 89.5 [67.5–175] days.

• Definitive Repair: Two patients (9%) whose families requested definitive cardiac repair following initial palliative surgery successfully achieved biventricular repair (1 VSD closure and 1 DORV repair).

Discussion

In this single-center retrospective study, palliative cardiac surgical intervention in 22 infants with T13 and T18 led to substantial hemodynamic improvement and facilitated an 82% rate of successful transition to home care. Furthermore, two patients (9%) achieved complete definitive repair following initial palliation. These findings contribute to the growing

international body of evidence challenging the historical paradigm that cardiac intervention in patients with T13 and T18 is non-beneficial or 'futile' [3–7].

Evolving Paradigms and Clinical Guidelines

Historically, T13 and T18 were considered universally lethal conditions, and comfort care was almost exclusively recommended. However, recent large-scale population studies and clinical guidelines have shifted this perspective toward individualized, family-centered decision-making [1, 3, 6]. The 2023 American Association for Thoracic Surgery (AATS) Expert Consensus Document explicitly states that treatment decisions should not be based solely on the presence of trisomy, but rather on a case-by-case evaluation considering cardiac lesion complexity and coexisting extracardiac anomalies (Class IIa, LOE C-LD) [6]. Nationwide data from Japan show that active management—including palliative surgery in 33% and radical repair in 5%—is increasingly offered [2, 8]. Recent comparative analyses by Koshida et al. further demonstrate that active neonatal intensive care significantly improves 3-year survival rates (33% vs. 0%, $p < 0.001$) and hospital discharge rates (50% vs. 0%, $p = 0.049$) compared to conservative non-intensive care [9]. Our institution's experience reflects this modern era of proactive intervention, demonstrating that well-selected infants can achieve high discharge rates (82%) when surgical management is integrated into a comprehensive care framework.

Hemodynamic Relief, Pulmonary Vascular Protection, and Timing of Surgery

A major mechanism by which palliative procedures (such as PAB and PDA ligation) confer a survival benefit is the control of pulmonary hyperperfusion and prevention of early pulmonary vascular disease (PVD). Histopathological studies have confirmed that infants with T18 and T13 have a marked structural predisposition to early-onset medial hypertrophy and pulmonary arteriopathy. Uncontrolled left-to-right shunting rapidly leads to irreversible

pulmonary hypertension, which directly increases both in-hospital and late mortality. In our cohort, PAB and/or PDA ligation effectively reduced cardiac volume overload, reflected in the sharp postoperative decline in serum BNP.

Regarding surgical strategy, controversy remains as to whether primary complete repair or staged palliation is superior [6, 7, 10, 11]. Recent evidence from Greene et al. demonstrated that primary cardiac repair in two-ventricle CHD yields excellent 1-year (79%) and 5-year (70%) survival rates compared to non-operated controls (52% and 35%, respectively; HR 3.28) [7]. Similarly, Peterson et al. noted that older and heavier infants (>3 kg, >3 months) who underwent complete repair achieved superior long-term survival compared to those requiring early neonatal palliation [10]. Conversely, Nakai et al. showed that initial PAB significantly prolonged survival in infants with acute heart failure who were too fragile for open-heart surgery [11]. In our institution, initial palliation was selected for high-risk neonates as a life-saving bridge to control heart failure, stabilize hemodynamics, and enable discharge home. For infants with favorable ongoing clinical trajectories, complete repair can subsequently be pursued, as achieved in two of our cases.

Comorbidities, Technological Dependency, and Healthcare Utilization

Despite the survival benefits of cardiac intervention, healthcare providers and families must remain fully cognizant of the significant postoperative morbidity and ongoing medical resource utilization [1, 3]. Cortezzo et al. highlighted that surviving infants with T13 and T18 exhibit high healthcare utilization throughout their lifespans, characterized by frequent hospital readmissions (up to 48%), prolonged hospitalizations, and technology dependency [1]. In our series, postoperative complications occurred in 23% of patients, including phrenic nerve palsy requiring diaphragm plication (9%) and chylothorax/chylopericardium (9%). Furthermore, 23% of discharged infants required home oxygen therapy and 9% required tracheostomy. For PDA ligation, a left-sided thoracotomy was initially the preferred

approach; however, suspecting that intraoperative compression of the diaphragm might be more likely to induce nerve paralysis in these patients compared to those without T13/18 trisomy, we shifted to a median sternotomy as the primary approach during the latter part of the cohort study.

Extracardiac anomalies—such as esophageal atresia, omphalocele, and central apnea—substantially increase perioperative complexity [1, 3, 6]. The AATS guidelines advise that major extracardiac defects should be adequately managed prior to or in conjunction with cardiac procedures (Class IIb, LOE C-LD) [6]. Preoperative mechanical ventilation is a well-established risk factor for increased mortality and long-term tracheostomy dependence [4, 10]. However, as emphasized in recent consensus guidelines, ventilator dependency alone should not serve as an absolute contraindication to surgery, as relieving pulmonary overcirculation can facilitate successful weaning from respiratory support [6]. In our series, despite 73% of cases being intubated preoperatively, 82% were discharged home, and only two of those required a tracheostomy. This suggests that unnecessary hesitation should be avoided.

Multidisciplinary Decision-Making and Family-Centered Care

The decision to offer cardiac surgery to an infant with T13 or T18 cannot be dictated solely by anatomical feasibility; it requires an alignment of medical goals with family values through shared decision-making [3, 6]. As supported by AATS recommendations, an interdisciplinary team—comprising neonatologists, pediatric cardiologists, cardiac surgeons, clinical psychologists, and pediatric palliative care specialists—should engage families prenatally or early postnatally [6]. Establishing a clear birth plan and setting realistic goals (e.g., controlling symptoms, achieving home discharge, and maximizing meaningful family interaction) helps mitigate conflict and ensures holistic patient care [3, 6].

Limitations

This study has several limitations. First, its retrospective, single-center design with a relatively small sample size (n = 22) limits statistical power and generalizability. Second, potential referral and selection biases exist regarding which families chose to pursue surgical intervention versus conservative care. Finally, long-term functional and neurodevelopmental quality-of-life assessments were not formally quantified using standardized instruments. Future multi-center prospective registries evaluating long-term survival, functional outcomes, and family quality of life are strongly warranted.

Conclusion

Palliative cardiac surgery for infants with T13 and T18 effectively alleviates heart failure symptoms, reduces serum BNP levels, and supports high rates of transition to home care. In selected cases with favorable conditions, progression to definitive repair is achievable. A tailored therapeutic approach based on thorough multidisciplinary discussion and parental values remains imperative.

Statements and Declarations

Funding: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing Interests: The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Review Board of Toho University Omori Medical Center (M24078).

Consent to Participate / Consent for Publication: Informed consent for surgical procedures, data collection, and publication was obtained from the parents or legal guardians of all individual participants included in the study.

Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Use of Generative AI Statement: During the preparation of this manuscript, the authors used Gemini (Google LLC, Mountain View, CA, USA) for language editing, readability refinement, and manuscript formatting. The authors reviewed and edited all content as necessary and take full responsibility for the content of the published article.

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Table Legends

Table 1. Patient Characteristics, Surgical Procedures, and Perioperative Factors (N = 22). Detailed individual clinical profiles including karyotype, intracardiac lesions, associated extra-cardiac anomalies, preoperative endotracheal intubation status and duration, primary surgical procedures, and surgical approach.

Abbreviations: GA, gestational age; mo, months; BW, body weight; Preop Vent, preoperative endotracheal intubation/mechanical ventilation; PDA, patent ductus arteriosus; PFO, patent foramen ovale; VSD, ventricular septal defect; SSS, sick sinus syndrome; TEF, tracheoesophageal fistula; DORV, double outlet right ventricle; ASD, atrial septal defect; CoA, coarctation of the aorta; IAA, interrupted aortic arch; vPS, valvular pulmonary stenosis; PAB, pulmonary artery banding; lig., ligation; PMI, permanent pacemaker implantation.

Table 2. Postoperative Complications, Survival Outcomes and Discharge Status (N = 22).

• Table 2A. Postoperative Complications in Patients Receiving Cardiac Surgery (N = 22). Breakdown of overall complications including phrenic nerve palsy, chylothorax/chylopericardium, and arrhythmia.

• Table 2B. Mortality and Timing of Death (N = 22). Overall mortality, 90-day mortality, in-hospital mortality, post-discharge mortality, and mean age at death.

• Table 2C. Clinical Outcomes and Transition to Home Care (N = 22). Successful home discharge rates, post-discharge medical technology dependency (home oxygen therapy and tracheostomy).

Figure Legends

Figure 1. Comparison of preoperative and postoperative serum B-type natriuretic peptide (BNP) levels (n = 20, two patients without postoperative BNP measurements were excluded). BNP levels demonstrated a statistically significant reduction postoperatively (preoperative:

736.5 [441.2–3316] pg/mL vs. postoperative: 164.7 [133.2–335.6] pg/mL; $p < 0.05$; Wilcoxon signed-rank test). The boxplot displays the median, interquartile range (IQR), whiskers, and individual outliers.

Table 1. Patient Characteristics, Surgical Procedures, and Perioperative Factors (N = 22)

Case	Sex	GA	Age (mo)	BW (kg)	Karyotype	Intracardiac Lesions	Extra-cardiac Anomalies	Preop Vent	Preop Vent Duration (days)	Surgical Procedure	Approach
1	F	41w0d	0	1.7	T18	PDA, PFO	Omphalocele	+	8	PDA lig.	Thoracotomy
2	M	37w5d	2	1.7	T18	VSD, SSS	TEF	+	88	PAB, PMI	Sternotomy
3	F	35w0d	1	1.2	T18	VSD	None	+	3	PDA lig.	Thoracotomy
4	F	39w2d	1	1.8	T18	DORV	None	-	-	PAB	Thoracotomy
5	F	39w3d	1	2.0	T18	VSD, ASD	None	-	-	PAB	Sternotomy
6	F	38w3d	0	1.4	T18	VSD, PDA	None	+	8	PAB, PDA lig.	Thoracotomy
7	F	38w2d	0	1.5	T18	VSD, PDA	None	-	-	PDA lig.	Thoracotomy
8	F	40w3d	1	1.6	T18	VSD, PDA	Malrotation	-	-	PAB, PDA lig.	Thoracotomy
9	F	38w1d	1	1.8	T18	VSD, PDA	None	+	35	PAB, PDA lig.	Thoracotomy
10	F	37w0d	0	1.7	T18	VSD, PDA	None	+	1	PAB, PDA lig.	Thoracotomy
11	F	31w5d	3	1.6	T18	VSD	None	-	-	PAB	Sternotomy
12	F	37w6d	0	2.8	T13	VSD, PDA	Hiatus hernia, Omphalocele	+	4	PAB, PDA lig.	Thoracotomy
13	M	37w6d	0	1.3	T18	VSD, PDA, CoA	None	+	22	PAB, PDA lig.	Thoracotomy
14	F	34w2d	1	1.3	T18	IAA (type B)	None	+	49	Bilateral PAB	Sternotomy
15	M	34w6d	1	1.5	T18	VSD, PDA	Gastric volvulus, Cerebellar hypoplasia	+	6	PAB	Thoracotomy
16	F	37w2d	1	1.8	T18	DORV	Esophageal atresia	+	58	PAB	Thoracotomy
17	F	34w6d	0	1.0	T18	DORV, PDA	None	+	17	PAB, PDA lig.	Thoracotomy
18	F	34w5d	0	1.4	T13	DORV	None	+	20	PAB	Thoracotomy
19	F	33w5d	0	1.1	T18	VSD, PDA	None	+	15	PAB, PDA lig.	Sternotomy
20	F	38w4d	0	1.7	T18	DORV, vPS, PDA	None	+	2	PAB	Thoracotomy
21	F	33w0d	1	1.6	T13	DORV	None	+	30	PAB	Sternotomy
22	M	34w0d	0	0.9	T18	CoA complex	None	+	12	Bilateral PAB	Sternotomy

Table 2A. Postoperative Complications in Patients Receiving Cardiac Surgery (N = 22)

	n	(%)
Overall Complications	**5**	**23**
Phrenic nerve palsy (requiring diaphragm plication)	2	9
Chylothorax / Chylopericardium	2	9
Arrhythmia	1	4

Table 2B. Mortality and Timing of Death (N = 22)

	n	(%)
Overall Mortality	**8**	**36%**
90-day mortality	1	4%
In-hospital mortality	3	14%
Post-discharge mortality	4	18%
Age at death (months)	—	13.5 [7-33]

Table 2C. Clinical Outcomes and Transition to Home Care (N = 22)

	n	(%)
Successful Home Discharge	**18**	**82%**
Home oxygen therapy	5	23%
Tracheostomy	2	9%

Figure 1.

