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Factors Prolonging Length of Stay in the Cardiac Intensive Care Unit Following the Arterial Switch Operation

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Abstract

The arterial switch operation has become the preferred procedure for surgical management of transposition of the great arteries. We conducted a retrospective evaluation of our experience in sixty-one infants with transposition from January, 1997 to July, 2003 in order to determine the factors that are associated with a prolonged postoperative course following the arterial switch operation. Factors independently associated with a prolonged postoperative stay in the cardiac intensive care unit included prematurity, difficulty feeding, capillary leak, need for preoperative inotropic support, and postoperative infectious complications. Future research designed to minimize the impact of capillary leak and postoperative infectious complications is warranted. In addition, based on these results, our practice has evolved to initiate enteral feedings in the preoperative period if feasible and to resume enteral feedings as soon as possible following surgery.

Keywords

transposition of the great arteries; congenital heart disease; Taussig-Bing anomaly; residual cardiac abnormalities; pediatric cardiac intensive care

Introduction

The arterial switch operation¹ has become the preferred procedure for surgical management of transposition of the great arteries (defined as the combination of concordant atrioventricular with discordant ventriculo-arterial connections).^{2–6} While the postoperative management of these patients is usually straightforward, a small proportion of infants with transposition still experience a complicated and prolonged postoperative course following the arterial switch operation. A recent study suggests that longer postoperative cardiac intensive care unit length of stay is independently associated with worse cognitive function at 8 years of age.⁷ While residual cardiac and hemodynamic abnormalities increase the risk of readmission to the hospital⁸ and are likely to prolong postoperative length of stay following the arterial switch operation, supportive data are lacking.⁹ We therefore reviewed our experience with the arterial switch operation from January, 1997 to July, 2003 in order to determine what factors, including residual cardiac and hemodynamic abnormalities, are associated with a prolonged postoperative course.

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Materials and Methods

The records of all children undergoing the arterial switch operation at our institution from January, 1997 to July, 2003 were reviewed following approval by the Institutional Review Board at the Cincinnati Children's Hospital Medical Center. Due to the retrospective nature of our study, the need for informed consent was waived. We reviewed hospital records, preoperative cardiac catheterizations, operative notes, and echocardiography reports up to 12 months following hospital discharge. The endpoint for the definition of length of stay was defined prospectively as the day at which the patient met discharge criteria from the cardiac intensive care unit (breathing comfortably on supplemental oxygen via nasal cannula at 1 liter per minute or less with fractional inhaled oxygen less than or equal to 0.30; stable and normal hemodynamics, heart rate, blood pressure on oral medications only). We used the number of days in the cardiac intensive care unit rather than the number of hours in order to avoid any potential differences in time of discharge due to extraneous factors (nursing issues, bed availability, discharge in the middle of the night, etc).

We recorded and analyzed anatomic factors, including presence of a ventricular septal defect, aortic arch obstruction (coarctation of the aorta or interrupted aortic arch), or abnormal coronary artery anatomy. We recorded and analyzed preoperative factors, including prematurity, birth weight, age at surgery, presence of extracardiac anomalies, preoperative length of stay, and the need for inotropic support, mechanical ventilatory support, or prostaglandin E₁ on the morning of surgery. We recorded and analyzed intraoperative factors, including surgeon, total cardiopulmonary bypass time, aortic cross-clamp time, and circulatory arrest time. Finally, we analyzed postoperative factors, such as postoperative bleeding, cardiac tamponade, chylothorax, pneumothorax, infection, diaphragmatic paralysis, presence of seizures or other central nervous system (CNS) complications, history of feeding difficulties, need for inotropic support (inotrope score on postoperative day 1, 2, and 3, as well as the length of time inotropic support was required), duration of mechanical ventilatory support, need for extracorporeal life support or inhaled nitric oxide, fluid balance (recorded from the hourly intake/output) on postoperative day 1 and 2, PaO₂/FIO₂ (P/F) ratio on postoperative day 1 and 2, oxygenation index (OI) on postoperative day 1 and 2, dynamic lung compliance on postoperative day 1 and 2, and the presence of residual cardiac and hemodynamic abnormalities. The P/F ratio was calculated from oxygen saturation (measured via pulse oximetry) and arterial PaO₂ obtained from an indwelling arterial line and represented the lowest value measured on postoperative day 1 and 2. Similarly, the OI was calculated as (Mean Airway Pressure x FIO₂)/PaO₂. Dynamic lung compliance was calculated as the Expiratory tidal volume/(peak inspiratory pressure – positive end-expiratory pressure). Again, the lowest values measured on postoperative day 1 and 2 were used for both OI and dynamic lung compliance.

Bleeding complications were defined as uncontrolled mediastinal bleeding requiring surgical intervention despite correction of coagulopathy or thrombocytopenia. Infections were prospectively defined as any positive blood, urine, or respiratory culture; sepsis syndrome, defined according to the International Pediatric Sepsis Consensus Conference guidelines;¹⁰ surgical site infections, defined according to the Centers for Disease Control and Prevention;^{11, 12} catheter-associated bloodstream infections and ventilator-associated pneumonia, defined according to the National Nosocomial Infections Surveillance System.^{13, 14} We prospectively defined residual cardiac and hemodynamic abnormalities as one or more of the following: greater than or equal to moderate regurgitation of the systemic atrioventricular valve;¹⁵ greater than or equal to moderate regurgitation of a semilunar valve; greater than or equal to moderate ventricular dysfunction or dilation;¹⁵ residual coarctation with peak Doppler gradient 30 mm Hg or greater; right ventricular hypertension defined as greater than 50% left ventricular pressure; greater than or equal to moderate residual shunts at the atrial or ventricular level; or

arrhythmias which required treatment with medications and/or temporary pacing. Residual cardiac and hemodynamic lesions were noted on postoperative echocardiographic studies performed during the first week following surgery. Low cardiac output syndrome was defined as tachycardia, hypotension, low urine output (less than 0.5 milliliters per kilogram body weight per hour), acidosis, and clinical signs of tissue hypoperfusion despite maximal inotropic support (i.e. greater than 5 micrograms per kilogram body weight per minute dopamine AND 0.5 micrograms per kilogram body weight per minute milrinone).¹⁶ In order to quantify inotropic support both preoperatively and postoperatively, an inotrope score was calculated as the sum of all inotrope doses, correcting for potency (dopamine, dobutamine, amrinone=1, milrinone=15, epinephrine=100), as previously described.^{16, 17}

Data Analysis

Data was analyzed using SigmaStat for Windows Version 3.11 software (Systat Software, Inc, San Jose, CA). Data are described as frequencies, medians with ranges, and means with standard error of the mean, where appropriate. We chose to analyze factors that were associated with a prolonged postoperative cardiac intensive care unit length of stay, rather than total cardiac intensive care unit length of stay, in order to avoid confounding factors associated with the timing of surgery (scheduling, surgeon availability, etc). Correlation analyses were performed to determine which factors were associated with prolonged postoperative cardiac intensive care unit length of stay (Spearman, univariate regression). For purposes of model building, variables which were associated with postoperative cardiac intensive care unit length of stay at a p-value less than or equal to 0.10 were then included in a list of potential independent risk factors in stepwise linear regression analysis, with LOS the dependent variable. A p-value less than or equal to 0.05 was considered significant.

Results

Patient characteristics

During the study period, 61 arterial switch operations were performed by the same two surgeons. The study group comprised forty-one (67.2 percent) male and 20 female (32.8 percent) infants with a mean birth weight 3.53 plus or minus 0.07 kilograms (range 2.0 to 5.3 kilograms). Five (8.2 percent) infants were born prematurely (less than 34 weeks gestation), and additional extra-cardiac anomalies were present in 5 infants (8 percent), including renal agenesis, choanal atresia, congenital hydrocephalus, and lower extremity contractures.

Thirty-two infants (52 percent) had simple transposition: isolated ventriculoarterial discordance with an intact ventricular septum.¹⁸ Associated cardiac anomalies included a ventricular septal defect in 29 infants (48 percent), coarctation of the aorta in 5 infants (8 percent), and interrupted aortic arch (Type A) in 2 infants (3 percent). The Taussig-Bing malformation was present in 8 infants (13 percent).¹⁹ The great vessels were arranged in an anterior/posterior orientation in 54 infants (89 percent) and side-to-side orientation in 7 infants (11 percent). The coronary arteries were arranged in the usual pattern (left anterior descending and left circumflex arising from the left facing sinus, right coronary from the right facing sinus) in 43 infants (70 percent), circumflex from RCA in 6 infants (10 percent), single RCA in 4 infants (7 percent), single LCA in 3 infants (5 percent), inverted circumflex and RCA in 2 infants (3 percent), inverted in 1 infant (1 percent), intramural LCA in 1 infant (1 percent), and anomalous origin of the LCA from the pulmonary artery was present in 1 infant (1 percent).²⁰

Preoperative Management

Balloon atrial septostomy was performed in 42 infants (69 percent), most (40 infants, 95 percent) of which were performed at the bedside under echocardiographic guidance. Thirteen infants (21 percent) remained on mechanical ventilatory support, 21 infants remained ductal-

dependent on prostaglandin E₁ (34 percent), and 12 infants (20 percent) remained on inotropic support on the morning of surgery. The median inotrope score^{16, 17} in these 12 infants was 5. Three infants required inhaled nitric oxide and one required mechanical cardiac support preoperatively for pulmonary hypertension.

Surgical Management

The median age at surgery was 6 days (range 2 to 138 days). The arterial switch operation was performed as previously described^{1, 20-22} with few modifications. Briefly, arterial switch operation was performed using moderate hypothermic (28°C) cardiopulmonary bypass, bicaval cannulation, and no circulatory arrest. The arterial duct was ligated upon initiation of cardiopulmonary bypass. Myocardial protection was induced with antegrade blood cardioplegia. The right atrium was opened and the atrial and ventricular septal defects, if present were closed via this exposure. Subsequent doses of retrograde blood cardioplegic solution were delivered at 20 minute intervals through the remainder of the aortic cross clamp period. After coronary translocation and aortic reanastomosis, the defect in the posterior neo-pulmonary artery from coronary harvest was repaired with a pantaloony-shaped, autologous pericardial patch. Dopamine and milrinone infusions were routinely initiated prior to weaning from cardiopulmonary.¹⁶ All infants underwent conventional ultrafiltration during rewarming and modified ultrafiltration after separation from cardiopulmonary bypass. In cases with associated aortic arch obstruction (coarctation or interrupted aortic arch), deep hypothermia (18 °C) and a brief period of circulatory arrest were employed while aortic arch augmentation was performed utilizing a homograft or pericardial patch.^{23, 24}

Since August, 2000 we have adopted the practice of routine administration of methylprednisolone, 30 milligrams per kilogram body weight intravenously 6 hours before surgery.²⁵ Eighteen infants (28.6 percent) received corticosteroids prior to surgery. Length of stay was not significantly different between infants who received preoperative corticosteroids compared to those infants who did not receive preoperative corticosteroids (median 11 days versus 9 days, respectively; p-value equal 0.8). The median cardiopulmonary bypass time and aortic cross-clamp time was 210 minutes (interquartile range, 180 to 247 minutes) and 125 minutes (interquartile range, 105 to 156 minutes), respectively. Two infants were managed with deep hypothermic circulatory arrest with a median circulatory arrest time of 50 minutes. Delayed sternal closure was performed in 7 infants (11%). One infant could not be weaned from cardiopulmonary bypass and was placed on mechanical cardiac support for 3 days. Cardiac function recovered completely and the infant was tracheally extubated and transferred to the cardiology ward from the cardiac intensive care unit after 14 days.

Postoperative Management

Infants were sedated (fentanyl at 5-10 micrograms per kilogram body weight per hour or morphine sulfate at 0.1 milligrams per kilogram body weight per hour) and mechanically ventilated with a Servo 300 ventilator (Siemens Medical Solutions USA, Inc, Malvern, PA) in a synchronized intermittent mandatory ventilation, volume control mode with tidal volume set at 10-15 milliliters per kilogram body weight, positive end-expiratory pressure 4 to 5 centimeters H₂O, and inspiratory time 0.6 to 0.8 seconds. Baseline fractional inhalation of oxygen was adjusted to maintain systemic oxygen saturation 93-99% and ranged from 0.30 to 0.60. Baseline ventilator rate was adjusted to maintain normal pH and partial pressure of carbon dioxide. Mechanical ventilatory support was weaned by the respiratory therapist according to our local protocol, and tracheal extubation was performed following successful completion of a spontaneous breathing trial. Infants required a median of 76 hours (range, 24 to 248 hours) of mechanical ventilation post-operatively. Two infants failed the initial attempt at tracheal extubation and required an additional 24 hours of mechanical ventilation.

All infants received dopamine at 3 to 10 micrograms per kilogram body weight per minute and milrinone 0.3 to 0.75 micrograms per kilogram body weight per minute. Epinephrine 0.03 to 0.2 micrograms per kilogram body weight per minute and calcium chloride 10-20 milligrams per kilogram body weight per hour were administered to augment cardiac output and maintain adequate systemic blood pressure as necessary. Inotropic support was required for a median of 3 days (range, 2 to 11 days) post-operatively. Our practice is to continue low-dose inotropic support (generally, milrinone, 0.5 micrograms per kilogram body weight per minute and dopamine 3-5 micrograms per kilogram body weight per minute) until after tracheal extubation. However, once an infant is extubated, inotropic support is rapidly weaned and discontinued. Sixteen infants (26 percent) required temporary cardiac pacing via epicardial pacing wires to maintain adequate heart rate and cardiac output.

Enteral feedings were initiated prior to surgery in 37 infants (59 percent). Enteral feedings were re-initiated a median 2 days following surgery, with a median of 3 days required to establish full enteral nutrition. Eleven infants (18 percent) were discharged to home on nasogastric feedings. The remaining patients required a median 5 days to establish full enteral feedings by mouth.

Complications

There were no perioperative deaths, and all 61 infants survived to hospital discharge. Median hospital length of stay, cardiac intensive care unit length of stay, and postoperative cardiac intensive care unit length of stay were 15 days, 8 days, and 5 days, respectively. Forty-two residual cardiac abnormalities were noted in 27 infants (44 percent) (Table 1). Twenty children (33 percent) developed postoperative arrhythmias, all of which resolved by the time of discharge from the cardiac intensive care unit. Low cardiac output syndrome was diagnosed in 24 (39 percent) of children. Two children developed a chylothorax in the postoperative period requiring drainage via chest tube placement, while 4 children developed a pneumothorax requiring drainage via chest tube placement. Three children developed seizures, one of which had mild hydrocephalus on a subsequent head computerized tomography (CT) scan. These three children were treated with phenobarbital and remained seizure-free until hospital discharge. Thirteen children (21 percent) were treated for infectious complications, including 4 cases of culture-negative surgical wound infection and 9 cases of sepsis syndrome. However, only one of these children had a positive blood culture (*Enterococcus faecalis*). Nine children underwent additional surgical procedures prior to discharge. These included delayed sternal closure in 7 children, as well as re-exploration for post-operative bleeding in 2 children.

Factors associated with Postoperative Cardiac Intensive Care Unit Length of Stay

Not surprisingly, there was a significant linear correlation between cardiac intensive care unit postoperative length of stay and the duration of postoperative mechanical ventilatory support (Spearman correlation coefficient equal to 0.72, p-value less than 0.001), as well as the duration of inotropic support (Spearman correlation coefficient equal to 0.54, p-value less than 0.001). Similarly, there was a significant linear correlation between cardiac intensive care unit postoperative length of stay and the number of days before enteral feeds were initiated following surgery (Spearman correlation coefficient equal to 0.64, p-value less than 0.001), the number of days before full enteral feeds were established (Spearman correlation coefficient equal to 0.66, p-value less than 0.001), and the number of days before full oral feeds were established (Spearman correlation coefficient equal to 0.54, p-value less than 0.001). Several factors were correlated with increased cardiac intensive care unit postoperative length of stay on univariate analysis (Table 2). Pre-operative factors that were highly significant included prematurity (p-value equal 0.001), presence of aortic arch obstruction (p-value equal 0.03), the number of days requiring inotropic support prior to surgery (p-value equal 0.02), and lack of initiation of enteral feeding prior to surgery (p-value less than 0.001). Not surprisingly, the pre-

operative length of stay was also associated with a prolonged cardiac intensive care unit postoperative length of stay (p-value equal 0.05). The length of cardiopulmonary bypass, aortic cross-clamp time, and circulatory arrest time were not associated with prolonged cardiac intensive care unit post-operative length of stay. In addition, there was no significant difference in cardiac intensive care unit postoperative length of stay between the two surgeons. Postoperative factors that were highly significant included the P/F ratio (p-value equal 0.07) and OI (p-value equal 0.06) on postoperative day 1, net fluid balance on postoperative day 2 (p-value equal 0.004), and the duration of mechanical ventilation, both postoperative and total duration (both p-values less than 0.001). Also highly significant were the need for temporary pacing (p-value equal 0.04), and the number of days requiring inotropic support, both postoperatively (p-value equal 0.04) and total duration (p-value less than 0.001). Feeding problems were also significantly associated with prolonged length of stay, including the total number of days before initiating enteral feeding (p-value less than 0.001) and the total number of days to establish full oral feedings (p-value equal 0.001). Finally, infectious complications (p-value less than 0.001) and the presence of residual cardiac and hemodynamic abnormalities (p-value less than 0.001) were highly associated with prolonged postoperative cardiac intensive care unit length of stay.

All factors associated with increased cardiac intensive care unit postoperative length of stay on univariate analysis with a p-value less than or equal to 0.2 were subsequently included in a stepwise multiple regression analysis. Prematurity (p-value equal 0.012), infectious complications (p-value less than 0.001), the number of days requiring inotropic support prior to surgery (p-value equal 0.04), the net fluid balance on postoperative day 2 (p-value equal 0.004), and the number of days before enteral feeds was initiated following surgery (p-value equal to 0.01). Previous studies have suggested that low cardiac output syndrome is an independent risk factor for prolonged cardiac intensive care unit length of stay following cardiopulmonary bypass.⁹ We repeated stepwise multivariate regression analysis, combining low cardiac output syndrome with residual cardiac and hemodynamic abnormalities. The factors identified above remained independent predictors of prolonged cardiac intensive care unit length of stay.

Discussion

The arterial switch operation is the procedure of choice for surgical management of transposition due to excellent perioperative and long-term morbidity and mortality. For example, the Congenital Heart Surgeons Society reported 1-month, 1-year, and 5-year survival rates of 84 percent, 82 percent, and 82 percent, respectively in 513 infants (383 transposition with intact ventricular septum and 129 transposition with associated ventricular septal defect) following the arterial switch operation.²⁶ Several large centers have confirmed these results, including ours (100 percent survival at hospital discharge and at 1-year follow-up in the current series).^{4, 27-33} However, there remains a subset of infants with transposition in whom the postoperative course following the arterial switch operation is prolonged, which may have long term consequences, including less favorable long-term cognitive outcome.⁷ In our series of 61 infants with transposition, prematurity, infectious complications, the number of days requiring inotropic support prior to surgery, the net fluid balance on postoperative day 2, and a delay in initiating enteral feeds were all independently associated with a prolonged length of stay in the cardiac intensive care unit.

Dibardino and colleagues³⁴ recently reported that lower weight at operation, lower birth weight, and the presence of extracardiac anomalies were significant risk factors for prolonged cardiac intensive care unit and hospital length of stay in 125 infants following the arterial switch operation. Consistent with these data, prematurity was independently associated with prolonged cardiac intensive care unit length of stay in our series. Lower birth weight and lower

weight on the day of surgery were not associated with prolonged length of stay in the current series, though this may have been a reflection of the small sample size and the small number of patients in this category. However, even with a risk for prolonged postoperative stay, the available data strongly suggest that early arterial switch operation is preferable in this group of patients in order to minimize the risk of early surgical morbidity and mortality.³⁵⁻³⁷

The presence of associated cardiac defects (e.g., coarctation of the aorta, ventricular septal defect) and the need for preoperative mechanical ventilatory support have also been associated with prolonged cardiac intensive care unit length of stay following the arterial switch operation.^{34, 38} Consistent with these reports, the presence of aortic arch obstruction was associated with prolonged cardiac intensive care unit length of stay on univariate analysis in our series, but not on subsequent multivariate analysis. The results of our study support the view that single-stage primary repair of TGA with aortic arch obstruction is associated with acceptable morbidity and remains the procedure of choice.²⁴

Mackie and colleagues⁸ noted that residual cardiac and hemodynamic abnormalities increased the risk for readmission to the hospital following either arterial switch operation or the Norwood procedure. While it seems intuitive that residual cardiac and hemodynamic abnormalities would increase the length of cardiac intensive care unit and hospital stay, supportive data are lacking. Given the potential adverse effects of increased cardiac intensive care unit stay on long-term neurologic outcome,⁷ factors that prolong the postoperative course should be vigorously identified and minimized whenever feasible. While relatively common (27 out of 61, 44 percent), residual cardiac and hemodynamic abnormalities were not independently associated with prolonged cardiac intensive care unit length of stay in our series. We utilized a relatively liberal definition of residual lesions, which may have biased our results. Even when we included low cardiac output syndrome as a residual cardiac and hemodynamic abnormality, the results of our analysis did not change. Regardless, we continue to stress that residual cardiac and hemodynamic abnormalities should be suspected in children with a relatively complicated or difficult postoperative course following the arterial switch operation.

Feeding difficulties were also independently associated with prolonged postoperative cardiac intensive care unit length of stay in our series. One potential limitation of our series is the fact that feeding difficulties were defined prospectively by an increased number of days to initiate enteral feedings, and as such, feeding difficulties would be anticipated to be statistically associated with a prolonged length of stay. Nevertheless, difficulty in establishing a normal feeding routine remains a significant concern in discharge planning following neonatal cardiac surgery. Early introduction of oral feedings in preterm infants accelerates the time necessary for transition from tube feeding to oral feeding.^{39, 40} These findings support our preference to initiate tube or preferably oral enteral feedings during the preoperative period whenever feasible.

Postoperative infectious complications were also significantly associated with increased postoperative cardiac intensive care unit length of stay. Cardiopulmonary bypass, likely in combination with ischemia-reperfusion injury, hypothermia, and surgical trauma, elicits an inflammatory response that is characterized by activation of the complement cascade, release of endotoxin, activation of leukocytes and the vascular endothelium, and release of proinflammatory cytokines.^{41, 42} The administration of preoperative corticosteroids to attenuate this proinflammatory response has become relatively commonplace in most congenital heart centers today.^{25, 43} Myocardial dysfunction and tissue injury after cardiac surgery arises primarily from this cardiopulmonary bypass-related inflammatory response.⁴² In addition, cardiopulmonary bypass elicits a complex humoral and cellular-mediated immune response which may result in a transient and relative state of immune suppression, often referred to as "immunoparalysis".^{41, 44-46} For example, whole blood obtained from children

following cardiopulmonary bypass stimulated *ex vivo* with lipopolysaccharide results in markedly diminished proinflammatory cytokine production,⁴⁴ consistent with the phenomenon known as “endotoxin tolerance”.^{47, 48} Pertinent to the present discussion, this state of immunoparalysis may result in an increased risk of nosocomial infections in children undergoing cardiac surgery for palliation or repair of congenital heart disease.^{14, 49-51} Of note, the effect of preoperative corticosteroid administration on the incidence of postoperative infections is not known, and the number of infants who received corticosteroids in the current study was too small (28.6 percent) to definitively address this question. Given the implications, we strongly advocate implementing measures targeted at reducing the incidence of postoperative infections, such as ventilator-associated pneumonia, catheter-associated bloodstream infections, urinary tract infections, and sternal wound infections.

Cardiopulmonary bypass frequently results in systemic capillary leak, especially in neonates and young infants.⁵²⁻⁵⁴ The postoperative net fluid balance is frequently used as a crude measure of capillary leak. In the current series, the net fluid balance on postoperative day 2 was independently associated with an increased length of stay in the cardiac intensive care unit. These data suggest that further research on the early recognition and treatment of capillary leak is warranted and may result in improved outcomes following cardiopulmonary bypass.⁵⁵⁻⁵⁸

In conclusion, we describe our experience with arterial switch operations performed at our institution over an approximately 6-year period. Factors independently associated with a prolonged postoperative stay in the cardiac intensive care unit included prematurity, need for inotropic support prior to surgery, difficulty feeding, evidence of systemic capillary leak on postoperative day 2, and postoperative infectious complications. Given the association between prolonged postoperative stay in the cardiac intensive care unit and cognitive outcome,⁷ these factors should be minimized whenever possible. Future research designed to minimize the impact of capillary leak and postoperative infectious complications is warranted. In addition, based on these results, our practice has evolved to initiate enteral feedings in the preoperative period if feasible and to resume enteral feedings as soon as possible following surgery.

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Table 1

Forty-two residual cardiac abnormalities were noted in 27 patients following arterial switch operation for transposition during the study period.

RESIDUAL CARDIAC ABNORMALITIES	NO. OF LESIONS
Arrhythmias	(Total patients = 20)
Accelerated junctional rhythm	7
Junctional ectopic tachycardia	5
Atrioventricular block	4 [#]
Ectopic atrial tachycardia	2
Supraventricular tachycardia	1
Ventricular tachycardia	1
Residual shunts	(Total patients = 4)
Atrial level shunts	1
Ventricular level shunts	4
Residual anatomic lesions	(Total patients = 11)[*]
Mitral valve	2 (moderate regurgitation)
Tricuspid valve	6 (moderate regurgitation)
Pulmonary valve	2 (moderate stenosis)
Aortic valve	6 (5 moderate regurgitation, 1 stenosis)
Residual Coarctation	0
RV hypertension	1

[#] One patient developed 1st degree atrioventricular block, one patient developed 2nd atrioventricular block, and two patients developed complete atrioventricular block

^{*} Eight patients in this group also had co-existing arrhythmias and/or residual atrial-level or ventricular-level shunts

Table 2

Factors associated with increased postoperative length of stay in the cardiac intensive care unit (by univariate analysis) following the arterial switch operation.

Factors associated with increased postoperative Cardiac Intensive Care Unit Length of Stay		p-value
Preoperative factors		
Admission pH < 7.25, no. (%)	9 (14.7)	0.36
Admission base excess > -5, no. (%)	12 (19.7)	0.80
Prematurity (gestational age < 37 weeks), no. (%)	5 (8.2)	0.001
Birth weight < 5 th percentile, no. (%)	3 (5)	0.41
Birth weight (kg), median (IQR)	3.5 (3.1, 3.9)	0.68
Presence of extracardiac anomalies, no. (%)	5 (8.2)	0.59
Presence of ventricular septal defect, no. (%)	29 (48)	0.10
Presence of aortic arch obstruction, no. (%)	7 (11.5)	0.03
Presence of coronary artery anomalies, no. (%)	18 (29.5)	0.97
Balloon atrial septostomy, no. (%)	42 (69)	0.46
No. of days hospitalized prior to surgery, median (IQR)	5 (4, 8)	0.05
No. of days required inotropes before surgery, median (IQR)	0 (0, 5)	0.02
Enteral feeds not started before surgery, no. (%)	24 (39.3)	Less than 0.001
Need for ventilatory support on the morning of surgery, no. (%)	13 (21)	0.82
Need for PGE1 on the morning of surgery, no. (%)	21 (34)	0.99
Need for inotropic support on the morning of surgery, no. (%)	12 (19.7)	0.74
Intraoperative factors		
Age at surgery, median (IQR)	6 (4, 8.5)	0.77
Cardiopulmonary bypass time (mins), median (IQR)	210 (180, 247)	0.13
Aortic cross-clamp time (min), median (IQR)	125 (105, 156)	0.21
Circulatory arrest time (min), n=2		0.98
Need for delayed sternal closure, no. (%)	7 (11)	0.59
Preoperative steroids, no. (%)	18 (28.6)	0.31
Inotrope score immediately following surgery, median (IQR)	10 (10, 14)	0.95
Need for extracorporeal life support, no. (%)	1 (1)	0.14
Postoperative factors		
Net fluid balance, postoperative day 1 (mL), median (IQR)	+92 (35, 189)	0.90
Net fluid balance, postoperative day 2 (mL), median (IQR)	0 (-86, 95)	0.004
P/F Ratio, postoperative day 1	310 (200, 360)	0.07
P/F ratio, postoperative day 2	305 (222, 385)	0.67
OI, postoperative day 1	2.5 (2.0, 4.1)	0.06
OI, postoperative day 2	2.3 (1.9, 3.5)	0.40
Dynamic compliance, postoperative day 1	3.2 (2.8, 3.5)	0.42
Dynamic compliance, postoperative day 2	3.1 (2.6, 3.6)	0.69
Duration of mechanical ventilation, post-operative (h), median (IQR)	76 (51, 116)	Less than 0.001
Duration of mechanical ventilation, total (h), median (IQR)	111 (76, 170)	Less than 0.001

Factors associated with increased postoperative Cardiac Intensive Care Unit Length of Stay		p-value
Need for temporary pacing, no. (%)	16 (26.2)	0.04
Inotrope score, postoperative day 1, median (IQR)	11 (10, 16.25)	0.35
Inotrope score, postoperative day 2, median (IQR)	10 (8, 13)	0.14
No. of days required inotropes after surgery, median (IQR)	3 (2, 5)	0.04
No. of days required inotropes (total), median (IQR)	4 (3, 7)	Less than 0.001
No. of days to start enteral feeds following surgery, median (IQR)	2 (2, 3)	0.001
No. of days to full enteral feeds, median (IQR)	3 (2.25, 4.75)	Less than 0.001
No. of days to full po feeds	5 (3, 11)	0.001
Infection	13 (21)	Less than 0.001
Seizures, no. (%)	3 (4.9)	0.56
Chylothorax, no. (%)	2 (3.3)	0.21
Pneumothorax, no. (%)	4 (6.6)	0.78
Low cardiac output syndrome (LCOS), no. (%)	24 (39.3)	0.15
Presence of residual cardiac/hemodynamic abnormalities	27 (44)	Less than 0.001