TITLE: Variations in the Intensive Care Management and Course of Single Ventricle Patients Following Stage I Palliation: A Report from the National Pediatric Cardiology Quality Improvement Collaborative

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Abstract:

Quality initiatives can significantly improve care and outcomes in patients with chronic disease. Ten to fifteen percent of children with hypoplastic left heart syndrome (HLHS) die between the first and second palliative surgeries. To address this issue, the Joint Council on Congenital Heart Disease initiated a quality improvement project to enhance interstage survival following Stage I palliation. We report variations in the post-surgical intensive care course and management of the first 100 patients entered into the National Pediatric Cardiology Quality Improvement Collaborative data registry (NPC-QIC).

Using standardized data collection methods, we evaluated variation in the intensive care unit management and course of single ventricle infants requiring Stage I palliation. Patients were surgically treated at one of 21 contributing hospital based programs across the United States. Subjects were entered into the discharged alive from Stage I palliation between July 2008 and February 2010.

The median duration of hospitalization in the intensive care unit following the initial palliative procedure was 11 days (IQR: 8, 20.5 days). Ninety-seven percent of patients received inotropic and vasoactive agents. Agents received included milrinone (87%), dopamine (64%), and epinephrine (62%). Norepinephrine was used least commonly (1%). Twenty subjects underwent reoperation. Cardiac arrest occurred in three patients. Twenty patients underwent cardiac catheterization, and of those, 15 (67%) required a catheter-based intervention. Twenty-two patients developed post-operative arrhythmias, 55% of whom received treatment.

The first initiative of the NPC-QIC is to provide data on the care and outcomes of infants during the interstage between Stage I and Stage II palliative procedures. Our study

summarizes variations in the post operative intensive care course and management of Stage I palliation recipients. Our results show variation in inotropic agent use and high rates of reoperation and post-surgical catheterization.

Introduction:

Congenital heart disease is the most common congenital heart disorder in children[1] and is the second most common cause of early childhood death (www.nlm.nih.gov). Each year 4,000 children are born with hypoplastic left heart syndrome (HLHS) or single ventricle physiology requiring Stage I palliation.[2,3] Of the various forms of congenital heart disease, HLHS (and its variants) represent the most severe forms of congenital heart disease. Without surgery, HLHS is uniformly fatal.

Despite recent advances in the management of children with HLHS, annual mortality rates remain higher than that of other forms of congenital heart disease. Furthermore, mortality rates among HLHS patients are particularly high during the first interstage period with an estimated mortality of 10-15%.[4,5,6]

To date there have been no quality improvement initiatives with the aim of improving outcomes in children with single ventricle. Data regarding the best care practices within the immediate post operative period are lacking. Many studies support the need for standardization of care for patients with single ventricle physiology, but no such practices exist.[7,8]

The Joint Council on Congenital Heart Disease (JCCHD) was established in 2003 as a leadership alliance to enhance communication and to coordinate efforts among congenital heart disease specialists.[9] Participating organizations include the American

Heart Association, American Board of Pediatrics, American Academy of Pediatrics and American College of Cardiology. In 2006, the Council initiated the Pediatric Cardiology National Quality Improvement collaborative (NPC-QIC). This is the first quality improvement initiative launched by the collaborative. The primary purpose of this initiative is to improve survival during the first interstage among single ventricle patients who require staged palliative surgery. Specific goals include: (1) to reduce mortality in the interstage between Stage I and Stage II palliative procedures, (2) to improve quality of life in the interstage, and (3) to establish a national patient data registry for quality and clinical research.

The purpose of this study is to describe the intensive care unit (ICU) management and course of the first 100 patients enrolled in the NPC-QIC data registry. We identify and describe variation in duration of ICU hospitalization following Stage I palliation, variation in inotropic and vasoactive agent use, as well as variation in reoperation and procedural based interventions.

Methods:

Patient population:

Study subjects included the first 100 patients enrolled in the NPC-QIC data registry. At the time of our study, there were 21 contributing centers (Table 1). Criteria for participation in the NPC-QIC included all HLHS or other single ventricle patients who underwent a Stage I palliation and who were discharged to home. Subjects who did not survive the first interstage period were excluded. No patients received cardiac transplantation.

Data Collection:

Demographic data was obtained at the time of enrollment. Data was recorded by individual sites on standardized data collection forms (Appendix 1). Recorded information included demographic, surgical, hospital course and discharge data.

Primary and secondary diagnoses were entered for all enrollees. Primary diagnoses included: hypoplastic left heart with aortic and mitral atresia, hypoplastic left heart with aortic atresia and mitral hypoplasia, hypoplastic left heart with aortic hypoplasia and mitral atresia, hypoplastic left heart with aortic and mitral hypoplasia, double inlet left ventricle, double inlet right ventricle, unbalanced atrioventricular canal, double outlet right ventricle with left sided hypoplasia, tricuspid atresia with aortic arch hypoplasia, congenitally corrected transposition of the great arteries, and severe left ventricular outflow tract obstruction. Secondary diagnoses included: a restrictive atrial septum, moderate to severe atrioventricular valve regurgitation, moderate to severe ventricular dysfunction, second or third degree heart block, and arrhythmia requiring therapy.

Information regarding pre-surgical conditions, including the presence of identifiable genetic syndromes, was also recorded. Fetal diagnoses and the accuracy of the fetal diagnosis was recorded. In addition, information was provided as to whether or not a fetal intervention was performed.

A separate data form was completed to describe the neonatal surgery and post surgical hospital course. Surgical information included the type of Norwood procedure performed. Subjects received a Norwood with modified Blalock-Taussig-Thomas shunt (mBTS), a Norwood with right ventricle to pulmonary artery (Sano), a Hybrid pcrocedure, or a Damus Kaye Stansel procedure with mBTS. Post operative information included

admission dates, operative procedures performed, types of inotropic agents prescribed (i.e. milrinone, epinephrine, dopamine, dobutamine, norepinephrine, calcium, vasopressin, nipride, etc), whether cardiac reoperation was necessary and the type of reoperation performed. Additional information included whether a post operative cardiac catheterization was performed, the type of interventional procedure performed, and whether or not a patient was discharged from the ICU more than 1 time. Information regarding post operative complications including (but limited to) arrhythmias and required procedures was also collected.

Summary statistics were carried out on all demographic, preoperative, operative and post operative data. Categorical variables were analyzed using frequencies and percentages. Continuous variables were analyzed using medians and interquantile range.

Results:

Twenty-one sites contributed to the collaborative data registry at the time of this study. The largest number of patients enrolled by a single site was 12. The majority of centers enrolled 4 or fewer subjects. The majority of patients had a primary diagnosis of HLHS with variable degrees of mitral and aortic valve disease (i.e. stenosis or atresia) (N=71). The remaining 29 enrolled patients had other forms of single ventricle physiology requiring Stage I palliation. Five of the subjects were diagnosed with tricuspid atresia with aortic arch hypoplasia and transposition of the great arteries. Additional diagnoses included severe left ventricular outflow obstruction non amenable to two ventricle repair and included patients with a large ventricular septal defect and aortic arch hypoplasia. The remaining subjects were diagnosed with double inlet left ventricle, double inlet right ventricle, and double outlet right ventricle with left ventricular hypoplasia.

Patients were admitted to the intensive care unit of the hospital where they would later undergo Stage I palliation. The median duration from delivery to the time of ICU admission was 5 days (range: 0 to 11 days). The total duration of ICU hospitalization varied. The majority of patients remained in the ICU for 19 or more days (median: 19 days, IQR: 13, 27.5 days). Following Stage I palliation, the median duration of hospitalization was 11 days (IQR: 8, 20.5 days). Sixteen subjects had more than 1 transfer back to the ICU from the ward or step-down unit. Potential reasons for more prolonged ICU hospitalization included post operative complications such as arrhythmia and the need for a post operative procedure. The subject with the longest recorded hospitalization was a patient with a birth weight less than 2kg, prematurity at 33 weeks and a restrictive atrial septum that was not prenatally diagnosed.

All patients were born in the United States. The majority were male and white. Nine percent of subjects had an identifiable genetic syndrome. Identified genetic syndromes included Down's syndrome (N=2), heterotaxy syndrome (N=3), hemoglobin SC (N=1), loss m 16q 22.1 (N=1), additional genetic material on chromosome 13 (N=1), and a partial chromosome (unspecified) deletion, (N=1).

Surgical approaches to single ventricle palliation varied. The majority of subjects received a right ventricle to pulmonary artery conduit (Sano) (55%). Twenty-eight percent of subjects received a Norwood with modified Blalock-Tausig shunt (mBTS). Ten percent of subjects underwent a Hybrid procedure. The remaining subjects underwent a Damus Kaye Stansel (DKS) procedure with mBTS. Of the subjects with HLHS, the majority underwent a Norwood with Sano (44/71, 62%). Of the remaining patients with HLHS, (N=16/71) 24% received a Norwood with mBTS.

Following surgery, variations not only existed in the type of inotropic agents administered but there was also variation in the types of inotropic agents administered by site (Figure 2). Vasoactive medications most commonly prescribed included milrinone, epinephrine, and dopamine. Most, but not all patients (87%) received milrinone and 62% received epinephrine. Sixty-four percent of patients received dopamine. Norepinephrine was the least commonly prescribed inotropic agent (1%). Among patients who did not receive milrinone (N=13), 2 received epinephrine alone (15%), 3 received epinephrine and dopamine (23%), 1 received epinephrine and norepinephrine (7.6%), 1 received epinephrine and calcium, 1 received epinephrine and vasopressin and 2 received dopamine alone (15%). Three patients were recorded as having received no inotropes post surgery. Of those where sites reported no intropic or vasoactive agent administration, two patients underwent Hybrid procedures for HLHS and one patient underwent a DKS procedure and had a diagnosis of DILV.

In our study, post operative arrhythmias occurred in 22% of patients. Of the patients who developed post-operative arrhythmia, 3/22 developed non sustained ventricular tachycardia (VT), 3/22 developed non sustained reentrant supraventricular tachycardia (SVT), 6/22 developed ectopic atrial tachycardia (EAT), and 4/22 developed junctional ectopic tachycardia (JET). The type of rhythm disturbance was not described in 6/22 patients. Two patients were reported as having developed more than 1 type of arrhythmia. One Norwood with mBTS recipient developed sinus bradycardia and SVT. While one patient with DORV who underwent a DKS procedure developed EAT and JET. Of the three patients with documented nonsustained VT, 2/3 received anti-arrhythmic therapy and one of the two who received treatment also underwent

cardioversion. Two out of three patients with SVT received anti-arrhythmic therapy. One third of patients with EAT received anti-arrhythmic therapy.

Additional complications included the need for mechanical circulatory support following surgery and reoperation. Three percent of subjects required extracorporeal membrane oxygenation (ECMO) following surgery. The indications for ECMO support were not specified.

The reoperation rate was 20%. Reoperations excluded delayed sternal closure. The most common indication for reoperation was post operative bleeding (7/20) (Table 3). Patients may have undergone more than one type of reoperation. The patient with the highest number of reoperations was the only patient enrolled from one of the contributing centers. This patient carried a primary diagnosis of hypoplastic left heart variant with aortic stenosis, mitral stenosis and a hypoplastic aortic arch.

Among the remaining subjects who required reoperation, one subject underwent a Sano conduit takedown followed by placement of a BT shunt. By report, this subject was noted as having hypoxia. One subject underwent delayed sternal closure. Again, it was unclear if additional patients underwent delayed sternal closure as this data was not consistently reported in the registry. Other reasons for reoperation included: mediastinal debridement, ECMO decannulation, aortic arch repair, mBTS revision, Sano revision, thoracic duct ligation, aortopexy and tricuspid valve repair.

Nine patients developed respiratory insufficiency following surgery and underwent reintubation. Five percent of subjects were intubated for >14 days (N=5). Of the 100 initial study subjects, 21 underwent more than one extubation.

Twenty percent of patients received post operative cardiac catheterization procedures. Fifteen of the twenty patients underwent an interventional procedure and the remainder received only diagnostic cardiac catheterizations. Of the 15 reported interventional procedures, seven underwent dynamic atrial balloon septostomy as a scheduled part of the Hybrid procedure. The remaining 8 subjects underwent placement of a mBTS stent (N=2), placement of a Sano stent (N=1), Sano dilation (N=1), mBTS dilation (N=1), pulmonary artery dilation (N=1), atrial septum dilation (N=1), and placement of aortic arch stent (N=1). Post operative cardiac catheterization procedures were well tolerated with only 2 reports of post cardiac catheterization arrhythmia and one report of post cardiac catheterization right femoral vessel pseudoaneurysm formation.

The majority of subjects experienced a post operative complication. Four patients suffered cardiac arrest, a different 4 patients required mechanical circulatory support, 2 required temporary pacemakers with none requiring permanent pacemaker placement, 1 developed a pericardial effusion requiring drainage, 1 developed systemic venous obstruction, 2 were noted to have pulmonary hypertension, 3 developed a pneumothorax, 9 developed pleural effusions requiring drainage, 13 developed a chylothorax, and 2 required temporary dialysis. Postoperative infections also occurred. Three subjects developed tracheitis, 2 developed a urinary tract infection, 2 developed sternal dehiscence, 6 developed a wound infection, 1 developed mediastinitis, 1 developed endocarditis, 3 developed septicemia, 2 developed a central line infection and 4 developed necrotizing enterocolitis.

Additional complications included the development of nerve and central nervous system injury. There were three reported cases of phrenic nerve injury. Additionally, 2 subjects

developed a persistent neurologic deficit at time of discharge. Two patients developed a transient neurologic deficit. Four patients developed seizures post operatively.

Finally, there were 34 reported postoperative procedures performed (aside from cardiac catheterization and reoperation). Procedures performed included: cardioversion (N=1), pericardiocentesis (N=1), thoracocentesis (N=2), bronchoscopy (N=4), tracheostomy (N=1), G-tube placement (N=6), fundoplication (N=3), diaphragm placation (N=1), thoracic duct ligation (N=1), dialysis (N=1), and peritoneal drain placement (N=10).

Discussion:

The first step toward improving quality of clinical care is to identify variations in practice and to identify therapies and practices that add value. Quality improvement initiatives have shown that standardization of care can decrease cost and improve mortality and morbidity among patients treated with a similar condition. Among children with chronic illness, quality improvement initiatives have been shown to improve clinical outcomes, to result in safer practices, and to result in more efficient use of resources and cost reduction. [10,11,12,13,14,15] In addition, standardized care has been shown to result in more predictable outcomes.

The care of patients with HLHS patients is associated with greater resource utilization and higher cost compared to other forms of congenital heart disease. HLHS comprises only 2% of patients with congenital heart disease and yet total lifetime costs associated with single ventricle patients have been estimated at $62million.[16,17,18] These estimates include direct (.e. hospital costs, special services, etc) and indirect costs (i.e. loss of employment, etc). Our study found that there are many variations in ICU practice even

among the first 100 patients enrolled in the NPC-QIC data registry that may contribute to increased cost.

Striking results from this study were the number of patients requiring reoperation. Reoperation rates following Norwood surgery have been reported by others. Previously, identified risk factors for reoperation have included anatomy (i.e. presence of aortic atresia), smaller ascending aorta diameter, prematurity, low birth weight, additional cardiac anomalies, non-cardiac anomalies, chromosomal abnormalities, lower postoperative pH, longer circulatory arrest or cardiopulmonary bypass time, and the presence of significant tricuspid valve regurgitation.[19,20,21,22,23]

Although we did not examine mortality following the Stage I palliation, study results from a single institution's experience revealed an operative survival of 78% in patients with HLHS (74% with aortic atresia, 87% with aortic stenosis) and 75% for patients with other diagnoses.[5] In this study, multivariate risk analysis revealed birth weight (OR 0.18/kg) was associated with decreased survival. In particular, hospital survival for infants weighing less than 2.5kg was 62% compared to 82% for patients weighing greater than 2.5kg. Other factors associated with decreased survival included associated cardiac anomalies (OR=4.5), longer total support time (minutes) (OR1.07), ventricular assist device or ECMO support (OR=17.8). Factors associated with decreased 1 year survival were the presence of extra-cardiac anomalies, an associated genetic syndrome (OR=2.7), or the presence of an additional cardiac defect (OR=3.99). More recent studies have suggested that in the population of HLHS patients receiving RV to PA conduits, that gestational age less than 37 weeks (p=0.002), weight less than 2.5kg (p=0.01) and severity of tricuspid valve regurgitation (p=0.04) are significantly associated with increased mortality among Stage I palliated patients.[24] Our population

demographic analysis revealed a median weight of 3.2kg at the time of surgery and a minority of subjects with identified genetic syndromes. This finding may support earlier published reports that smaller children and children with syndromes are less likely to survive the interstage period. Published data has shown that patients with weights below 2.5kg at the time of surgery have higher post operative mortality rates. More specifically, the same study reported mortality rates of 30% in lower weight HLHS infants versus 21% mortality among those weighing 2.5 to 4kg at the time of surgery, p=0.03. The study reported an even greater difference among those who received RV to PA conduits (24.4% versus 6.2%), p<0.01. [24]

In our study, another significant finding was the number of post operative complications. There were at least 75 reported post operative complications with more than one half of all study subjects developing a severe complication. Arrhythmia followed by the need for reintubation and complications requiring procedural interventions (i.e. development of pleural effusion requiring chest tube placement, etc.) were high. In our study, post operative arrhythmias occurred in 22% of patients. This was slightly lower than published data in which authors reported 29% prevalence of arrhythmias in the post operative period following congenital heart disease surgery.[25] These findings point to the importance of close monitoring and possibly even more conservative management of children in the ICU post Stage I palliation. Although, it is not certain, (based upon preliminary data) our findings suggest that arrhythmia and additional post operative complications are among the reasons for prolonged ICU hospitalization and therefore increased cost and utilization of resources.

There has been a growing focus on the neurologic and neurocognitive complications following cardiac surgery.[26] We found a small but significant percentage of children who

developed neurologic injury (i.e. seizures) post operatively. Further investigation of perioperative factors and their potential role in the development of neurologic and neurocognitive injury is indicated.

Limitations of our study at the current time are many. Registry data captures information regarding many of the events occurring during the post operative period. However, causation cannot be established in many cases and it is left to the reviewer to piece together findings and to determine factors that may have contributed to particular outcomes. Data can be incomplete and may not have been entered correctly by the site or by the programmer(s). There are also may limitations based upon the design of the study. For instance, participation in the study was based upon survival to time of discharge following Stage I palliation. Therefore, there is no available data regarding patients who did not survive. It is unknown whether lower birth weight, gestational age or intact atrial septum were risk factors for increased mortality (were they not recorded because the subjects died or because there were limited numbers of such patients in this cohort). Only 9% of patients studied were premature. It is unclear whether this participation percentage supports previously published data that premature infants are more likely to die during the first interstage. Similarly, only 5% of patients studied weighed less than 2.5kg at the time of surgery. Based upon the available data, it is unclear whether particular inotropic agents or other additional complications are associated with a greater morbidity, longer ICU hospitalization or greater mortality.

However, though there are many limitations to our study, our study provided additional data not previously reported by other studies regarding the post operative course of Stage I single ventricle recipients. Additional data provided included information regarding the accuracy of prenatal diagnosis and the prevalence of particular post

operative complications (previously not described). In our study, most patients were recognized to have disease early in gestation, even if no fetal diagnosis was made (n=25). Fetal diagnosis was fairly accurate in this study with 99% accuracy (74/75).

The NPC-QIC is also an ongoing quality initiative with the flexibility to provide record of additional information not originally captured. Variables that were omitted but that may be of interest can be captured. Information that could be added to the registry includes inotropic agent dosing, pre and post operative oxygen saturations, to name a few.

Conclusion:

The JCCHD is leading the way toward safer practices and improved outcome for patients with single ventricle patients following Stage I palliation. Once there has been greater enrollment, we will hopefully have sufficient power to investigate ICU practices affecting the short and long term outcome of children with HLHS and other forms of single ventricle physiology. As previously described, quality initiatives play an important role in converting an understanding of practice variation into improved patient outcomes.[27] As all good quality improvement initiatives, our initiative involves (1) evaluating information regarding current practices, (2) identifying areas for improvement, (3) developing and implementing change initiatives, (4) measuring the effects of these initiatives, and (5) maintaining initiatives that bring about improved outcomes.

Currently there are over 200 patients enrolled in the NPC-QIC data registry. The number of participating centers has increased to 45. With continued efforts and increased subject recruitment, we will hopefully be able to improve care.

The JCCHD is not the only organization committed to improved outcomes among single ventricle patients.[6,7,8] Changes in existing practices have already resulted in improvements.[27] We can also compare our findings to the findings of others. For instance, Wernovsky et al. conducted a survey of 52 centers regarding the management of patients with HLHS. Our data supports some of the practice management detailed in this study. Specifically, the majority of patients receive Norwood procedures with RV to PA conduits as the source of pulmonary blood flow and most are managed with milrinone, dopamine and/or epinephrine post surgery. However, like this article, we found there was significant practice variability.

Comparison of current data with available data sources may also be helpful. In particular, analyzing data from Society of Thoracic Surgeon's National Congenital Database, Pediatric Health Information System Database, Healthcare Cost and Utilization Project's Kids Inpatient Database, and Nationwide Inpatient Sample may also be helpful toward the overall goal of quality improvement.

Optimization of care in the ICU is necessary in order to lead to further improvements in outcome for HLHS patients and single ventricle patients requiring Stage I palliation. Suggestions for systematic approach to ICU management of HLHS recipients include: (1) QI with detailed capture and recording of management differences, (2) larger sample numbers to achieve the statistical power necessary to fully evaluate the effects of these differences, (3) additional randomized controlled trials to investigate the potential benefits of a particular management style (i.e. PHN study of BTS versus Sano) and (4) ongoing monitoring and modification of currently recorded data.

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Tables and Figures

Table 1: Contributing Centers

Cincinnati Children's Hospital Medical Center
Children's Hospital Boston
Children's Hospital and Medical Center, Omaha
Mattel Children's Hospital, UCLA
Children's National Medical Center
Texas Children's Hospital
Children's Healthcare of Atlanta
Children's Memorial Hospital
Nationwide Children's Hospital
Arizona Pediatric Cardiology Consultants
University of Virginia Children's Hospital
Johns Hopkins Hospital
Mayo Clinic – Rochester
Lucile S. Packard Children's Hospital at Stanford
Monroe Carrell Jr Children's Hospital at Vanderbilt
Doernbecher Children's Hospital
Primary Children's Medical Center
Riley Hospital for Children
UC Davis Children's Hospital
Yale New Haven Children's Hospital
NYU Medical Center

Table 2: Demographic Data

Demographic Data		
Total, N=100	Median	IQR
Birth weight (kg)	3.1	(2.8, 3.5)
Gestational Age (weeks)	39	(38, 39)
Gender		
Male	59	
Female	41	
Birth Country		
USA	100	
Race		
White	68	
Black	14	
Alaskan/Native American	1	
Other	12	
Not recorded	5	
Primary Diagnoses	Total, N=100	
Hypoplastic Left Heart Syndrome	71	
Aortic Atresia/Mitral Atresia	35	
Aortic Atresia/Mitral Hypoplasia	12	
Aortic Stenosis/Mitral Atresia	4	
Aortic Hypoplasia/Mitral Hypoplasia	19	
Aortic stenosis/unknown mitral severity	1	
Double Inlet Left Ventricle	4	
Double Inlet Right Ventricle	1	
Unbalanced atrioventricular canal, right dominant	6	
Doube Outlet Right Ventricle	7	
Tricuspid Atresia with Aortic Arch hypoplasia	5	
Congenitally Corrected Transposition of the Great Arteries	1	
Severe left ventricular outflow tract obstruction	5	
Secondary Diagnoses		
Restrictive atrial septum	16	
Moderate to severe atrioventricular valve regurgitation	3	
Moderate to severe ventricular dysfunction	3	
Second or third degree atrioventricular block	0	
Arryhthmia requiring therapy	2	
Other	22	

Table 3: Post Operative Complications

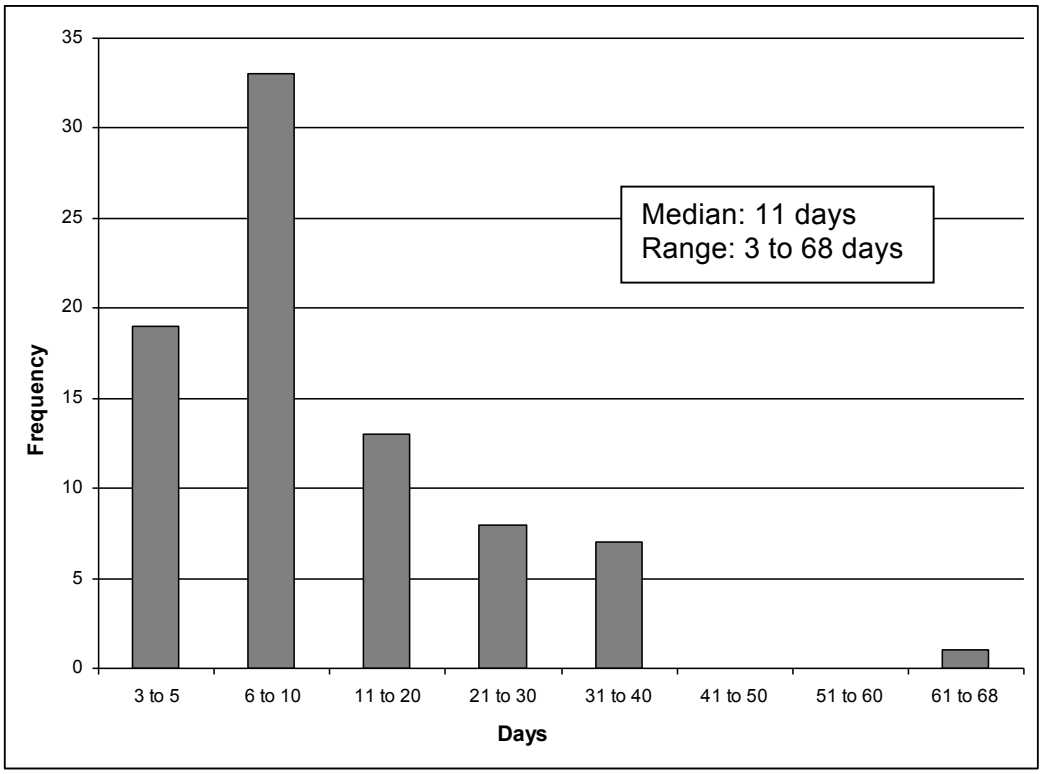
Post Operative Complications

Total, N=100

	N	%		N	%		N
Reoperation	20		Cardiac Catheterization	20		Other Procedures	34
Bleeding	7	35	Diagnostic	5	25	G-tube	6
Mediastinal debridement	2	10	Interventional	15	75	Fundoplication	3
ECMO decannulation	3	15	Scheduled*	7		Cardioversion	1
Aortic arch repair	2	10	Atrial septectomy			Pericardiocentesis	1
mBTS revision	2	10	Unscheduled	8		Thoracocentesis	2
Sano revision	1	5	Sano stent	1	13	Bronchoscopy	4
Atrial Septectomy	0	0	mBTS stent	2	25	Tracheostomy	1
Thoracic duct ligation	1	5	Aortic arch stent	1	13	Diaphragm Plication	1
Aortopexy	1	5	Sano balloon dilation	1	13	Thoracic Duct Ligation	1
Tricuspid valve repair	1	5	mBTS balloon dilation	1	13	Dialysis	1
			PA dilation	1	13	Peritoneal Drain	10
						ECMO	3

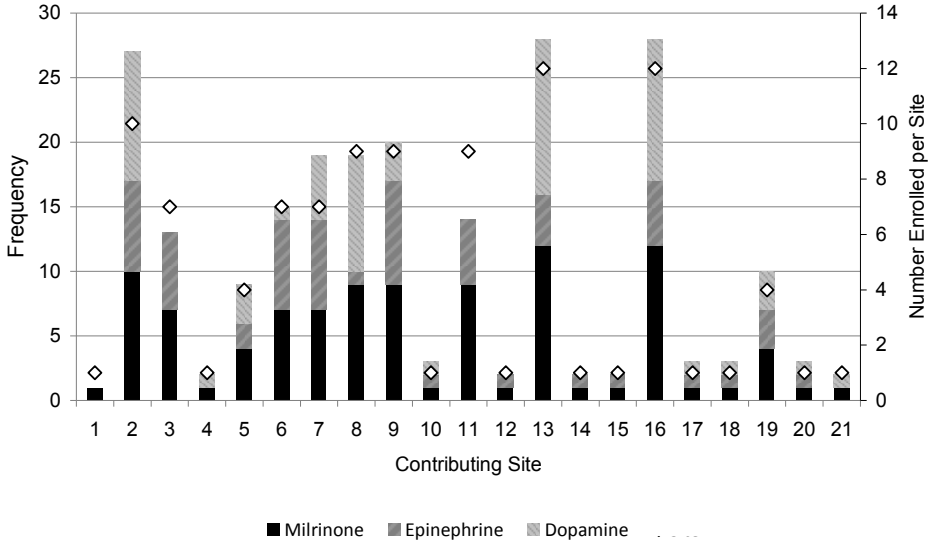
*part of Hybrid procedure

Figure 1: Duration of Intensive Care Unit Hospitalization Following Stage I Palliation



Legend: Number of days remaining in the intensive care unit following Stage I palliation (X-axis). The minimimum duration of hospitalization following Stage I palliation was 3 days. The maximum duration of hospitalization following Stage I palliation was 68 days. The median duration was 11 days.

Figure 2: Variations in Inotropic Agent Use by Contributing Site



Legend: Reported use of inotropic and vasoactive agents by contributing site. Primary X-axis: Frequency of particular inotropic agent by site. Secondary X-axis: Number of enrolled patients by contributing site. Patients may have received combinations of inotropic agents. Site 16 enrolled 12 subjects: 12/12 received milrinone, 5/12 received epinephrine and 11/12 received dopamine.