

Invasive Cardiac Procedures in Interstage Single Ventricle Patients in Emergent Hospitalizations

Brena S. Haughey, DO^a, Shelby C. White, MD^b, Garrett S. Pacheco, MD^c, Kenneth A. Fox, MD^d, Michael D. Seckeler, MD, MSc^b

Affiliations: ^aUniversity of Arizona, Department of Pediatrics, 1501 North Campbell Avenue, Tucson AZ, 85724; ^bUniversity of Arizona, Department of Pediatrics (Cardiology), 1501 North Campbell Avenue, Tucson AZ, 85724; ^cUniversity of Arizona, Department of Emergency Medicine, 1501 North Campbell Avenue, Tucson AZ, 85724; ^dUniversity of Arizona, Department of Surgery (Pediatric Cardiothoracic), 1501 North Campbell Avenue, Tucson AZ, 85724.

Address correspondence to: Michael D. Seckeler, MD, MSc, University of Arizona, Department of Pediatrics (Cardiology), email: mseckeler@peds.arizona.edu, phone: (520) 626-5585, fax: (520) 626-6571

Abstract:

Background

Single ventricle congenital heart disease (SV CHD) patients are at risk of morbidity and mortality between the first and second palliative surgical procedures (interstage). When these patients present acutely they often require invasive intervention. This study sought to compare the outcomes and costs of elective and emergent invasive cardiac procedures for interstage patients.

Methods

Retrospective review of discharge data from The Vizient Clinical Data Base/Resource Manager™, a national health care analytics platform. The database was queried for admissions from 10/2014 - 12/2017 for children 1-6 months old with ICD-9 or ICD-10 codes for SV CHD who underwent invasive cardiac procedures. Demographics, length of stay (LOS), complication rate, in-hospital mortality and direct costs were compared between elective and emergent admissions using t-test or χ^2 , as appropriate. The three most frequently performed procedures were also compared.

Results

871 admissions identified, with 141 (16%) emergent. Age of emergent admission was younger than elective (2.9 vs 4 months $p<0.001$). Emergent admissions including cardiac catheterization or superior cavo-pulmonary anastomosis had longer LOS (58.7 vs 25.8 day, $p<0.001$ and 54.8 vs 22.6 days, $p<0.001$) and higher costs (\$134,774 vs \$84,253, $p=0.013$ and \$158,679 vs \$81,899, $p=0.017$).

Conclusion

Emergent admissions for interstage SV CHD patients undergoing cardiac catheterization or superior cavo-pulmonary anastomosis are associated with longer LOS and higher direct costs, but with no differences in complications or mortality. These findings support aggressive interstage monitoring to minimize the need for emergent interventions for this fragile patient population.

Keywords:

Interstage, Intervention, Outcomes, Emergency

Introduction

Single ventricle congenital heart disease (SV CHD) is rare, comprising approximately 8% of all CHD [1]. The period between stage I and stage II palliation surgeries (interstage) is a time when patients are at increased risk of morbidity and mortality due to their tenuous hemodynamic status. The efforts of the National Pediatric Cardiology Quality Improvement Collaborative have markedly improved the survival of interstage patients, but mortality continues to range from 2.8-12.6% [2]. While implementation of at-home interstage monitoring programs has decreased unplanned admissions to the hospital, emergent intervention occurs frequently in this population [3, 4]. No prior studies have evaluated the differences in this population between invasive cardiac procedures performed during elective and emergent hospital admissions.

We hypothesized that invasive cardiac procedures performed for interstage SV CHD patients after emergent hospital admission would have higher mortality and incur higher resource utilization. The aim of this study was to compare the outcomes and costs of invasive cardiac procedures for interstage SV CHD patients during elective and emergent hospital admissions.

Methods

The Vizient Clinical Data Base/Resource Manager™ is an analytic platform for performance improvement populated by 450 health systems and community hospitals nationwide, including nearly all academic medical centers. The database includes comparative benchmarks such as demographic, mortality, length of stay, complication rates, readmission rates, diagnosis, procedure, resource utilization and other information. We performed a retrospective review from October 2014 to December 2017 for inpatient admissions of patients 1-6 months old with ICD-9 and ICD-10 codes for SV CHD (746.7, 746.1, 745.3 and Q23.4, Q22.4, Q20.4, Q22.6) and a primary procedure code for invasive cardiac procedures. The Clinical Data Base/Resource Manager™ has an established data field for hospital admission via the Emergency Department which was used to identify emergent admissions from the data query. Only hospitals with >100 congenital cardiac surgeries during the study period were included to minimize the potential biases of including low-volume surgical centers. The three most frequently performed procedures (cardiac catheterization, aorto-pulmonary shunt and superior cavo-pulmonary anastomosis)

were identified for analysis. Data obtained included demographics, length of stay (LOS), in-hospital mortality rate and direct hospital costs. Normally-distributed data were compared using t-test and categorical data using χ^2 .

Results

There were 871 admissions identified during the study period, consisting of 730 (84%) Elective admissions and 141 (16%) Emergent admissions. Demographics for the groups are shown in Table I. Hypoplastic left heart syndrome was the most common diagnosis and the incidence did not differ between the groups. Outcomes and costs for the three most frequent procedures are shown in Table II.

Age of Emergent admissions was lower than Elective admissions with no other differences in demographics between the groups (Table I). While mortality was not significantly different between the two groups, Emergent admissions with cardiac catheterizations or superior cavo-pulmonary anastomosis had longer LOS and higher direct costs while Elective admissions with aorto-pulmonary artery shunts had higher complication rates (Table II).

Discussion

In this retrospective review of a large administrative database, we have found that SV CHD patients in the interstage period who undergo invasive cardiac procedures during an emergent hospitalization are younger than those who undergo elective procedures. In addition, cardiac catheterizations and superior cavo-pulmonary anastomoses performed during emergent hospitalizations were associated with longer LOS and higher costs. Aorto-pulmonary artery shunts performed during elective hospitalizations were associated with higher complication rates.

Interstage SV CHD patients are a high-risk population group with high morbidity and mortality due to their tenuous hemodynamic status. Thanks to the efforts of the National Pediatric Cardiology Quality Improvement Collaborative, many centers have adopted an aggressive interstage monitoring program, including daily weights and pulse oximetry recordings as home as well as at least biweekly outpatient cardiology visits [5, 6]. To date, the only modifiable factor to improve post-operative outcomes after stage II palliation has been consistent interstage weight gain.⁷ However, when interstage SV CHD patients require emergency evaluation and treatment, they are at increased risk for worse post-procedure outcomes than those who do not require emergent intervention. In the current study,

interstage SV CHD patients emergently hospitalized who underwent cardiac catheterization or superior cavo-pulmonary anastomosis were admitted for over 1 month longer than those admitted electively for these procedures. In addition, the hospital costs were 1.5 to 2 times higher. Interestingly, the only outcome difference for patients undergoing aorto-pulmonary artery shunts was a higher complication rate in those admitted electively, which we believe reflects the high perioperative fragility after this surgery for all SV CHD patients. Also, despite the expectation that patients with hypoplastic left heart syndrome are the most at risk during the interstage period, there were not more of these patients in the Emergent admission group.

The importance of resource management is increasingly recognized in patient care and hospital quality measures. The additional resource utilization and costs incurred during emergent hospitalizations emphasizes the importance of prior work advocating vigilant interstage monitoring to prevent these emergencies [3, 7]. There are variations in the timing of stage II palliation, typically between 3 and 6 month, with limited data suggesting that surgery before 5 months of age has no negative impact on outcomes or LOS with potentially lower mortality [8]. However, optimal timing of intervention remains unclear due to the medical fragility of this population and limited rigorous data. While the patients in this study who were emergently hospitalized were younger than those who underwent elective hospitalizations, this study was not designed to answer the question of appropriate timing for interventions in the interstage SV CHD population.

There are several limitations to this study. Databases rely on accurate ICD-9 and ICD-10 code entry and there is potential for errors in documentation and coding. Prior studies report that ICD-9 codes in administrative databases have an 80–85% specificity for congenital heart disease [9]. Given the large number of admissions analyzed in this study, it is unlikely that a small number of coding errors would affect our findings. Due to limitations in the detail of ICD-9 and ICD-10 codes, we could not identify different severities of possible co-existing conditions, such as systemic atrioventricular valve regurgitation or ventricular systolic function, that may also have contributed to differences between the study populations. Additionally, we were unable to determine which patients were undergoing interstage home monitoring or the reason for emergent hospitalization. The database does not provide information regarding cause of death.

Conclusion

The current study supports continuing the practice of aggressive interstage monitoring of SV CHD patients to minimize the need for emergent interventions for this fragile population and limit the additional clinical and financial burdens of prolonged hospitalizations. Future studies may be able to identify the highest risk SV CHD patients who could benefit from earlier elective invasive cardiac procedures as a means to prevent emergent interventions.

Compliance with Ethical Standards

Funding: No funding was received for this study.

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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Table I - Demographics for Elective and Emergent admissions.

	Elective (n = 730)	Emergent (n = 141)	<i>p</i>
Age (months)	4.0 ± 1.3	2.9 ± 1.4	<0.001
Female (n, %)	288 (39)	60 (43)	0.512
Race/Ethnicity (n, %)			
White	460 (63)	75 (53)	0.148
Black	100 (14)	26 (18)	
Hispanic	111 (15)	25 (18)	
Asian	23 (3)	2 (1)	
Diagnosis (n, %)			
Hypoplastic left heart syndrome	420 (57)	95 (67)	0.281
Tricuspid atresia	153 (21)	27 (19)	
Double inlet left ventricle	163 (22)	22 (15)	
Hypoplastic right heart	68 (9)	12 (8)	
Common ventricle	57 (8)	9 (6)	

Table I – Demographics for Elective and Emergent admissions. The only difference between the groups is a younger age at admission for the Emergent group. Note, some patients have multiple cardiac diagnoses. Data from the Vizient Clinical Data Base/Resource Manager™ used by permission of Vizient. All rights reserved.

Table II - Outcomes and costs for the three most common invasive cardiac procedures associated with Elective compared to Emergent admissions.

Procedure	Elective	Emergent	<i>p</i>
Cardiac catheterization			
Admissions	352	125	
LOS (d)	25.76 ± 47.23	58.71 ± 66.65	<0.001
Direct costs (\$)	84,253 ± 187,444	134,774 ± 160,180	0.013
Complications (n, %)	31 (9)	7 (6)	0.255
Death (n, %)	16 (5)	9 (7)	0.253

Aorto-pulmonary artery shunt			
Admissions	41	22	
LOS (d)	45.24 ± 59.57	67.55 ± 71.81	0.192
Direct costs (\$)	119,312 ± 129,789	166,231 ± 174,761	0.265
Complications (n, %)	11 (27)	0 (0)	0.007
Death (n, %)	6 (15)	1 (5)	0.225

Superior cavo-pulmonary anastomosis			
Admissions	451	54	
LOS (d)	22.63 ± 40.77	54.83 ± 57.57	<0.001
Direct costs (\$)	81,899 ± 222,344	158,679 ± 181,587	0.017
Complications (n, %)	32 (7)	3 (5)	0.674
Death (n, %)	11 (2)	2 (4)	0.579

Table II - Outcomes and costs for the three most common invasive cardiac procedures associated with Elective compared to Emergent admissions. Cardiac catheterizations and superior cavo-pulmonary anastomoses during Emergent admissions incurred longer length of stay (LOS) and costs. Aorto-pulmonary artery shunts during Elective admissions had higher complication rates. Data from the Vizient Clinical Data Base/Resource Manager™ used by permission of Vizient. All rights reserved.