Risk Factors for Unanticipated Readmissions During the Interstage: A Report From the National Pediatric Cardiology Quality Improvement Collaborative

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This study describes unanticipated interstage readmissions in patients with hypoplastic left heart syndrome, identifies independent risk factors for unanticipated interstage readmissions, and evaluates variation in unanticipated readmission rates among collaborative centers. Retrospective data of patients enrolled in the National Pediatric Cardiology Quality Improvement Collaborative registry from July 2008 to July 2013 were analyzed. Risk factors present at the beginning of the interstage were captured. Competing risks time to event analyses determined the association between these factors and unanticipated interstage readmission. Readmission center variation was examined using funnel plots. Unanticipated interstage readmissions occurred in 66% of 815 patients at 50 centers. The median readmission length of stay was 2 days (interquartile range: 0-6) and median time to first readmission was 29 days (interquartile range: 9-63). Most readmissions were prompted by minor changes in clinical status (64%), whereas only 6% were major adverse event readmissions. Independent readmission risk factors included genetic syndrome (HR = 1.40, 95% CI: 1.05-1.88), center volume (small vs large HR = 1.32, CI: 1.04-1.66, medium vs large HR = 1.35, CI: 1.09-1.68), preoperative ventricular dysfunction (HR = 2.02, CI: 1.31-3.10), tricuspid regurgitation (HR = 1.36, CI: 1.08-1.72), duration of circulatory arrest (HR = 0.99, CI: 0.989-0.998), and undergoing Hybrid procedure relative to Norwood/right ventricle to pulmonary artery conduit (HR = 1.40, CI: 1.02-1.93). There was significant center variation in the number of readmissions and duration of readmissions. Unanticipated readmissions are common during the interstage period with notable center variation. However, these readmissions are short and are rarely in response to major adverse events.

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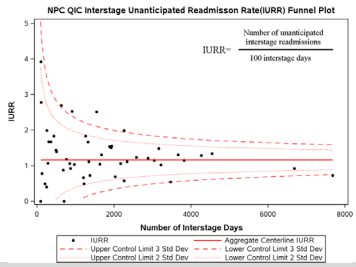

Funnel chart of the hospital variation in the frequency of interstage readmissions

Central Message

Interstage readmissions are common with notable center variation and independent risk factors. Major event readmissions are rare.

Perspective statement

In a review of the National Pediatric Cardiology Quality Improvement Collaborative registry, unanticipated interstage readmissions occurred frequently with wide variation between centers. Few readmissions represented major adverse events. Six independent patient and center-level risk factors were associated with increased readmissions. It remains unclear if some readmissions protect against major adverse events and mortality.

See Editorial Commentary pages 815-816.

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INTRODUCTION

Infants with hypoplastic left heart syndrome (HLHS) who are discharged home following the stage 1 palliation (S1P) represent a high-risk pediatric population with estimated mortality rates of 0%-15% in the interstage period between discharge after S1P and stage 2 palliation (S2P) or superior cavopulmonary connection.[1-8] Secondary to significant morbidities, these patients often require numerous unanticipated clinic visits and readmissions in addition to scheduled readmissions for procedures such as hemodynamic catheterization before S2P. However, the frequency of and risk factors for unanticipated

readmissions in this high-risk population have not previously been reported.

Although hospital readmissions following heart failure and acute myocardial infarctions are used as quality indicators in adult patients, the applicability of similar measures to pediatric populations is uncertain.[9-11] In a single center report, 11% of infants who underwent S1P operation were readmitted within 30 days of hospital discharge; residual hemodynamic problems and <2 days of full oral intake before S1P discharge were independent risk factors of readmission.[12] The generalizability of these findings to multiple centers is uncertain.

The National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC) offers a unique opportunity to study readmissions in infants with HLHS in the interstage period. The NPC-QIC seeks to study and improve care and outcomes for patients with HLHS.[13] To facilitate this work, NPC-QIC established a multicenter registry of patients with interstage HLHS. Along with information about the S1P hospitalization, the registry includes data on all readmissions and clinic visits during the interstage period.[13] The purpose of this study was to use the NPC-QIC registry to retrospectively describe the frequency, type, and duration of unanticipated interstage readmissions, to examine the relationship between unanticipated readmissions during the interstage period and factors present at the time of S1P hospital discharge, and to evaluate variation in unanticipated readmission rates among centers.

METHODS

Study Design and Data Source

This was a retrospective analysis of patients enrolled in the NPC-QIC registry. Local institutional review board approval for contributing data to the registry was obtained by each participating center. Informed consent to submit data to the registry was obtained from the parent or legal caregiver of each eligible patient. To be included in the registry, patients must have undergone S1P for HLHS or other complex univentricular defects and be discharged home following S1P. S1P consisted of either Norwood procedure (Damus-Kaye-Stansel [DKS] anastomosis, aortic reconstruction, atrial septectomy and Blalock-Taussig [BT] shunt, or right ventricle to pulmonary artery conduit [RV-PA]) or Hybrid procedure (stenting of the patent ductus arteriosus and bilateral branch pulmonary artery band placement).

For each patient, participating sites collect clinical information regarding the initial hospitalization for S1P, interstage clinic visits and hospital readmissions, and the S2P hospitalization. The interstage is defined as the period between discharge from S1P and admission for S2P. The registry has standardized data definitions and monthly data quality checks. Semiannual enrollment audits are performed across participating sites. Deidentified data are entered into the registry by each center via a Web-based, secure, password-protected system (Research Electronic Data Capture)[14] and housed in a secure server at Cincinnati Children's Hospital Medical Center.

Study Population

All patients enrolled in the registry from its inception in July 2008 to July 31, 2013 that completed the interstage (ie, underwent S2P, a heart transplant, or died during the interstage period) were included for analysis. These patients were treated at 50 different pediatric cardiology centers in the United States.

Data Collection and Outcomes

We examined several a priori identified risk factor variables present at the time of S1P discharge including demographics, echocardiogram characteristics, clinical status at S1P discharge, and S1P discharge process factors, to determine their association with unanticipated readmissions. We defined unanticipated readmissions as those readmissions that are not for a scheduled procedure such as cardiac catheterization before S2P. Unanticipated readmissions were categorized using red flag and major adverse event definitions from the NPC-QIC registry. Red flag events are specific warning signs and symptoms provided to caretakers that may indicate illness, such as feeding problems, breathing problems, increased cyanosis, poor weight gain, vomiting, diarrhea, and fever. Major adverse events include cardiac arrest, shunt occlusion, life-threatening arrhythmia, seizures, stroke, aspiration, and infection requiring intravenous antibiotics.

To allow for comparison of readmission rates among centers with variable practice patterns (eg, S1P length of stay, age at S2P), 2 outcome variables were developed to account for the number of interstage days when patients are at risk for readmission. The interstage unanticipated readmission rate (IURR) was calculated as the number of unique unanticipated interstage readmission encounters per 100 interstage days. The interstage unanticipated hospitalization fraction (IUHF) is defined as the number of unanticipated hospitalization days during the interstage period per 100 interstage days.