

# Standardization of Care Reduces Length of Stay for Postoperative Congenital Heart Disease Patients

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## Abstract

**Introduction:** Congenital heart disease (CHD), the most common congenital malformation, often requires surgical correction. As surgical mortality rates are low, a common quality marker linked with surgical outcomes is hospital length of stay (LOS). Reduced LOS is associated with better long-term outcomes, reduced hospital-acquired complications, and improved patient-family satisfaction. This project aimed to reduce aggregate median postoperative LOS for four CHD lesions from a baseline of 6.2 days by 10%.

**Methods:** This single-center study utilized the Institute for Healthcare Improvement model to achieve the project aim. A diuretic wean protocol implemented in April 2018 entailed weaning to a homegoing diuretic regimen upon transfer from the cardiac intensive care unit to the inpatient step-down unit. A discharge milestone checklist implemented in September 2018 contained milestones necessary for discharge and an anticipated date of discharge. Outcome measures included aggregate median postoperative LOS and  $\Delta$ LOS. Balancing measures included cardiac intensive care unit bounce back, pleural chest tube replacement, and readmission rates.

**Results:** Our baseline aggregate median postoperative LOS for the lesions studied was 6.2 days. Following diuretic protocol implementation, the aggregate median LOS decreased to 4.4 days. Baseline  $\Delta$ LOS decreased from 5.5 to 0.42 days. Postoperative cost fell by an average of \$11,874. Balancing measures demonstrated no unintended consequences. **Conclusions:** Implementation of a diuretic wean protocol led to sustained improvement in postoperative LOS, and  $\Delta$ LOS in a subset of CHD patients with no unintended consequences supporting that standardization of postoperative care is effective for improvement efforts and can reduce overall practice variation. (*Pediatr Qual Saf* 2021;6:e493; doi: 10.1097/pq9.0000000000000493; Published online December 15, 2021.)

## INTRODUCTION

Congenital heart disease (CHD) affects 1 in 100 children. It represents the most common congenital malformation, the treatment of which consumes considerable resources. As healthcare shifts from volume to value-based care, institutions are

under pressure to provide the highest quality care at the lowest cost.<sup>1</sup> A multicenter study evaluating common CHD operations demonstrated a wide variation in costs between institutions, with the postoperative length of stay (LOS) independently accounting for 23% of the variation.<sup>2</sup> Subsequent analyses showed an average excess cost of \$17,836 per day above the median LOS, even after adjusting for postoperative complications.<sup>3</sup>

Historically, the most widely used metric to assess surgical care quality has been postoperative mortality in pediatric and adult surgical specialties.<sup>4</sup> With advances in surgical techniques, postoperative mortality following CHD repair has markedly improved over recent decades, with a 3% rate in the current era.<sup>5</sup> Because of the low mortality rate, the sensitivity of mortality as a quality metric is controversial<sup>6</sup>; therefore, greater emphasis is placed on morbidity metrics, including LOS.<sup>7</sup>

Postoperative LOS is an important quality metric for payers, providers, patients, and families. Increased hospital LOS has been associated with increased medical errors,<sup>8</sup> parental stress in postoperative CHD patients,<sup>9</sup> and hospital-acquired infections in adults undergoing cardiac surgery.<sup>10</sup> Prior studies have established that prolonged postoperative LOS in the CHD population

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Supplemental Figure 1 <http://links.lww.com/PQ9/A328> and 2 <http://links.lww.com/PQ9/A329>.

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is associated with worse long-term neurodevelopmental outcomes even after adjusting for other factors<sup>11,12</sup> with LOS used as a surrogate marker for overall postoperative morbidity.<sup>4</sup>

Compared with national benchmarking organizations, such as the Society of Thoracic Surgeons Congenital Heart Surgery Database, our institution's baseline postoperative LOS for the CHD lesions of interest was slightly shorter. However, we chose to focus on postoperative LOS. We felt that any improvements achieved would translate to numerous benefits for our patients and families, given the known morbidity associated with prolonged LOS. This project aimed to reduce the aggregate median postoperative LOS for four congenital heart defects status post their initial complete surgical repair from a baseline of 6.2 days by 10% by July 1, 2018, and sustain indefinitely.

## METHODS

### *Context*

This project is a single-center quality improvement study conducted at Nationwide Children's Hospital (NCH) in Columbus, Ohio. The Heart Center within NCH performs over 350 thoracic surgical cases per year. It encompasses a 20-bed Cardiac Intensive Care Unit (CTICU) staffed by 10 cardiac intensivists and a 24-bed Acute Care Cardiology Unit (ACCU) staffed by 8 cardiologists. All postoperative patients return to the CTICU with an overall stay dependent on multiple factors, including patient acuity, level of required monitoring, and attending preference. Patients are transferred from the CTICU to the ACCU when clinically indicated following a bedside handoff.

The ACCU medical team consists of one pediatric cardiologist, one pediatric cardiology fellow, two categorical pediatric residents, and one advanced practice nurse. Daily management decisions are made during family-centered bedside rounds by a multidisciplinary team consisting of the above medical team, charge nurse, bedside nurse, dietician, pharmacist, discharge planner, and social worker. Postoperative patients are discharged home once the above team determines they are medically ready with no set criteria at the onset of this project.

The vast majority of patients receive diuretics in the immediate postoperative period with an eventual wean to off or, more commonly, to a homegoing regimen. Each ACCU cardiologist approaches the wean of diuretics differently, and anecdotally, substantial variation exists within our institution regarding the frequency and magnitude of each wean.

The Society of Thoracic Surgeons CHD Database is the largest congenital cardiothoracic surgery registry in the world.<sup>5</sup> We chose to narrow the scope of our project to reducing postoperative LOS for four Society of Thoracic Surgeons CHSD Benchmark Operations: Tetralogy of Fallot (TOF), Ventricular Septal Defect (VSD), Complete Atrioventricular Canal Defect (CAVC),

and D- Transposition of the Great Arteries (D-TGA) status post their initial complete surgical repair. We included various lesions to promote the development of broadly applicable interventions while maintaining numbers necessary to detect whether interventions led to change. The included defects have designated STAT (Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery) categories of <3 to indicate operative risk of morbidity and mortality, with category 1 having the lowest risk and category 5 the highest.

### *Preintervention*

In December of 2017, we assembled a multidisciplinary team consisting of division-level leadership, including the section chief and ACCU medical director, ACCU cardiologists, a cardiology fellow, inpatient nurse manager, charge nurse, discharge planner, cardiothoracic surgeon, cardiothoracic surgery advanced practice nurse, and front line staff, including an advanced practice nurse and pediatric resident. The team utilized strategies derived from the Institute of Healthcare Improvement model for improvement, including Aim Statement, Key Driver Diagram, and Plan-Do-Study-Act (PDSA) cycles. Baseline data were collected retrospectively over 11 consecutive months from January through November 2017. Initial team project discussions occurred in December of 2017. These discussions involved reviewing the current literature on the topic and creating a fishbone diagram identifying key drivers and perceived barriers for discharge. This information was then converted into a Key Driver Diagram (Fig. 1).

### *Interventions*

We developed and implemented a diuretic wean protocol in April 2018. It was felt that a substantial number of postoperative patients who are ready for discharge otherwise remain hospitalized for the sole purpose of weaning diuretics. The team also concluded that there is no evidence-based method currently employed at our institution (nor in the literature) to inform weaning diuretics with a great deal of variation among providers. Finally, one of our cardiothoracic surgeons hypothesized that a protracted diuretic wean was likely not necessary in patients undergoing a two ventricular repair in the current era of cardiopulmonary bypass. We standardized the wean of diuretics in our cohort by asking the ACCU medical team to transition the patient to a home going diuretic regimen (1 mg/kg twice daily oral furosemide) upon transfer from the CTICU to the ACCU. Escalation of diuretics was encouraged in cases where the patient developed symptomatic fluid retention.

The second intervention for our project involved the creation and implementation of a discharge milestone checklist. This visual tool was designed for display at the patient's bedside upon return from the OR with the intent to follow the patient throughout their postoperative admission. The checklist (Fig. 2) contains necessary

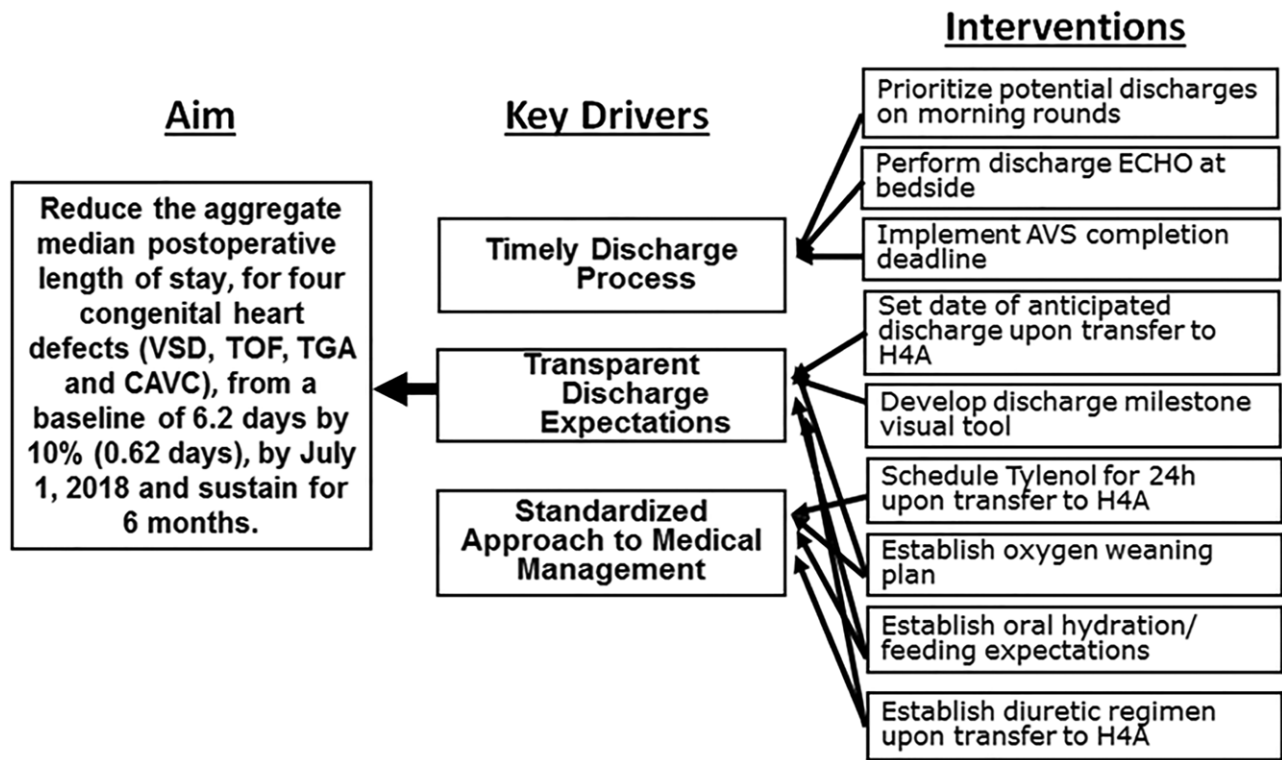


Fig. 1. Key Driver Diagram. ECHO, echocardiogram; H4A is synonymous with Acute Care Cardiology Unit.

milestones for discharge in addition to an anticipated date of discharge, a date set based on lesion-specific baseline data. Our team hypothesized that this checklist would create a shared mental model with key stakeholders, including the medical team, ancillary staff, patient, and family, with a reduction in provider practice variation. The checklist was implemented in September 2018 and has undergone several aesthetic and functional iterations with subsequent PDSA cycles.

**Study of Interventions**

There were no known changes to routine postoperative care in either the CTICU or ACCU during the study period. Additionally, to our knowledge, there were no other concurrent process improvement initiatives related to postoperative LOS. The observed improvements in our Statistical Process Control (SPC) charts were directly related to practice changes resulting from this project.

**Measures and Data Collection**

Outcome Measures included:

1. Aggregate Median Postoperative LOS for four CHD lesions following their initial complete surgical repair, including TOF, VSD, CAVC, and D-TGA.
2. Mean Variation from Target LOS ( $\Delta$ LOS): Obtained by taking the actual LOS minus the lesion-specific expected LOS and then averaging values for a given calendar month with the goal  $\Delta$ LOS being < 0 as this

would reflect an actual LOS less than expected LOS. This metric was chosen as the aggregate median postoperative LOS does not account for variations in the case mix. The actual LOS was determined using the date of the operation and the date of discharge to home. The expected LOS was lesion-specific and based on our internal baseline median LOS for each lesion, which was as follows: VSD 4 days, TOF 6 days, D-TGA 8.5 days, and CAVC 10 days. We did not use national benchmarking data as our internal data were superior to national data.

3. Postoperative costs: the patient bill was totaled for the services received post-surgery in the pre and postintervention group. The hospital’s cost then reduced these charges to Charge Ratio obtained from the most recent Medicare Cost Report.

Process Measures included compliance with interventions, including;

1. Diuretic Wean Protocol: compliance with the protocol was evaluated by retrospective chart review, which gathered the date of transfer from the CTICU to ACCU and compared this date with when the patient was weaned to a homegoing diuretic regimen. We considered compliance with the protocol wean to a homegoing regimen within 24 hours of transfer.
2. Discharge Milestone Checklist: compliance with this tool was assessed by the physical collection of checklists from the patient’s bedside at the time of

discharge and evaluating whether the checklist was completed. We considered the checklists complete if providers used both checkboxes to indicate when milestones were accomplished and designated an anticipated discharge date.

Balancing Measures included:

1. Readmissions rates at 7 and 30 days post-discharge,
2. CTICU bounce backs: the number of patients who after transfer to the ACCU required transfer back to the CTICU, and
3. Pleural chest tube replacements: the number of patients who after pleural chest tube removal required replacement.

Baseline data were collected retrospectively over 11 consecutive months in 2017 (January through November) for both outcome and balancing measures. The project began in December of 2017 with a prospective collection of the outcome, process, and balancing measures.

### Data Analysis

We obtained our data for analysis from a custom-built surgical database. The database serves as a case log and functions as a repository for reporting surgical data. Data, including surgical date and discharge date, amongst other data, are maintained by a surgical nurse administrator. SPC charts were generated using an Excel plug-in developed by an in-house statistician, and special cause variation was identified using the Nelson rules.<sup>13</sup>

### Ethical Considerations

The Institutional Review Board at NCH determined that this project was quality improvement and not human subjects research. Therefore, Institutional Review board review and approval were not required per institutional policy. We followed the Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) Guidelines for this publication.<sup>14</sup>

## RESULTS

Our baseline aggregate median postoperative LOS for our patient cohort was 6.2 days. We saw a shift on our SPC chart (Fig. 3), plotting this measure beginning in December of 2017, coinciding with the project team's initial assembly. Our patient cohort's new aggregate median LOS is 4.4 days with sustained improvement for over 2 years. See Figure (Supplemental Digital Content 2, which shows S-chart plotting LOS standard deviation in days with a reduction from 11.8 days to 2.8 days, <http://links.lww.com/PQ9/A329>).

Our  $\Delta$ LOS during the baseline period for our patient cohort was 5.5 days. We saw a shift on our SPC chart plotting this measure (Fig. 4) in January of 2018, again coinciding with team assembly. Our new  $\Delta$ LOS for the defects studied is 0.42 days, with sustained improvement for over 2 years.

Our average cost per case dropped in three of the four surgical procedure groups, ranging from \$9,675 to \$25,241 per case, with only D-TGA showing a \$10,054 increase. Net cost savings for all procedures combined were \$1,413,036. Of the three procedures with reduced postoperative costs, they ranged from 40% - 43%.

Compliance with the diuretic wean protocol was performed by retrospective chart review on all patients in this study. Depending on the month, compliance ranged from 70 to 80%, with the most common reasons for not following the protocol being evidence of pleural effusions on a chest x-ray at the time of transfer from the CTICU to ACCU, a persistent oxygen requirement, or provider preference.

Compliance with the discharge milestone checklist was more challenging to assess, given the need for the physical collection of the completed checklist upon discharge. At best, compliance with the discharge checklist for a given month during the study period was <50% despite multiple PDSA cycles aimed at improving visibility and ease of use. Barriers to assessing compliance include misplaced checklists upon transfer from the CTICU to ACCU and lack of a standardized process for checklist collection upon patient discharge.

Regarding balancing measures, there were no perceived unintended consequences of the project with zero 7 and 30 day readmissions for cardiac reasons. There was a single patient readmitted within 30 days during the study period for gastroenteritis and dehydration. Additionally, one patient returned to the CTICU after transfer to the ACCU, a 24-day old status post TOF repair who had developed low cardiac output syndrome requiring re-initiation of inotropic support. Importantly, this patient had not undergone a wean of diuretics per the protocol, and therefore, this event was felt to be unrelated to our intervention. Finally, no patients required pleural chest tube replacement following initial tube removal in patients who followed the diuretic wean protocol.

## DISCUSSION

### Summary

Implementation of a diuretic wean protocol led to significant and sustained improvement in postoperative LOS,  $\Delta$ LOS, and cost in a subset of CHD patients undergoing primary surgical repair. There were no perceived unintended consequences of our interventions concerning the impact on readmissions, CTICU bounce backs, or pleural chest tube replacement.

### Interpretation

To the best of our knowledge, this is the first study in pediatrics that sought to reduce postoperative LOS in a subset of CHD patients undergoing surgical repair utilizing a diuretic wean protocol. We saw a shift on our control charts plotting both outcome measures occurring temporally with our improvement team's assembly before



Patient Care Services

# Getting Ready For Discharge

*Use this checklist during your stay to track your progress.*

- \_\_\_\_\_ Return to home feeds
- \_\_\_\_\_ No supplemental oxygen
- \_\_\_\_\_ Oral pain control
- \_\_\_\_\_ Homegoing Lasix (water pill) dose
- \_\_\_\_\_ Absence of fever
- \_\_\_\_\_ Discharge studies completed and acceptable

## Anticipated Day of Discharge

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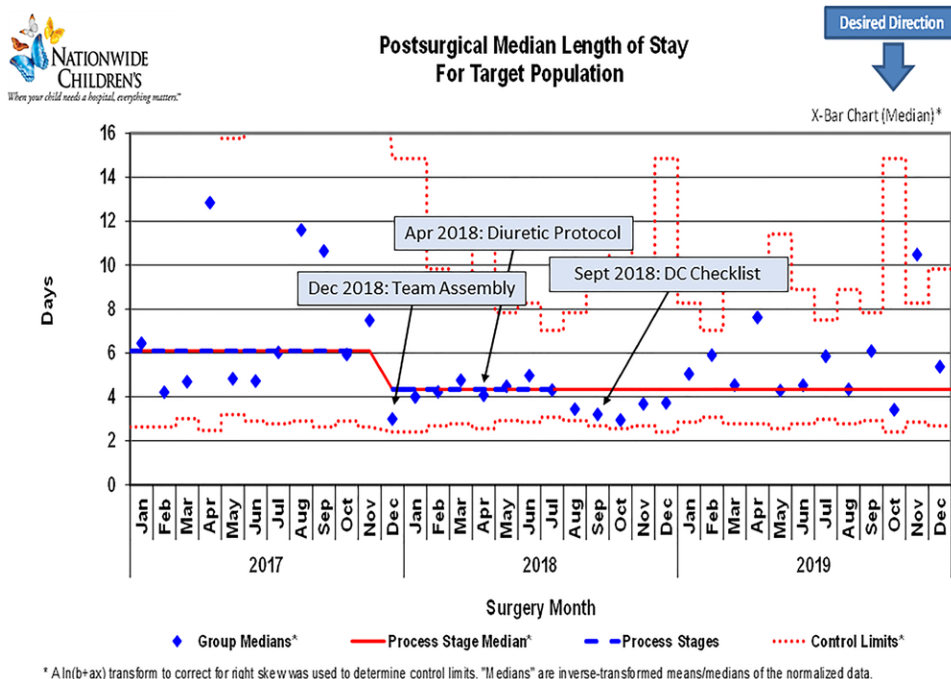


Fig. 2. Discharge Milestone Checklist.

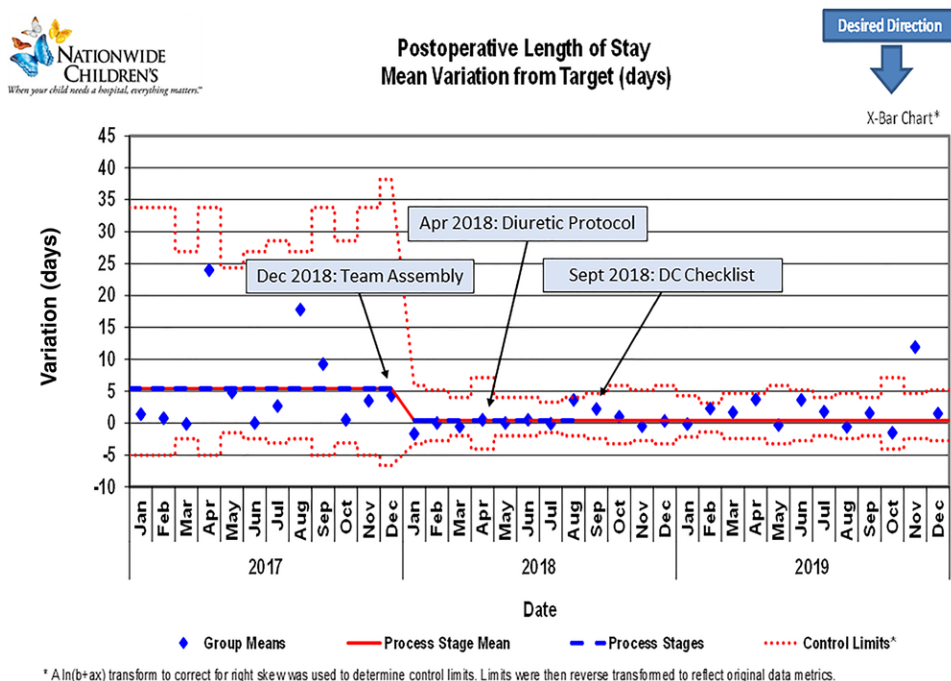
implementation of interventions. We attribute this initial improvement to the “Hawthorne effect,” where individuals modify their behavior in response to the awareness of being observed. As one would not expect this alone to result in over 2 years of sustained improvement, we are optimistic that the diuretic wean protocol impacted our results. Compliance with the diuretic wean protocol is high, with 75%–80% of eligible patients undergoing the wean. Additionally, there have been no other known changes to standard postoperative care in either the CTICU or ACCU, leading us to believe that observed

improvements in our control charts are directly related to practice changes resulting from this project.

We do not feel that implementing the discharge milestone checklist has had any impact on our outcome measures as improvements were achieved more than 9 months before checklist implementation. This finding is not surprising, as compliance with checklist use has been poor despite multiple PDSA cycles with adapted aesthetic and functional components of the tool. Despite these adaptations, we discovered multiple barriers to successful use of the checklist, including (1) the tool becoming misplaced upon



**Fig. 3.** Statistical Process Control Chart with Primary Outcome Measure: Aggregate Median Length of Stay for four Congenital Heart Defects following their initial complete surgical repair including TOF, VSD, D-TGA, and CAVC. Arrows and annotations correspond to interventions.



**Fig. 4.** Statistical Process Control Chart with Secondary Outcome Measure: Post-Operative Mean Variation from Target ( $\Delta$ LOS). Arrows and annotations correspond to interventions.

transfer from the CTICU to the ACCU, (2) family-centered rounds occurring outside of the room for patients on isolation precautions (checklist located inside the room on patient’s bed), and finally, (3) difficulty remembering to use the checklist given the relatively small number of

CHD operations included in this study. Additionally, accurate assessment of checklist compliance was hindered by the lack of a standardized process for checklist collection upon patient discharge. Project sharing at national pediatric cardiology quality collaborative meetings has suggested

that Stanford (Lucile Packard Children's Hospital) has achieved impressive improvements in postoperative LOS utilizing similar "target-based" strategies to our discharge milestone checklist. However, their findings have not yet been published for reference. We postulate that Stanford's more widespread implementation of target-based care, making its use standard of practice, likely accounts for the discrepancy in impact between our two centers.

Despite the vast amount of literature retrospectively evaluating predictors of a prolonged postoperative LOS, there is a lack of literature published that utilizes QI methodology to reduce postoperative LOS in the pediatric CHD population. One single-center study evaluated a postoperative protocol's impact (standardizing medication dosing, anticoagulation, fluid restriction, and dietary factors) on single ventricle patients undergoing Fontan palliation. After protocol implementation, the authors showed a reduction in overall pleural chest tube duration with subsequent reduction in postoperative LOS from a median of 8 days to 6 days.<sup>15</sup> An additional single-center study evaluated the impact of fast-tracking strategies (including same-day surgical admission, anesthetic management aiming for early extubation and early mobilization) on pediatric ASD and VSD patients undergoing surgical repair. Patients who had undergone fast-tracking had a reduction in median LOS (ASD from 2 to 1 day and VSD from 4 to 3 days) with cost-saving benefits.<sup>16</sup> Despite focusing our efforts on different CHD surgical operations, our study supports these previous publications by highlighting the effectiveness of standardizing clinical practice in improvement efforts and the subsequent effect this can have on overall practice variation.

### Limitations

The findings from this project should be interpreted with several limitations in mind. This study was limited to a single center and a small subset of CHD operations; therefore, the generalizability of this work may be limited. Additionally, standard postoperative practice at our institution tends to favor early extubation, removal of pleural chest tubes, and transfer from the CTICU to the ACCU, which is likely to impact our overall postoperative LOS, which may differ from other cardiac centers. Our outcome measure, aggregate median postoperative LOS, does not account for variations in the case-mix, which was mitigated by evaluating  $\Delta$ LOS. For additional case mix information, please see Figure (Supplemental Digital Content 1, which shows baseline versus intervention cohort lesion distribution data, <http://links.lww.com/PQ9/A328>). Costs were calculated using the overall hospital charges to Charge Ratio. Individual departments may have different charges to Charge Ratios that, if available, could have led to a different result. Finally, NCH has a strong culture rooted in continuous improvement coupled with a robust QI Services department allocating resources to each division for improvement projects. Institutions without these resources may have difficulty in duplicating our work.

## CONCLUSIONS

Implementation of a diuretic wean protocol in a subset of CHD patients undergoing primary surgical repair can effectively reduce postoperative LOS as there is a great deal of practice variation with no established evidence-based guidelines. There were no perceived unintended consequences in our cohort of patients, who all underwent a two ventricular repair. However, the generalizability of a diuretic wean protocol is unclear, especially in patients with differing postoperative physiology, which could be the subject of future studies. It is evident that standardization of postoperative care is effective for improvement efforts and can reduce overall practice variation.

## DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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