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ORIGINAL ARTICLE

Reduced Length of Stay after Implementation of a Clinical Pathway following Repair of Ventricular Septal Defect

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Abstract

Background: There is variation in care and hospital length of stay following surgical repair of ventricular septal defects. The use of clinical pathways in a variety of pediatric care settings have been shown to reduce practice variability and overall length of stay without increasing the rate of adverse events.

Methods: A clinical pathway was created and used to guide care following surgical repair of ventricular septal defects. A retrospective review was done to compare patients two years prior and three years after the pathway was implemented. Analyses were conducted to compare the pre and pathway groups and model the impact of various independent variables.

Results: There were 23 pre-pathway patients and 25 pathway patients. Demographic characteristics were similar between groups. Univariate analysis demonstrated a significantly lower time to initiation of enteral intake in the pathway patients (median time to first enteral intake was 360 minutes in pre-pathway patients and 180 minutes in pathway patients, $p < 0.01$).

Multivariate regression analyses demonstrated that the pathway use was independently associated with a decrease in time to first enteral intake (-203 minutes), hospital length of stay (-23.1 hours), and ICU length of stay (-20.5 hours).

No adverse events were associated with the use of the pathway, including mortality, reintubation rate, AKI, increased bleeding from chest tube, or readmissions.

Conclusions: The use of the clinical pathway improved time to initiation of enteral intake and decreased length of stay. Surgery-specific pathways may decrease variability in care while also improving quality metrics.

Keywords

Pediatric, Congenital heart surgery, Intensive care, Infant, Ventricular septal defect, Postoperative care, Congenital heart disease (CHD)

Introduction

Variation in treatment and inconsistent care may affect quality of care and specifically length of stay for pediatric patients in the hospital setting. Reducing variability in care can assist in creating consistent outcomes for patients following cardiac surgery. Optimizing that care plan may also improve outcomes. The use of clinical pathways in a variety of pediatric care settings have been shown to reduce overall length of stay without increasing the rate of adverse events [1,2].

Interprovider variability can account for variation in care following surgery, as well as extended length of stays (LOS) [2]. Longer postoperative length of stays account for increased hospital costs [2-4], an increased risk of hospital acquired infections as well as errors, and worse long-term neurodevelopmental outcomes [1,2].

Clinical pathways aimed at decreasing inter-provider variability have been used for several years and have been associated with reductions in morbidity, mortality, resource usage, and hospital length of stay [2,5,6]. Clinical pathways have also shown to improve patient care in a variety of patient-specific settings [1-3]. There has been some study of reducing hospital length of stay following cardiac surgery using problem specific pathways such as feeding advancement [7]. However,

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surgery-specific pathways offering a more complete guide to post-operative care may further reduce LOS, but are rarely described in recent literature.

We organized a small cohort of providers and nursing staff to build a surgery-specific fast-track pathway for patients following ventricular septal defect (VSD) repair. After establishing the pathway, we retrospectively compared a historical control of patients with VSD repair prior to pathway usage and compared them to patients whose care was managed with the clinical pathway. Our hypothesis was that the introduction of a pathway would reduce variability in clinical outcomes and reduce length of stay.

Methods

We created a clinical pathway to care for patients following surgical VSD repair with the guidance of a small, interprofessional, task force. The initial framework for the clinical pathway was based on standard of care and group consensus as well as evidence-based care [8-12]. The pathway was then approved by the entire provider and nursing leadership (CICU) team. The draft-protocol was used with a number of patients prior to formal implementation. We then implemented the pathway as a tool to guide care following VSD repair. Education was carried out on a monthly basis with each new set of rotating providers, as well as regular updates at faculty meetings. The outpatient cardiologists were also included in education on the pathway to assist in managing parental expectations of care and hospital length of stay.

This fast-track pathway [10,11] included timing of when milestones in care should be achieved. Important aspects of this pathway include: 1) Early extubation in the operating room or within six hours of CICU admission 2) Early PO intake allowed (as early as two hours after admission) 3) Early initiation and maintenance of scheduled furosemide (starts three hours after admission) 4) Use of only as needed opioid analgesics rather than a continuous infusion with transition to enteral as early as the first postoperative night 5) Scheduled adjunct medications for pain control (ketorolac within 6 hours of admission and scheduled acetaminophen) 6) Weaning oxygen therapy expeditiously 7) Early mobilization with urinary catheter removal no later than post operative morning one.

This retrospective historical control study took place at Advocate Children's Hospital, in Oak Lawn, Illinois. Institutional Review Board approval was obtained. All patients consecutively who had simple ventricular septal defect repair were evaluated for inclusion. Pre-pathway patients were identified from a surgical database for two years prior to implementation of the pathway. Four patients were excluded during a washout period as we tested the initial protocol. After 3 years of implementation, all patients post-VSD repair were identified for the post-implementation group. Inclusion criteria were: 1) Patients ages 0-18 years, 2) Ventricular septal defect repair, including patients who also had a patent ductus arteriosus (PDA) ligation and/or the closure of an atrial septal defect (ASD). Exclusion criteria included: 1) Patients over 1 year of age with an unrestrictive VSD prior to repair (due to this population having higher risk for pulmonary hypertension), 2) Patients with other cardiac defects beyond PDAs and ASDs, 3) Prematurity defined as gestational age less than 36 weeks at the time of repair, 4) Patients with chronic kidney disease, 5) Patients with a genetic syndrome other than trisomy 21, 6) Significant non-cardiac diagnosis (such as tracheostomy, use of gastrostomy tube, severe neurologic impairment, heterotaxy), 7) Patients intubated longer than 3 hours following CICU admission.

Data was collected from the electronic medical records that included demographics, surgical repair, and outcomes, such as time to first enteral intake, need for re-intubation, etc. Milestone data was identified as the achievement of a particular protocol recommendation that was completed within the recommended time frame and was evaluated prospectively. There were a total of 43 possible milestones within the overall pathway, not all were applicable to each patient, as the pathway was used on varying age groups. Additionally, five milestones thought to be critical to pathway success were separately evaluated. These critical milestones included: the VSD surgery performed as the first surgical case of the day and arriving to the cardiac ICU prior to 1400, administration of the first dose of furosemide within 4 hours post-operatively, initiation of enteral feedings within 4 hours, transition to enteral pain control by the morning following surgery, and no initiation of continuous sedation or opioid infusions. We did not distinguish between the provider not achieving the milestone in the recommended time period due to the patient's condition vs. non-compliance to the pathway.

Descriptive variables are described as absolute frequency and percentage. Continuous variables are described as median and range. Patients were divided into two groups: those cared for before and after the institution of the clinical pathway. Descriptive variables were compared between the groups using Fisher exact tests while continuous variables were compared between the groups using a Mann-Whitney-U test (Table 1).

Next, a series of regression analyses were conducted. First a linear regression was conducted in stepwise fashion with time to enteral intake as the dependent variable. Next, a linear regression was conducted with intensive care unit length of stay as the dependent variable. Finally, a linear regression was conducted with postoperative hospital length of stay as the dependent variable.

Table 1: Characteristics between those who underwent ventricular septal defect closure before and after the introduction of the clinical pathway.

	Before pathway (n = 23)	After pathway (n = 25)	p-value
Gender (2)	16	22	0.16
Weight	8.0 (4.0 to 53.8)	6.9 (4.1 to 88.3)	
Cardiopulmonary bypass time	62 (33 to 150)	57 (42 to 97)	0.66
Cross clamp time	49 (21 to 131)	40 (24 to 68)	0.21
Inotrope score	0 (0 to 10)	5 (0 to 10)	0.15
Peak lactate	2.8 (1.5 to 8.6)	2.7 (1.5 to 9.3)	0.90
Time to feeding (minutes)	360 (120 to 1,320)	180 (90 to 1,245)	< 0.01
Emesis with feeds	4	8	0.32
Total intensive care unit length of stay (hours)	31 (26 to 179)	33 (23 to 58)	0.65
Total postoperative hospital length of stay (hours)	70 (44 to 218)	50 (26 to 121)	0.04
Readmission	1	0	0.47

All statistical analyses were conducted using SPSS VErsion 23.0. A p-value of less than 0.05 was considered statistically significant. Any use of the word "significant" or "significance" in this manuscript implies statistical significance unless explicitly stated otherwise.

Results

A total of 48 patients were included in the final analyses. Of these, 23 patients underwent surgical VSD closures prior to implementation and 25 patients following implementation of a clinical pathway. Demographic data including age, gender, and weight did not differ between the two groups. Perioperative factors including cardiopulmonary bypass time and cross clamp time also did not differ between the two groups. There was a 82% rate of achievement of all possible milestones prescribed in the pathway. Amongst the milestones deemed critical, 80% of the milestones were achieved. The most common reason for lack of achievement of milestones is delay in initial administration of furosemide.

Inotrope score and peak serum lactate did not differ between the two groups. Time to first enteral intake was significantly lower in patients cared for after pathway implementation (180 vs. 360 minutes, $p < 0.01$). Total postoperative hospital LOS was significantly shorter in patients cared for after pathway implementation (50 hours vs. 70 hours, $p = 0.04$). There was no significant difference in need for readmission (none in both groups).

Multivariable regression analysis with time to first enteral intake as the dependent variable demonstrated that peak lactate (beta-coefficient = 75.1, $p < 0.01$) and the pathway (beta-coefficient = -203.4, $p < 0.01$) were significantly associated with time to enteral intake. Phrased differently, every 1 mmol/L increase in peak serum lactate was associated with a 75 minute increase in time to enteral intake, and being operated on after implementation of the clinical pathway was associated with a 203 minute decrease in time to enteral intake.

Multivariable regression analysis with intensive care unit LOS as the dependent variable demonstrated that weight (beta-coefficient -2.0, $p < 0.01$), cardiopulmonary bypass time (beta-coefficient 1.6, $p = 0.02$), cross clamp time (beta-coefficient -2.1, $p = 0.04$), peak lactate (beta-coefficient 7.5, $p = 0.04$), and the pathway (beta-coefficient -20.5, $p = 0.03$) were significantly associated with intensive care unit LOS. Phrased differently, every 1kg increase in weight was associated with a 2 hour decrease in intensive care unit LOS, every 1 minute increase in cardiopulmonary bypass time was associated with a 1.6 hour increase intensive care unit LOS, every 1 minute increase in cross clamp time was associated with a 2.1 hour decrease in intensive care unit LOS, every 1 mmol/L increase in peak serum lactate was associated with a 7.5 hour increase in intensive care unit LOS, and being operated on after implementation of the clinical pathway was associated with a 20 hour decrease in intensive care unit LOS.

Multivariable regression analysis with postoperative length of hospital stay as the dependent variable demonstrated that the pathway (beta-coefficient -22.7, $p = 0.03$) was significantly associated with reduced postoperative length of hospital stay.

Comment

The introduction of a clinical pathway reduced the LOS for patients following VSD repair by almost a day. There was also a reduction in time to first enteral intake with pathway usage. We presumed, given the high compliance in achieving milestones prescribed by the pathway that there was decreased variability in treatment plans for patients following VSD repair.

DeSomma, et al. [6] studied the use of a clinical pathway for patients following ASD repair and found that the use of their pathway decreased hospital LOS and resource utilization. This pathway includes daily goals for patient outcomes for the care team to achieve, starting on postoperative day (POD) 1 with a goal of discharge on POD 2. Our pathway functioned similarly by defining goals for patient management, but in a more specific time-frame, including the de-escalation of care the evening of surgery. We also found a reduction in LOS using this method (Supplementary Table S1).

Of the milestones identified as critical, compliance rates were the lowest for the timing of administration of the first dose of furosemide, and the initiation of a continuous infusion of dexmedetomidine. Furosemide administered after 4 hours postoperatively was considered non-compliant. Furosemide was typically administered early, but not always within this strict time frame. It is likely furosemide was administered earlier than during the historical comparison period. The non-compliance related to the use of a continuous infusion was meant for opioids, but was often marked off due to the use of dexmedetomidine. A primary focus of the pathway was to encourage lower opioid use, and the administration of dexmedetomidine is not ideal, but may not be as deleterious.

We used a very prescriptive approach to reducing variation and decreasing LOS. Conversely, Shin, et al. [13] described benchmarking results and then displaying visual targets for a variety of care goals in patient care that encouraged the team to decrease variability and hospital LOS. This approach resulted in decreased variability, mechanical ventilation time, ICU LOS, and hospital LOS. Shin, et al. [13] dispensed with the need to go through the process of building specific care plans and still improved outcomes without directing individual provider management.

Our study evaluated the use of a clinical pathway, which was presented via a checklist of time-specific guidelines. The prescriptive approach to our clinical pathway prevents the omission of important care components and encourages timely care delivery in an otherwise distracting environment. Additionally, this presentation of achievable goals may motivate the user to progress care forward at a rate not otherwise considered. Both target based and prescriptive approaches are useful in decreasing LOS via individual methods of encouraging forward progression.

A prescriptive approach also allows for review of evidence-based or best practices to be incorporated into the unit culture. For example, a reduction in nil per os time for patients following VSD surgery may decrease fluid overload as intravenous crystalloid fluids are stopped when enteral intake is starting, possibly decreasing excessive fluid administration requiring increased diuresis. Patient agitation postoperatively is often related to thirst or hunger, and may be difficult to identify in the non-verbal population. Increased agitation can contribute to increased sedative and opioid administration in the initial postoperative recovery period. This earlier progression of enteral intake may also lead to improved patient comfort at an earlier time, possibly decreasing sedative and opioid administration.

Additionally, the more rapid timeline of patient care may further improve provider comfort in fast-track methods of care, encouraging providers to use similar methods in varying patient populations. The use of faster care progression in this subset of patients following VSD repair may benefit other patient populations with similar acuity post-cardiac surgery by reflecting these care techniques. This approach to patient management may further shorten hospital length of stay for a variety of congenital heart defects.

Limitations

During the implementation phase there was the addition of another cardiac surgeon, unit bed expansion by 40%, high bedside staff turn-over, and hiring of new providers and nursing staff which may have led to variable degrees of knowledge and comfort in executing the pathway. The clinical pathway was printed for each patient, and included a section that allowed for comments if the patient did not meet the goal within the identified time period. There was inconsistent documentation that highlighted these deviations from the pathway, making it difficult to determine if non-compliance was related to provider preference, incidental omission of forward progress, or patient clinical status.

Conclusions

The use of the clinical pathway improved time to initiation of enteral intake and decreased length of stay. Use of surgery specific pathways may decrease variability in care while also improving quality metrics. There were no adverse outcomes related to the use of the pathway.

Disclosures

All authors have no relevant financial or non-financial relationships to disclose.

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