

Reducing variation in feeding newborns with congenital heart disease

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Abstract

Objective: Enteral feeding is associated with decreased infection rates, decreased mechanical ventilation, decreased hospital length of stay, and improved wound healing. Enteral feeding difficulties are common in congenital heart disease. Our objective was to develop experience-based newborn feeding guidelines for the initiation and advancement of enteral feeding in the cardiothoracic intensive care unit.

Design: This is a retrospective analysis of a quality improvement project.

Setting: This quality improvement project was performed in a cardiothoracic intensive care unit.

Patients: Newborns admitted to the cardiothoracic intensive care unit for cardiac surgery from January 2011 to May 2015 were retrospectively reviewed.

Intervention: Newborn feeding guidelines for the initiation and advancement of enteral feeding were implemented in January 2012.

Outcome measures: Guideline compliance and clinical variables before and after guideline implementation were reviewed.

Results: Compliance with the guidelines increased from 83% in 2012 to 100% in the first two quarters of 2015. Preguidelines (January 2011–December 2011): 45 newborns underwent cardiac surgery; 8 deaths prior to discharge; 1 patient discharged from NICU, therefore, $N = 36$. Post-guidelines (January 2012–May 2015): 131 newborns with 12 deaths, 12 admitted from home, 8 in the NICU, 3 on the floor preop, and 3 back transferred, therefore, $N = 93$. No difference in feeding preop (post 75% vs pre 69%; $P = .5$) or full po feeds at discharge (post 78% vs pre 89%; $P = .2$). Mesenteric ischemia was not statistically different postguidelines (post 6% vs pre 14%; $P = .14$). Length of hospital stay decreased postguidelines (post 27 + 17 d vs pre 34 + 42 d; $P < .001$).

Conclusions: Implementation of experience-based newborn feeding guidelines for initiation and advancement of enteral feeding in the cardiothoracic intensive care unit was successful in reducing practice variation supported by increasing guideline compliance. Percentage of patient's full oral feeding at discharge did not change. Length of hospital stay was reduced although cannot be fully attributed to feeding guideline implementation.

KEYWORDS

cardiac surgery, congenital heart disease, feeding, quality improvement, intensive care unit, newborn

1 | INTRODUCTION

Enteral feeding is associated with decrease infection rate, decrease mechanical ventilation, decrease hospital length of stay, and improve wound healing.¹⁻⁶ However, enteral feeding difficulties are common in newborns with congenital heart disease.⁷⁻¹⁵ Factors contributing to feeding difficulties in this patient population include inadequate calorie intake, high metabolic demands, gastrointestinal pathology, genetic and extracardiac abnormalities.¹³⁻¹⁵ Advancement to nutritional goals may be slow in the perioperative period secondary to concerns for poor systemic output, the need for inotropic support, limitations of fluid intake, the risk of mesenteric ischemia and frequent interruptions in nutrient delivery.^{13,16,17} Poor nutrition is associated with worse outcomes in children undergoing surgery.^{18,19}

Nutrition protocols in this population are largely based on single-center experience and are influenced by hospital culture as well as care provider opinion.^{12,13,20} Review of newborn feeding in the cardiothoracic intensive care unit (CTICU) at our institution revealed inconsistency in the initiation of enteral feeds and the process of increasing enteral feeds. These issues led to a quality initiative to create standardized newborn feeding guidelines. We used the Institute for Healthcare Improvement (IHI) strategy to develop experience-based newborn feeding guidelines for initiation and advancement of enteral feeding in the CTICU to reduce practice variation while maintaining quality patient care.

2 | METHODS

2.1 | Ethical issues

This quality improvement work involved development of experience-based guidelines for initiation and advancement of enteral feeding in newborns in the CTICU. No interventions involved comparison of multiple devices or therapies, and patients were not subjected to randomization. Medical records were accessed by quality improvement team members as part of their normal responsibilities. No personal health information was shared outside of our institution. Therefore, institutional review board review was waived at our institution.

2.2 | Setting

Nationwide Children's Hospital is an academic, nonprofit, freestanding children's hospital located in Columbus, Ohio. The CTICU is a 20-bed unit with over 500 admissions per year. The top five most common admission diagnoses are postoperative ventricular septal defect repair, hybrid palliation stage I; hybrid palliation comprehensive stage II, pulmonary valve replacement, and Fontan procedure. Our center philosophy is one of the hybrid palliation rather than Norwood operation. Approximately 10% of our admissions are newborns, defined as less than 30 d of age. The pediatric CTICU staff includes a multidisciplinary team of critical care and cardiology physicians ($n = 8$), advanced nurse practitioners ($n = 10$), a dedicated clinical pharmacist ($n = 1$), registered nurses ($n = 61$), respiratory therapists ($n = 14$), physicians in fellowship

training in critical care and cardiology, clinical dietitians ($n = 3$), physical therapist, occupational therapist, child life specialist, and social worker.

2.3 | Planning the intervention

Retrospective review of all newborns admitted to the CTICU from January to May 2011 revealed inconsistencies in when to start enteral feeds, how to start enteral feeding, and how to increase enteral feeding. These issues led to a quality initiative to develop and implement standardized newborn feeding guidelines. We began by creating a SMART (specific, measurable, achievable, realistic, and timely) specific objective statement and key driver diagram.²¹ Patient factors, lack of guidelines, staff education, staff accountability, and measurable outcome were identified as our key drivers.

2.4 | Intervention

The interventions or process changes that were introduced included establishment of patient criteria for initiation of enteral feeding that were simple and minimally controversial; development of standardized feeding initiation and advancement guidelines that were also simple and minimally controversial; creation of electronic medical record SMART phrases for feeding initiation and advancement to simplify use; education and training of the CTICU staff regarding the guidelines and goals; obtaining CTICU staff buy-in and accountability; and development of outcome and compliance measures. Standardized initiation and advancing guidelines were initially implemented in January 2012 for newborns greater than 35 wk gestation admitted to the CTICU prior to cardiac surgery. Premature newborns were not included in this study population as they were more likely to be discharged from the NICU service postoperatively. Newborns who were admitted to either the floor ($n = 3$) or the NICU ($n = 8$) preoperatively were excluded. Newborns admitted for surgery from home ($n = 12$) were also excluded. Mesenteric ischemia was conservatively defined by clinical concerns resulting in no enteral feedings plus antibiotics for 7 d.

Guidelines were revised in 2013 to simplify their use based on feedback from the CTICU nursing staff. Initially we utilized a SMART phrase for electronic medical record (Epic Systems Incorporated, Verona, WI) ordering but it appeared very confusing in the nursing screen. The SMART phrase was modified to improve the appearance on the nursing screen shot. Our current feeding guidelines were revised again mid-2014 for further simplification and ease of Epic ordering. At that time we were able to create a specific CTICU newborn feeding Epic order set. We were unable to create an order set previously secondary to implementation of scheduled Epic upgrades which halt all other builds. Feeding guideline content did not change over this time frame, just the mode of ordering changed. Feeding guidelines are shown in Figure 1. All newborns in the CTICU also receive a consult from speech, occupational and physical therapy upon admission as per our standard of care. Heart Center dietician support was added so that a dietician could be present during rounds in the CTICU to address feeding issues, concerns, and continuing education as well as track real time data.

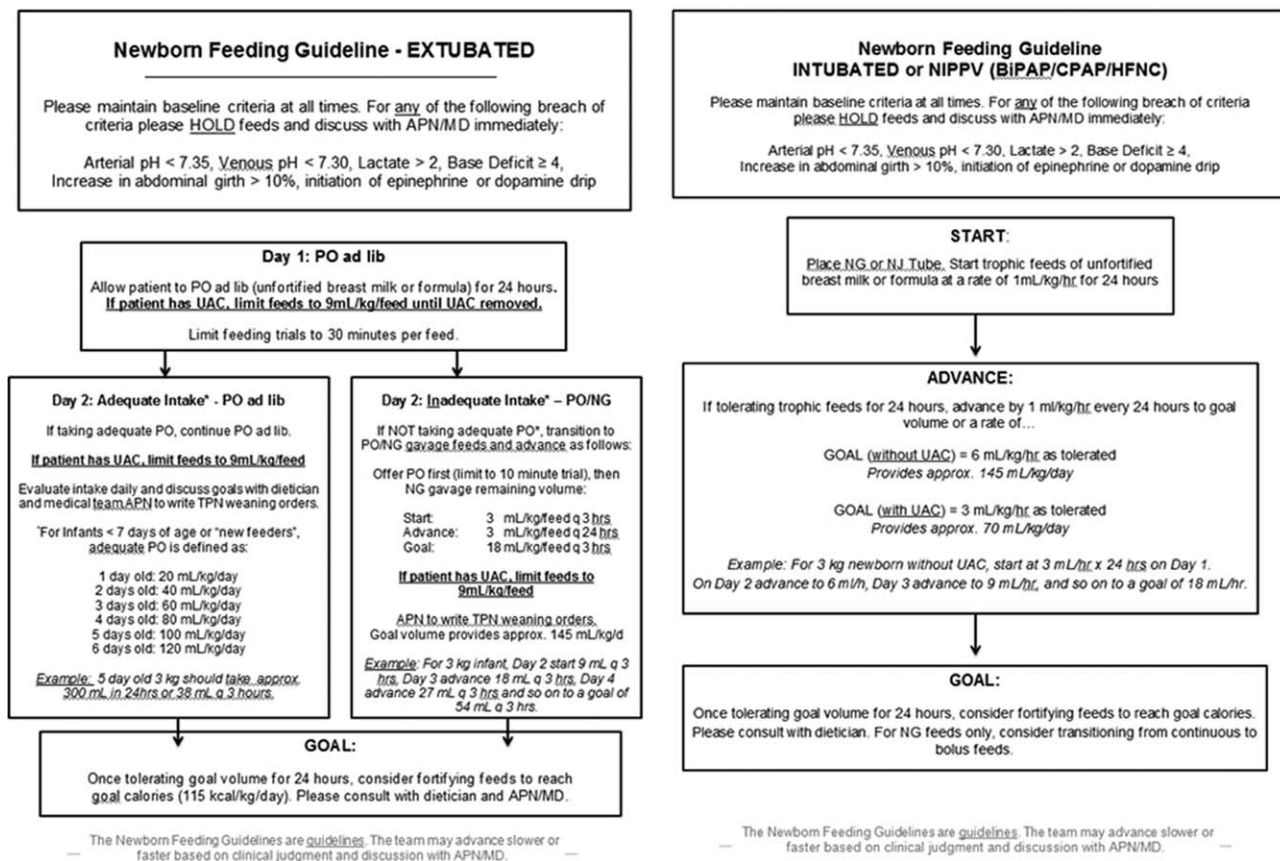


FIGURE 1 Newborn feeding guidelines

2.5 | Method of evaluation

Data on guideline usage compliance was tracked. Compliance was initially measured by utilization of the SMART phrase in our electronic medical record (Epic Systems Incorporated). And later an order set was developed for our electronic medical record system to enhance the ease of ordering and reduce the confusion at the bedside. We also altered the way compliance was tracked. Instead of measuring the SMART phrase, we elected to track the usage of the order set in our electronic medical record. This method was a more consistent and easily obtainable plan of tracking compliance with the newborn feeding guidelines.

2.6 | Statistical analysis

Retrospective review of outcome variables was performed with comparison of newborns from 2011 (before the standardized guidelines) and from January 2012 to May 2015 (after the standardized guidelines had been established). Data are expressed as mean ± SD. Statistical analysis was performed by using Fisher's exact test or chi-square tests where appropriate. Statistical significance was defined as a *P* value of <.05. Compliance data is demonstrated utilizing a p-chart. In statistical quality control, the p-chart is a type of control chart used to monitor the proportion of nonconforming units in a sample, where the sample proportion nonconforming is defined as the ratio of the number of nonconforming units to the sample size.²²

3 | RESULTS

From January to December 2011, preguidelines, 45 newborns underwent cardiac surgery with 8 deaths prior to discharge and 1 patient discharged from NICU therefore, 36 newborns comprised the prefeeding guideline group. From January 2012 to May 2015, postguidelines, there were 131 term newborns who underwent cardiac surgery with 12 deaths; 12 newborns were admitted for surgery from home; 8 were in the NICU preoperatively; 3 were on the floor preoperatively; and 3 had incomplete data secondary to back transfer to referring hospital. Therefore, 93 patients comprised the post feeding guideline group.

Weight and age at surgery were not different between the groups as seen in Table 1. There were more single ventricle patients in the post feeding guidelines group (*P* = .001). Forty-one of the 56 patients with ductal dependent systemic blood flow (73%) were orally fed preoperatively. Only 26 of the 70 (37%) newborns reached full volume feeds (120 mL/kg/d) preoperatively, and 30 of the 70 (43%) were fed via nasogastric tube at some point preoperatively. Admittedly, feeds were often stopped and restarted based on the baseline feeding criteria. Unfortunately, data is not available regarding how many times feeds were held for breach of feeding guideline baseline criteria. There was no difference in incidence of feeding before surgery (post 75% vs pre 69%; *P* = .5) or full oral feeds at discharge between the two groups (post 78% vs pre 89%; *P* = .2). There was no statistically significant difference between the two groups in those newborns discharged direct

TABLE 1 Patient characteristics and outcome variables before and after institution of newborn feeding guidelines

	Preguidelines	Postguidelines	P value
N	36	93	
Birth weight (kg)	3.2 ± 0.6	3.2 ± 0.5	.2
Single ventricle defects	16 (44%)	70 (75%)	.0003*
Feeds preop (%)	25 (69%)	70 (75%)	.5
Feeds with UAC (%)	8 (22%)	37 (40%)	.07
Age at surgery (d)	9 ± 7	8 ± 6	.3
Hybrid procedure (%)	10 (28%)	49 (53%)	.006*
Cardiopulmonary bypass procedure (%)	17 (47%)	11 (12%)	.0001*
Discharged with full oral feeds	32 (89%)	73 (78%)	.2
Direct breast-feeding postop (%)	7 (19%)	11 (12%)	.2
All formula feeds (%)	17 (47%)	31(33%)	.2
Fortified feeds to 24 or 27 cal/oz (%)	15 (42%)	57 (61%)	.08
“Special” formula at discharge (%) Elemental, soy or low fat	9 (25%) Isomil (1); elemental (5); enfaport (3)	9 (21%) Isomil (2); elemental (6); enfaport (1)	.05
Mesenteric ischemia (%)	5 (14%)	6 (6%)	.14
Hospital length of stay (d)	34 ± 42 24 (range 4–228)	27 ± 17 23 (range 5–89)	<.001*
Discharge weight for age Z-score	−1.5 ± 1.3 −1.2 (range 0.93–4.67)	−1.4 ± 1.1 −1.2 (range 0.96–5.1)	.22

Data are expressed as mean ± standard deviation and median with range.

*Statistical significant difference between pre- and postguidelines.

breast-feeding (with supplementation from the bottle as needed); those discharged with all formula feeds (no breast milk feeding even by bottle); and those discharged with increased caloric density feeds. There was a trend toward increased utilization of elemental, low fat and soy formulas in the preguideline group; however, this did not reach statistical significance.

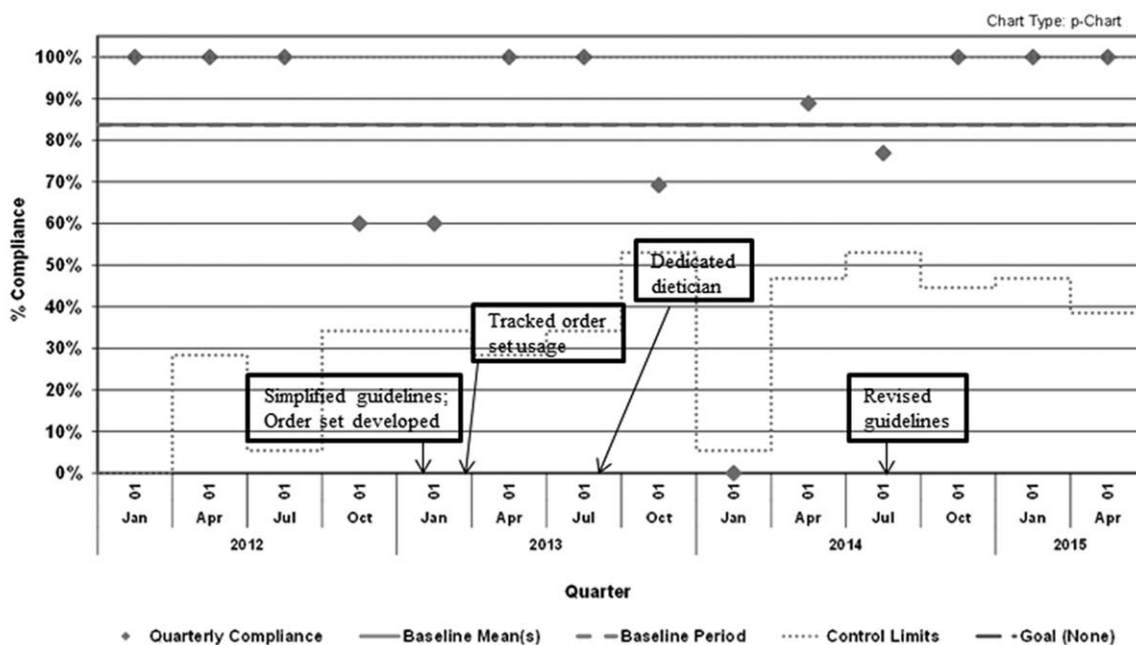
Forty percent of newborns in the postguideline group were fed in the presence of an umbilical artery catheter; none of these newborns had mesenteric ischemia. Whereas three of the eight patients fed in the presence of an umbilical artery catheter in the preguideline group developed mesenteric ischemia. Mesenteric ischemia was not statistically different post feeding guidelines (post 6% vs pre 14%; $P = .14$). Of the five preguideline patients who were treated for mesenteric ischemia, two had mesenteric ischemia before surgery (one with tricuspid atresia and hypoplastic arch and one with total anomalous pulmonary venous return), and three patients had mesenteric ischemia after surgery (all three with hypoplastic left heart syndrome s/p hybrid palliation). Of the six postguidelines, patients who were treated for mesenteric ischemia, two had mesenteric ischemia before surgery (one with aortic coarctation and one with tricuspid atresia and absent pulmonary valve) and four patients had mesenteric ischemia after surgery (two with hypoplastic left heart syndrome s/p hybrid palliation, one with truncus arteriosus s/p truncus repair, and one with ductal dependent pulmonary artery s/p stent placement). Length of hospital stay was reduced postfeeding guidelines (34 ± 42 d pre vs 27 ± 17 d post; $P < .001$).

Figure 2 is a p-chart illustrating quarterly compliance with the feeding guidelines. Compliance data was not available for one patient. Time frame by quarter is on the x-axis and percent compliance is on the y-axis. The annotations on the chart indicate the time frame of each intervention. The complaint audits vs the total audits are shown at the bottom of the chart. Overall compliance with the feeding guidelines over the entire time frame was 81%. Compliance increased from 83% in 2012 to 100% in the first two quarters of 2015. In depth, review of low compliance in the fourth quarter 2012 and first quarter 2013 was contributed to difficulty in tracking the SMART phrase and nursing confusion at the bedside. This was addressed by creation of an order set in the electronic medical record which was easier for the provider to use and less confusing to the bedside nurse. The guidelines were further simplified for ease of ordering and interpreting at the bedside in late 2013 based on nursing feedback, which may be the reason for the low compliance in the first quarter 2014.

4 | DISCUSSION

Clinical practice guidelines have been publicized as methods to reduce practice variation, improve quality of care, and contain cost.^{23,24} Guidelines require redesign of work processes, communication strategies and infrastructure, as well as sustained measurement and vigilance. According to the IHI strategy for designing systems, the first step is to create

Quarterly Compliance with Feeding Guidelines



Compliant Audits	1	4	2	3	3	4	5	9	0	8	10	8	9	6
Total Audits	1	4	2	5	5	4	5	13	2	9	13	8	9	6

FIGURE 2 P chart showing compliance with newborn feeding guidelines over time

a simple, standardized approach or guideline that is minimally controversial.²¹ The second step is to evaluate adherence to the guideline. The steps that follow use strategies of standard order sets, checklists, education, and training. Once the standardized process is in place, compliance is reviewed to identify failures to use the process to help identify barriers and understand the failures. This process leads to improvement of the guidelines. Practice guidelines are systematically developed statements intended to assist with decisions regarding appropriate care for certain medical situations.²³ Enteral feeding has been shown to decrease infection rates, decrease mechanical ventilation, decrease hospital length of stay, and improve wound healing.¹⁻⁶ However, enteral feeding difficulties are common in newborns with congenital heart disease.⁷⁻¹⁵ Our objective was to implement standardized newborn feeding guidelines in the CTICU to reduce practice variation while maintaining quality patient care.

Our initiation and advancement guidelines were based on evidence from the literature.^{12,20,25} We used the same guidelines both before and after cardiac surgery. Our baseline feeding criteria (see Figure 1) were developed as a conservative proactive guide to ensure safety with enteral feeding. We felt that following serial pH, lactate, base deficit, abdominal girth and monitoring inotropic requirements were important factors for continued consideration when enterally feeding these high risk patients, as abnormalities in these are indicators of low cardiac output syndrome. If a patient has evidence of decompensated low cardiac output syndrome enteral feeds are held. Our conservative advancement strategy (20 cc/kg/d) was both evidence and experience-

based secondary to the high incidence of feeding difficulties in this patient population.^{1,7-17,20,25}

Our strategy of enteral feeding while on low dose inotropic support is supported by King et al.²⁶ in a case series which demonstrated tolerance of feeds without adverse events while receiving a variety of inotropic support. We support feeding while on prostaglandins (PGE1) to maintain ductal patency as long as our baseline criteria are met much like our European colleagues.²⁷ Forty-one of the 56 patients with ductal dependent systemic blood flow (73%) were po fed preoperatively. We also support enteral feeding in patients with umbilical arterial catheters in place. In our patient population 40% were po feeding in the presence of an umbilical artery catheter. Although we limit the total maximum enteral goal volume by one-half secondary to historical concerns for potential compromised flow to the splanchnic bed, even though there is limited evidence in the literature.^{10,20,28} None of these patients suffered from mesenteric ischemia.

Our first step towards obtaining CTICU staff buy-in for the newborn feeding guidelines was to poll the eight CTICU physicians and 10 nurse practitioners regarding their individual style of feeding newborns. The inconsistency in initiation and advancement in feeding was obvious. As well as the inability to support in the literature what each individual felt was the best way to feed a newborn with congenital heart disease. The awareness of CTICU practitioner variation in newborn feeding and the paucity of data available to support each individual's feeding method resulted in enhanced practitioner buy in and accountability. This was reinforced by periodic review of feeding guideline usage

throughout year at staff meetings, via email communications and real-time discussion during rounds lead by the CTICU clinical dietitians.

One of this project's most difficult struggles was in creation of a computerized method of ordering that was both easy for the practitioner to use and easy for the bedside nurse to understand and utilize. Our first attempt with the SMART phrase was confusing to both the practitioner in the ordering phase and to bedside nurse in the utilization phase. This was addressed by (1) creating an order set that was both easy for the practitioner to order and easy for the bedside nurse to understand and implement; (2) supplying bedside laminated cards which outlined the feeding guidelines to use as a reference; and (3) having a clinical dietician attend rounds daily to address specific issues regarding the feeding guidelines and goals.

Comparison of the two groups before and after feeding guideline implementation revealed that weight and age at surgery were not different between the groups. There were more single ventricle patients postguidelines (post 75% vs pre 44%; $P = .0003$). It should be reiterated that our center philosophy is one of hybrid palliation rather than Norwood operation. Interestingly, there was no difference in the percentage of newborns who were full orally feeding at discharge before and after feeding guideline implementation (post 78% vs pre 89%; $P = .2$). Although, as others have also shown,³⁻⁷ the length of hospital stay was statistically less post feeding guidelines (34 + 42 d pre vs 27 + 17 d post; $P < .001$); the incidence of mesenteric ischemia while less postguidelines, was not statistically significant (post 6% vs pre 14%; $P = .17$). However, this is most likely multifactorial and not solely related to the institution of feeding guidelines.

4.1 | Limitations

Limitations include small patient population, patient heterogeneity, and limited feeding data available prior to institution of the guidelines. We only included patients who were admitted to the CTICU preop; thus excluding patients who were admitted to the floor or NICU prior to cardiac surgery. This quality initiative involves only a single, free-standing children's hospital system whose philosophy is one of the hybrid palliations rather than Norwood operation. Unfortunately, data are not available regarding how many times feeds were held for breach of guideline baseline criteria. Limitations also include those inherent to any retrospective data review.

4.2 | Lessons learned

Key components that we believe contributed to our successful process include involving a multidisciplinary team to question and explore practice variability, developing and implementing simple guidelines to reduce variation and change the practice pattern, holding appropriate staff accountable for implementation and outcomes; monitoring to ensure the intervention was successful, and sharing the results with the staff of the CTICU.

5 | CONCLUSIONS

Implementation of standardized newborn feeding guidelines in the CTICU was successful in reducing variation in feeding strategies while maintaining quality patient care. The percentage of newborns full po feeding at discharge did not increase. The length of hospital stay was reduced post feeding guideline implementation; as was the incidence of mesenteric ischemia (although not statistically significant). However, this is most likely multifactorial and not solely related to the institution of feeding guidelines. With appropriate vigilance and monitoring this high risk patient population can be enterally fed safely before and after cardiac surgery.

CONFLICT OF INTEREST

None of the authors have any conflicts of interest.

FINANCIAL DISCLOSURES

None of the authors have any financial disclosures.

AUTHOR CONTRIBUTIONS

Participated in research design, the acquisition, analysis, and interpretation of data, drafted the paper and revised it critically, and has approved the submitted and final versions: Simsic.

Participated in research design, the acquisition, analysis, and interpretation of data, drafted the paper, and has approved the submitted and final versions: Carpenito, Kirchner, Peters, Miller-Tate.

Participated in research design, the analysis, and interpretation of data, drafted the paper, and has approved the submitted and final versions: Joy, Galantowicz.

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