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Noncompliance to a Postoperative Algorithm Using Feeding Readiness Assessments Prolonged Length of Stay at a Pediatric Heart Institute

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Abstract

Introduction: Variable compliance to postoperative feeding algorithms after pediatric cardiac surgery may be associated with suboptimal growth, decreased parental satisfaction, and prolonged hospital length of stay (LOS). Our heart center performed an audit of compliance to a previously introduced postoperative feeding algorithm to guide quality improvement efforts. We hypothesized that algorithm noncompliance would be associated with increased LOS. **Methods:** We retrospectively identified children ≤ 3 months admitted for their first cardiac surgery between January 1, 2015 and December 31, 2016. The algorithm uses objective oral feeding readiness assessments (FRA). At the end of a predefined evaluation period, a "sentinel" FRA score is assigned. The sentinel FRA and FRA trend guide decisions to pursue gastrostomy tube (GT) or oral-only feeds. Among those who reached the sentinel FRA, we defined compliance as ≤ 3 days before pursuing GT or oral-only feeds once indicated by the algorithm. **Results:** Sixty-nine patients were included. Forty-nine complied with the algorithm (71%), and 45 received GT (65.2%). Noncompliers had significantly longer LOS (34 versus 25 days; $P = 0.01$). Among GT recipients, noncompliers waited 6 additional days for a GT compared with compliers ($P \leq 0.001$). Subjective decisions to extend oral feeding trials or await results of a swallow study were associated with algorithm noncompliance. **Conclusions:** This audit of compliance to a feeding algorithm after pediatric cardiac surgery highlighted variability of practice, including relying on subjective appraisals of feeding skills over objective FRAs. This variability was associated with increased LOS and can be hypothesis-generating for future quality improvement efforts. *(Pediatr Qual Saf 2017;2:e042; doi: 10.1097/pq9.0000000000000042; Published online September 28, 2017.)*

INTRODUCTION

Neonates and infants with complex congenital heart disease may demonstrate poor growth after cardiac surgery.[1–6] Growth challenges are likely due to increased energy expenditure, thereby decreasing myocardial performance, gastroesophageal reflux, swallow dysfunction, gastrointestinal malabsorption, additional genetic syndromes, and interruption in usual neurodevelopmental processes.[1–6] Among patients with single ventricle physiology, suboptimal weight gain after stage I palliation has been associated with increased complication rates (e.g., death, extracorporeal membrane oxygenation, additional procedures) and prolonged hospitalization.[7–9] Institutions have used various strategies to optimize postoperative nutrition, including feeding algorithms, which recommend discharging patients on nasogastric (NG) or gastrostomy tubes (GT) when deemed unable or unsafe to meet nutrition and growth goals via oral-only feeding.[10–13]

However, decisions relating to which discharge feeding method to pursue and when to pursue it may be arbitrary and can lead to significant variability in practice, both within and between institutions.[14–18] Standardization may promote improved in-hospital weight gain, shorten hospitalization lengths of stay (LOS), promote interstage weight gain, and decrease interstage and stage II perisurgical complications.[13–15,19] Since difficulties in predicting prolonged feeding issues

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may predispose to practice variability, our heart institute adopted a postoperative feeding algorithm in 2012 that sought to guide provider decision-making using objective measures of oral feeding readiness. Our heart center performed an audit of our compliance to this algorithm. We aimed to glean lessons for future quality improvement initiatives focused on promoting standardization of care and better outcomes. Furthermore, we hypothesized that algorithm noncompliance would be associated with increased LOS.

METHODS

Design and Patient Selection

This investigation was approved by the Children's Hospital Colorado Organizational Research Risk and Quality Improvement Review Panel as the preliminary phase of a quality improvement project. A retrospective review of electronic health records of patients ≤ 3 months old admitted to the cardiac intensive care unit (CICU) for their first cardiac surgery between January 1, 2015, and December 31, 2016, was performed. We excluded patients who were not hospitalized long enough to reach a key decision point in the algorithm [the "sentinel feeding readiness assessment (FRA)"] or if they were removed from the feeding algorithm for a medical reason (e.g., necrotizing enterocolitis). Variables collected included demographics (gender, early and late prematurity, diagnosis, single ventricle physiology, confirmed genetic anomaly, admission age), initial anthropomorphic metrics [admission weight and World Health Organization[20] or Fenton[21] premature weight-for-age Z-score (WAZ), as appropriate] and peri/postoperative data [Society for Thoracic Surgery-European Association of Cardiothoracic Surgeons (STAT) congenital heart surgery mortality categories for surgical complexity][22] and CICU LOS.

Postoperative Feeding Algorithm

At the beginning of our feeding algorithm (Fig. 1), all neonates and infants admitted to the CICU are assessed for safety with oral feeds using a bedside swallow study performed by a speech and/or occupational therapist. Critically ill infants begin to practice oral skills as soon as medically able and often receive most of their nourishment through continuous NG feeding in the days after their operation. Concurrently, oral feeding skills are assessed by the feeding therapist using a standardized FRA adapted from a previously published, comprehensive, evidenced-based oral feeding guideline (Fig. 1).[23] After a 3-day evaluation period that commences with reaching goal-volume bolus feeds, a sentinel FRA is assigned. If the sentinel FRA is unfavorable (FRA score 1-2b or 2C and not improving during evaluation period), a GT evaluation with an upper gastrointestinal (UGI) series and surgery consult is indicated. If the sentinel FRA score is favorable (FRA score 3 for two straight days or 2C and improving during the evaluation period), we remove the NG tube and discharge the patient on exclusively oral feeds. During the audit period, it was the practice of our heart institute to not send patients home with NG tubes. We defined compliance as ≤ 3 days before pursuing GT (UGI and surgery consult ordered) or oral-only feeds (NG tube pulled) once the sentinel FRA was assigned.

Outcome and Process Measures

The primary outcome measure was hospital LOS. The secondary outcome measure was WAZ change (discharge – admission). Global process measures included algorithm compliance and frequency of recommendation for GT placement versus actual GT placement before discharge. Previous experience dictated that GT recipients may be more likely to experience variability in practice compared with those discharged on oral-only feeds. Therefore, additional process measures were determined a priori to understand potential variation among GT recipients specifically. These included days until UGI, surgery consult and GT placement (once indicated by the sentinel FRA), weekday versus weekend timing of the sentinel FRA, switching of attending physicians on the day before, on, or day after assigning the sentinel FRA score, and provider type on the day of sentinel FRA (i.e., fellow, resident, advanced practice provider). After reaching the sentinel FRA, we recorded frequency of deviation from the algorithm to subjectively extend oral feeding trials or await results of a formal modified barium swallow study (MBSS) and frequency of 24- or 48-hour delay in obtaining the UGI or surgery consult, once ordered.

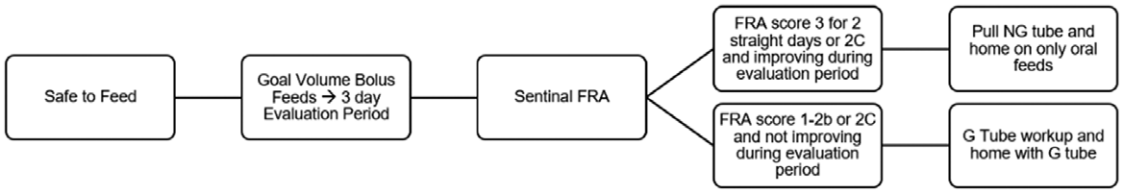
Analytic Approach

Analyses focused on comparing algorithm compliers and noncompliers. We report continuous variables as median with interquartile ranges and categorical variables as frequencies with proportions. Differences between categorical variables were analyzed with Fisher's exact test. Differences between continuous variables were determined by Wilcoxon rank sum tests. All statistical analyses were performed with SAS 9.4 (SAS Institute Inc., Cary, N.C.).

RESULTS

Sixty-nine patients met inclusion criteria. Patients were predominantly male (52.2%), term (≥ 37 weeks gestational age; 85.6%), and average weight (median WAZ 0.3; Table 1). Thirty-six (52.2%) had single ventricle physiology, and 51 (73.9%) underwent a complex cardiac surgery (STAT 4 or 5). Algorithm noncompliers were more likely to undergo complex cardiac surgery (STAT four or five 95% versus 65.3%; $P = 0.01$).

We illustrate algorithm compliance as it relates to discharge feeding method in Figure 2. Fifty-three patients (76.8%) were recommended to initiate a GT workup using the sentinel FRA score. Though all patients recommended



Feeding Readiness Assessment

Stage	Characteristics	Oral intake
Pre-feeding	- Emerging physiologic stability with handling - Short periods of quiet alert state - Weak oral reflexes - All nutrition by feeding tube or IV	0%
Non-nutritive sucking	- Physiologic stability with handing - Increasing duration of quiet alert state - Rooting or licking to show interest in sucking - Working on physiologic stability while sucking - All nutrition by feeding tube or IV	0%
Therapeutic tastes	- Stable breathing rate - Alert state for short periods with handling or sucking - Interest and enjoyment with small tastes - Monitored closely for physiologic stability - Most nutrition by a feeding tube or IV	Negligible amount, 5mL or less
Nutritive sucking 1	- Stable breathing rate - Maintains alert state for short periods while practicing feeding - Manages saliva by swallowing - Sucks on the pacifier, breast, or finger - May fall asleep quickly after starting oral feeding	<10%
Nutritive sucking 2a	- Stable breathing rate - Starts showing hunger cues at feeding times - Sucks, swallows, and breathes without stress during most feeding attempts - May not have energy to complete a full feeding	10-25%
Nutritive sucking 2b	See nutritive sucking 2a	25-50%
Nutritive sucking 2c	See nutritive sucking 2a	50-80%
Nutritive sucking 3	- Shows hunger cues at every feeding - Sucks, swallows, and breathes without stress for the whole feeding - Looks calm and satisfied at the end of feedings - Grows and gains weight with feeding by mouth	80-100%

Fig. 1. Postoperative feeding algorithm based on the sentinel FRA.

Table 1. Patient Demographics

Characteristics	All (n = 69)	Algorithm Compliers (n = 49)	Algorithm Noncompliers (n = 20)	*P**
Male sex	36 (52.2)	25 (51.2)	11 (55.0)	0.79
Late prematurity†	10 (14.5)	6 (12.2)	4 (20.0)	0.46
Confirmed genetic anomaly	13 (18.8))	9 (18.3)	4 (20.0)	1
Age at admission (d)	1 (0–2)	0 (0–3)	1 (0–2)	0.75
Days from admit until surgery	4 (3–6)	2 (4–6)	4 (4–6)	0.22
Admit WAZ	-0.3 (-1 to 0.3)	-0.3 (-1 to 0.3)	-0.5 (-0.9 to 0.5)	0.95
Preoperative single ventricle physiology	36 (52.2)	23 (47.0)	13 (65.0)	0.20
STAT category for cardiac surgery 4 or 5	51 (73.9)	32 (65.3)	19 (95.0)	**0.01**
CICU length of stay (d)	11 (8–15)	11 (7–15)	12 (8–22)	0.11

**P* from Fisher's exact test for categorical variables and Wilcoxon rank sum test for continuous variables on comparison of each characteristic between the 2 groups (algorithm compliers versus algorithm noncompliers). Bold indicates values that were statistically significant ($P < 0.05$).
†Greater than 35 but less than 37 weeks gestation.

for discharge on oral-only feeds did so without significant delay, those recommended for GT workup experienced variability of practice with 20/53 experiencing delays.

We illustrate the relationship between practice variability and process/outcome measures in Table 2. Noncompliers had longer hospital LOS (34 versus 25 days; $P = 0.01$; Fig. 3). There was no difference in WAZ change (discharge – admission). Among GT recipients, those who did not comply with the algorithm waited a median of 6 extra days to receive their GT compared with those that followed the algorithm, which was associated with significantly longer LOS (Fig. 3; $P \leq 0.001$). The workup for GT was initiated before the sentinel FRA in some patients with nonchanging unfavorable FRA scores, accounting

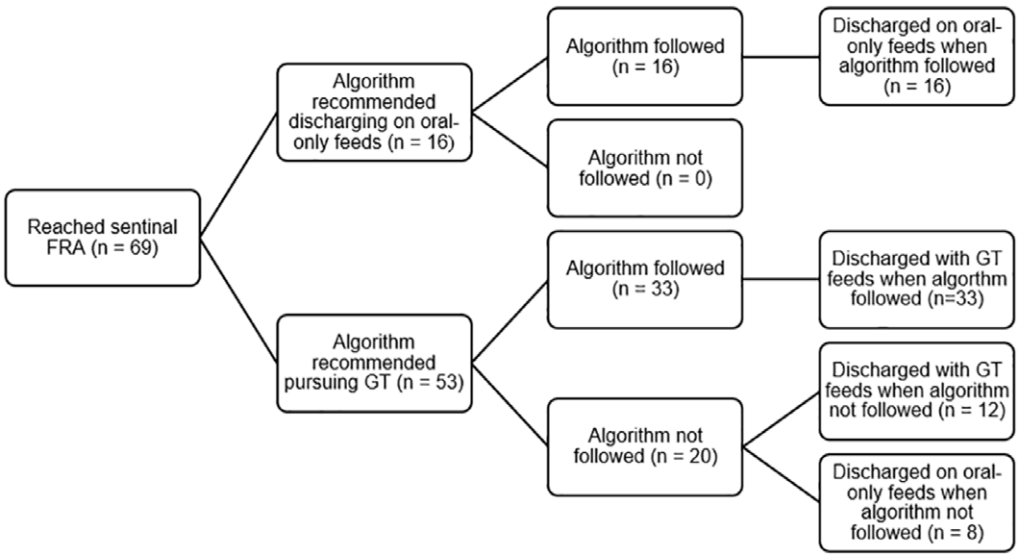


Fig. 2. Flowchart of algorithm adherence and discharge feeding regimen during the audit period.

Table 2. Process and Outcome Measures

Characteristics	All (n = 69)	Algorithm Compliers (n = 49)	Algorithm Noncompliers (n = 20)	*P**
Process				
GT recommended by algorithm	53 (76.8)	33 (67.3)	20 (100)	**< 0.001**
Discharged with GT	45 (65.2)	33 (67.3)	12 (60.0)	0.59
Among 45 GT recipients				
Days from sentinel FRA to UGI evaluation	1 (-1 to 3)	1 (-1 to 2)	4.5 (1–7)	**< 0.01**
Days from sentinel FRA to surgery consult	2 (-0.5 to 3.5)	0 (-1 to 2)	5.5 (2–8)	**< 0.001**
Days from sentinel FRA until GT placement	5 (2.5–9)	4 (2–6)	10 (9–14)	**< 0.001**
Days from GT placement until discharge	5 (4–6)	5 (3–6)	5 (4–12)	0.16
Surgery consult delayed while waiting for MBSS†	5 (7.2)	0 (0.0)	5 (25.0)	**< 0.01**
Provider decision to extend oral feeding trials	9 (13.0)	0 (0.0)	9 (45.0)	**< 0.001**
Outcome				
Weight for age z-score change	-1.2 (-1.6 to 0.8)	-1.1 (-1.5 to -0.7)	-1.3 (-1.9 to -0.9)	0.11
Total hospitalization length of stay, days, all-comers	27 (22–39)	25 (22–33)	34 (24–51)	**0.01**
Total hospitalization length of stay, days, GT recipients	31 (24–43)	28 (22–39)	37 (29.5–53)	**0.03**

**P* value from Fisher's exact test for categorical variables and Wilcoxon rank sum test for continuous variables on comparison of each characteristic between the 2 groups (algorithm compliers versus noncompliers). Bold indicates values that were statistically significant ($P < 0.05$).
†Reasons for delay in GT workup are not mutually exclusive.

for "negative" days between the sentinel FRA and UGI or surgery consult in the compliers group. Algorithm noncompliance was associated with subjective decisions to extend oral feeding trials ($P < 0.001$) or await results of a formal swallow study ($P < 0.01$). There were no contraindications to GT placement in the 3 days following the sentinel FRA. There were no major complications (e.g., significant bleeding, perforation, peritonitis, severe surgical-site infection, or need for reoperation) after GT placement during the audit period. Eight patients whose oral feeding trials were extended by providers ultimately discharged on oral-only feeds (15.1% of all patients recommended to pursue GT per the algorithm). There were no group differences in the other process measures studied.

DISCUSSION

In this audit of our heart center's compliance to a postoperative feeding algorithm for neonates and infants with complex congenital heart disease undergoing cardiac surgery, suboptimal compliance was associated with increased LOS. Key targets for future quality improvement efforts were elucidated, including a tendency to extend oral feeding trials or await the results of swallow studies when a GT workup was nevertheless indicated.

The failure to deliver standardized care despite an institutional algorithm in place highlights the challenges faced by many pediatric heart centers in numerous areas of care. There is significant variability of practice in postoperative feeding management,[14,17,18,24] and institutional algorithms continue to vary in their mechanism for advancing feeds and indications for discharging patients with feeding tubes.[25] Recently, efforts have been undertaken by the National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC) to promote standardized best postoperative feeding practices.[13,26,27] The NPC-QIC shares their postoperative feeding algorithms as best practice among the member centers.[13]

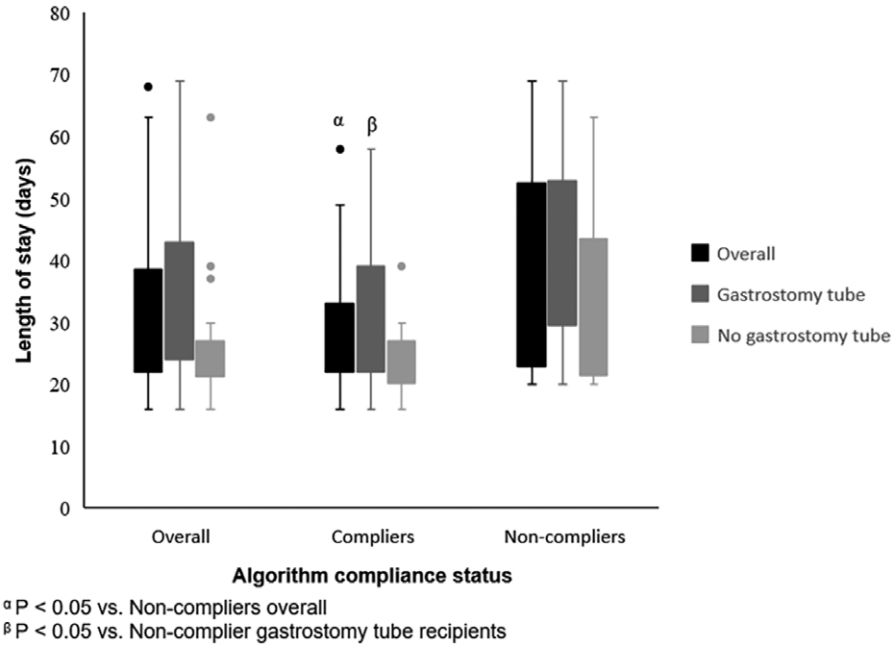


Fig. 3. Length of stay by algorithm adherence and discharge feeding regimen.

Increased adoption of the postoperative feeding algorithms among NPC-QIC institutions portended better outcomes in a follow-up study.[27] Standardization has been shown to decrease the incidence of necrotizing enterocolitis and improve interstage weight gain.[27–29] Given the association of higher prestage II and III WAZ score with decreased risk of perioperative complications,[7–9] standardization may have profound downstream benefits.

Our institutional algorithm attempted to standardize care in 2 ways. First, options for discharge feeding method were limited to GT or oral-only feeding. Thus, medical decision making is focused solely on whether to pursue GT. Second, we relied on objective measurements of oral feeding readiness, assigned at specific time points, to guide when GT workup should be initiated. Our pilot data suggested that there was a tendency to eschew these benchmarks in favor of subjective appraisals of feeding skills in some patients. Consciously extending oral feeding trials resulted in a 6-day delay in GT placement compared with those that relied exclusively on the FRA. This delay may have contributed to the significant difference in LOS. The practice of extending oral feeding trials may be rooted in some providers' past experiences. In-person interviews of many providers involved in this audit suggested that many have cared for patients who were ultimately discharged without a GT despite prolonged feeding difficulties. This observation should be further studied prospectively during future quality improvement efforts.

Our pilot data showed that 8 patients (15.1% of patients recommended for GT) were able to avoid a GT by this practice. Though this represents a minority of patients during the audit period, it does suggest that the sentinel FRA may lack specificity for the need for GT in some patients. Future studies should focus on using additional data (e.g., the FRA at various points during the hospitalization) to predict the need for supplemental tube feeding at discharge more accurately. Future pilot projects may include using the FRA may suggest other nonsurgical feeding plans at discharge (e.g., NG). This intervention may ultimately assuage provider concerns about an additional unnecessary surgery in some patients.

Algorithm noncompliers were more likely to have undergone a complex (STAT 4 or 5) surgery compared with compliers. We theorize that these patients may be at high risk for deviation from the feeding algorithm by 2 mechanisms. First, patients who have undergone a complex cardiac surgery may be afforded additional time to work on oral feeding skills. This practice may be related to expectations for prolonged feeding difficulties, which may inform provider biases, parental preferences, or both. Second, many of these patients have undergone complex arch reconstruction, predisposing to dysphagia.[30] We noted a tendency for GT placement to be delayed to obtain a swallow study, even in patients recommended for a GT based on their lack of feeding skills. During this delay period, as providers waited for patients to be able to take enough by mouth to complete the swallow study, we theorize that questions about feeding safety may have become conflated with questions of feeding skills. This theory may explain the associations between algorithm noncompliance, awaiting the results of an MBSS, and prolonged LOS. This possibility represents a target to improve standardization of care in our future quality improvement work.

We did not show an improvement in WAZ change by adhering to the feeding algorithm. Though improvements

in WAZ have been realized by following feeding algorithms in the interstage period,[27] our study is consistent with prior work failing to show an improvement during the initial hospitalization for cardiac surgery.[10,15,31–33] As in many prior studies, patients in our cohort experienced decreased WAZ throughout the hospitalization. Reasons for this are likely multifactorial,[34] and it remains a challenge for the congenital heart community that requires continued investigation.

Limitations to our study include issues intrinsic to a single center audit and, thus, may have limited generalizability. As this was a retrospective review, individual provider trends and granularity around clinical decision making cannot be fully analyzed. However, our heart institute nonetheless views the findings reported herein as valuable in understanding our current practice and potential targets for upcoming plan-do-study-act cycles. For example, based on the results of this analysis, we will institute and test numerous interventions to increase algorithm compliance. These include posting an in-room feeding roadmap to set expectations for parents and providers, changing the progress note template to include a selectable reason for deviating from the algorithm, and working with our feeding team to clarify the role of the MBSS as it relates to disposition feeding plans. Through these changes, we hope to decrease variability of practice, provider and parental frustration, and LOS, which may portend important medical, psychological, and financial benefits.

CONCLUSIONS

This audit of compliance to a feeding algorithm after pediatric cardiac surgery highlighted variability of practice, including relying on subjective appraisals of feeding skills instead of standardized, objective FRAs. This finding was associated with longer LOS and can be hypothesis-generating for future quality improvement efforts.

DISCLOSURE

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

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