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ORIGINAL ARTICLE

Evaluation of gastroschisis feeding protocol: A retrospective cohort study

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Aim: The primary objective of this study is to determine the impact of a standardised feeding protocol for infants with gastroschisis on early enteral feeds, suck feeds, management of gastric residuals and breastfeeding at discharge. Secondary objectives were evaluation of growth, length of stay in neonatal intensive care unit (NICU), the duration of total parental nutrition (TPN), blood-culture confirmed sepsis and serum bilirubin level (SBR).

Methods: This single-centre retrospective quality improvement project included infants admitted to a quaternary care NICU for management of gastroschisis from 2010 to 2021. The Gastroschisis feeding protocol, a standardised pathway for managing the feeding of infants with gastroschisis, was implemented in this NICU in 2016. The outcomes of infants in the pre-feeding protocol and post-feeding protocol groups were compared.

Results: Of the 100 infants included in the study, 49 were in the post-feeding protocol group. The baseline characteristics of the study population did not differ statistically in both groups. In post-feeding protocol group, there was significant reduction in the time to the first enteral feed (P value <0.0001) and first suck feed (P value = 0.002). The median length of stay in the post-feeding protocol group was significantly lower by 11 days (P value = 0.001). Duration of TPN was 241 h higher in the pre-feeding protocol group (P value 0.0007).

Conclusions: Implementation of a feeding protocol in infants with gastroschisis led to earlier initiation of enteral feeds and suck feeds. There is a likelihood of reduction in the use of TPN and duration of admission in NICU.

Key words: feeding; gastroschisis; newborn.

What is already known on this topic

1 Protocolised feeding post-gastroschisis repair is associated with early initiation of enteral feeding.

What this paper adds

1 Implementing a standardised feeding protocol facilitates earlier initiation of enteral feeds and first suck feeds, potentially reducing TPN use and duration of NICU admission.

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Author contributions: JJ designed the study and the data collection instruments, collected data, carried out the initial analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript. KJ-N drafted the initial manuscript. KS conceptualised and designed the study, designed the data collection instruments, drafted the initial manuscript, critically reviewed, and revised the manuscript. BP collected data and reviewed the manuscript. GT conceptualised and designed the study, and critically reviewed and revised the manuscript. AT conceptualised and designed the study, carried out the initial analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Gastroschisis is a congenital abdominal wall defect characterised by the herniation of abdominal contents through an opening near the umbilicus, without protective membrane coverage.[1] The exact aetiology of this anomaly remains unclear, with several theories proposed, including failure of ventral fusion, amniotic membrane rupture, paraumbilical tissue weakness and vascular accidents associated with the vitelline artery.[2] It is believed that the insult occurs between the 6th and 10th weeks of gestation. Over the past decade, there has been a significant increase in the incidence of gastroschisis, with international data estimating rates between 4.5 and 6 per 10 000 live births. In Australia and New Zealand, the prevalence has also been rising, with a reported rate of 2.8 per 10 000 births in Australia.[3,4]

While survival rates in gastroschisis exceed 90%, a subset of infants experienced significant morbidity, largely dependent on the severity of bowel injury at birth.[2,4] Improving outcomes and reducing morbidity in gastroschisis management requires focus on post-operative care, particularly the initiation and progression of enteral feeding. However, as the decision-making process involves surgeons, neonatologists and neonatal nurses, individual preferences often result in delayed initiation of feeds, increased length of hospitalisation, prolonged need for central venous access, reliance on total parental nutrition (TPN), small bowel bacterial overgrowth, sepsis risk and TPN-related cholestasis.[4]

Studies show that the early introduction of enteral feeds and the implementation of a standardised feeding protocol can lead to improved outcomes such as reduced episodes of sepsis, decreased need for TPN and time to reach full feeds.[1] In 2016, a standardised gastroschisis feeding protocol was implemented in our neonatal intensive care unit (NICU) for management of feeding in infants with simple gastroischisis.[4] This protocol guides the initiation and progression of feeding in four stages with measurable outcomes identified for each stage. These outcome measures were the duration of TPN, the time to initiate enteral feeds and the time to establishment of full breast or enteral feeds.[4] The objective of this study was to determine the impact of this feeding protocol on these outcomes.

Methods

This was a single-centre quality improvement project that examined the impact of implementation of a novel gastroschisis feeding protocol. The data for infants in pre-protocol group and the data for post-protocol group were collected retrospectively. Approval for the study was obtained from the local Human Research Ethics Committee.

Sample and settings

The study was conducted in a quaternary care surgical NICU in Australia. All infants admitted to NICU with a diagnosis of simple gastroschisis, either by primary repair or staged silo from 2010 to 2021 were included in the study. Our neonatal unit admitted an average of 10 neonates with gastroschisis each year over the past decade. Simple gastroschisis was defined as gastroschisis where the exteriorised bowel did not have intestinal complications such as atresia, stenosis, perforation, volvulus or necrosis. The study included infants born at all gestational ages. Infants born with gastroschisis who had the above-mentioned complications (complex gastroschisis) were excluded. The study population was divided into two cohorts: the pre-feeding protocol and the post-feeding protocol groups. The pre-feeding protocol group comprised consecutive infants admitted to the NICU with the diagnosis of simple gastroschisis prior to the implementation of feeding protocol; 2010–2015. Infants admitted from 2016 to 2021 whose feeding regimen was managed with the gastroschisis feeding protocol were included in the post-feeding protocol group.

Outcomes

The primary outcomes were initiation of enteral feeds, suck feeds and breastfeeding at discharge. The secondary outcome was growth measured by *Z*-score of weight at discharge, length of stay in NICU, the duration of TPN, blood-culture confirmed sepsis and serum bilirubin level (SBR).

Data collection

Data were collected retrospectively for both cohorts from the electronic medical record system. Demographic variables included sex, gestational age, birthweight, *Z*-scores of weight at birth and discharge, type of repair, length of stay in NICU, age at surgery, duration of TPN, age at initiation of enteral feeds, post-operative days at the initiation of enteral feeds, time to full enteral feeding, time to achieve full suck feeds, breastfeeding at discharge, blood-culture confirmed sepsis and SBR.

Intervention

Prior to 2016, feeding regimen of the infant's after gastroschisis repair was guided by treating teams and determined by the preferences of individual clinicians. After implementation of the Gastroschisis feeding protocol, all infants with simple gastroschisis were fed as per the protocol. The Gastroschisis feeding protocol is a two-part pathway of four stages of feeding progression and measurable outcomes identified for each stage (Fig. 1). Part A consist of four stages: Stage 1 – Trophic feeds commenced 24 h post closure of the defect and offered at the breast; Stage 2 – Suck feeds commenced, and TPN reduced; Stage 3 – Breastfeeding commenced, TPN ceased and central venous line removed; and Stage 4 – Demand breastfeeds at discharge with a reduced length of hospital stay. Part B guides the clinicians on how to manage vomiting and excessive gastric residuals.

Statistical analyses

Statistical analyses were performed using SAS version 9.4. Demographic and clinical characteristics and feeding outcomes were presented using range or median, quartiles and range for continuous variables and frequencies and percentages for categorical variables. Outcomes were compared between pre- and post-implementation periods using chi-square tests for categorical data and the Wilcoxon rank-sum test for continuous data. There was no adjustment made for multiple statistical comparisons and findings should be judged on both their clinical importance and the strength of statistical evidence. Results were considered statistically significant if the P value was below 0.05.

Results

Patient characteristics

A total of 123 infants with a diagnosis of gastroschisis were admitted during the study period. One hundred had simple gastroschisis, while 23 with complex gastroschisis were excluded. Of the 100 infants admitted with the diagnosis of simple gastroschisis, 51 who were admitted prior to implementation of the feeding protocol, were included in the pre-feeding protocol group. Forty-nine who were consecutively admitted after the implementation of the gastroschisis feeding protocol were part of the post-feeding protocol group. No infants with the diagnosis of simple gastroschisis were excluded.

The pre- and post-feeding protocol groups exhibited no difference in the median gestational age (both 36 weeks of gestation) and interquartile range (IQR) (both 35–37 weeks of gestation) (Table 1). The range of gestational age in the pre-feeding protocol group was 30–39 weeks and 29–39 weeks in the post-feeding protocol group. Median birthweights were 2390 (range 2180–2780) and 2430

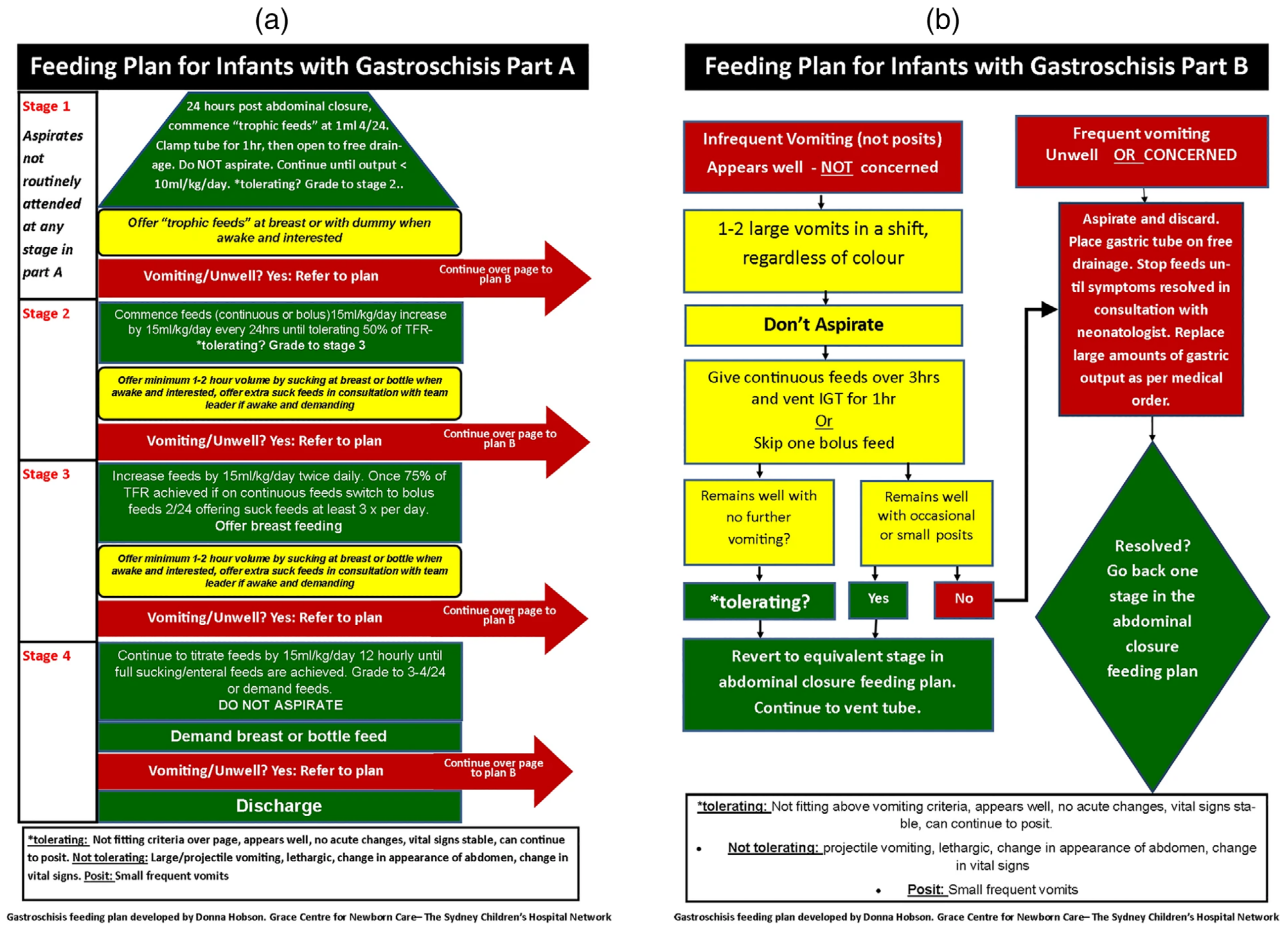

Fig. 1 Gastroschisis feeding protocol (Hobson *et al*., 2019).[4]

Table 1 Baseline characteristics of the study population

Characteristics	Pre-feeding protocol ($n = 51$)	Post-feeding protocol ($n = 49$)	P value
Gestational age	36 weeks (35–37)	36 weeks (35–37)	0.78
Birthweight	2390 g (2180–2780)	2430 g (2188–2983)	0.66
Male gender	41%	35%	0.5
Primary repair	59%	67%	0.37

Data presented as median (IQR) and percentage. IQR, interquartile range.

(range 2188–2983) grams for the pre- and post-feeding groups, respectively. While 41% ($n = 21$) of infants in the pre-feeding protocol group were male compared to 35% ($n = 17$) in the post-feeding protocol group, this difference did not reach statistical significance. Primary repair was performed in 59% of infants ($n = 30$) in the pre-feeding protocol group and 67% ($n = 33$) in the post-feeding protocol group ($P = 0.37$).

The proportion of neonates who were either discharged or transferred from intensive care for ongoing care did not differ between the two groups (P value = 0.73).

Feeding outcomes

The time to first enteral feeds after the final closure of gastroschisis was significantly earlier at a median of 2 days (IQR = 1–3 days) compared to 5 days (IQR = 3–7 days) for those in the pre-feeding protocol group ($P < 0.0001$). Infants in the post-feeding protocol group achieved their first suck feed significantly earlier at a median of 87 h (IQR = 53–133 h) compared to 152 h (IQR = 77.5–293 h) for those in the pre-feeding protocol group ($P = 0.002$). The infants in the post-feeding protocol group

Table 2 Feeding outcomes

Feeding outcomes	Pre-feeding protocol	Post-feeding protocol	*P* value
Time to first enteral feed after repair	5 days (3–7)	2 days (1–3)	<0.0001*
Time to first suck feed after repair	152 h (77.5–293)	87 h (53–133)	0.002*
Time to full enteral feeds	15.3 days (10.7–24.2)	13.9 days (10.6–20.3)	0.28
Breastfeeding at discharge	29%	30%	0.89

* *P* value <0.05. Data presented as median (IQR) and percentage. IQR, interquartile range.

Table 3 Clinical outcomes

Clinical outcomes	Pre-feeding protocol	Post-feeding protocol	*P* value
Z-score of weight at discharge	−2.1 (−3 to −0.8)	−1.3 (−2.3 to −0.6)	0.11
Length of stay in NICU	34 days (23–41)	23 days (19–32)	0.001*
Duration of TPN	617 h (431–807)	376 h (394–595)	0.0007*
Conjugated SBR >20 μmol/L	25%	0%	<0.001*
Total SBR in micromoles/L	57 (24–105)	44 (18–108)	0.37
Episodes of sepsis	21	10	0.042

* *P* value <0.05. Data presented as median (IQR) and percentage. IQR, interquartile range; NICU, neonatal intensive care unit; SBR, serum bilirubin; TPN, total parenteral nutrition.

reached full enteral nutrition marginally faster than the pre-feeding protocol group, at 13.9 days compared to 15.3 days, respectively; however, this difference of 1.4 days was not statistically significant. Rates of exclusive breastfeeding at discharge from NICU did not differ between the pre- (29%) and post-feeding protocol groups (30%) (Table 2). The infants who did not exclusively breastfeed were fed either formula or a combination of formula and breast milk.

Clinical outcomes

The median *Z*-score of weight at discharge from the NICU was −2.1 in the pre-feeding protocol group and −1.3 in the post-feeding protocol group. There was no statistical difference between the *Z*-scores of weights in pre- and post-feeding protocol groups (P value = 0.11). However, unlike the post-feeding protocol group, the *Z*-score of weight at discharge in the pre-feeding protocol group was less than two standard deviations, indicative of a more pronounced weight deficit. Infants in the pre-feeding protocol group stayed a median of 34 days, significantly longer than the 23 days for the post-feeding group ($P < 0.001$), resulting in an 11-day difference in median length of stay between the two groups. The median duration of TPN was significantly longer for the pre-feeding protocol group at 617 h (IQR = 431–807 h) compared to the post-feeding protocol group at 376 h (IQR = 394–595 h), with a P value of 0.0007. The number of episodes of culture-proven sepsis was lower in the post-feeding protocol group with borderline statistical significance (P value = 0.042). The incidence of conjugated hyperbilirubinemia was higher in the pre-feeding protocol group (P value = 0.001), but the total bilirubin did not differ (Table 3).

Time spent in each stage of the protocol

A progressive reduction in the median duration of time spent on each stage of feeding was observed among infants in the post-feeding protocol group. Median durations were longest for Stage 1 (5.7 days) and Stage 2 (4.3 days), followed by Stage 3 (1.7 days) and Stage 4 (0.9 days) (Table 4). Part B of the protocol was referred to 39 times in the included babies.

Discussion

This study has shown that using a standardised feeding protocol can change the post-operative feeding practices resulting in reduced length of NICU stay for neonates born with gastroschisis. Initiation and progression of feeding can be challenging in the setting of multiple health-care teams that may have individual preferences. In our unit, lack of uniform approach to feeding resulted in confusion regarding initiation, increasing the volume and frequency of feeds and managing gastric residuals. A

Table 4 Time spent on stages of the protocol

Stages of feeding protocol	Median	IQR	Range
Stage 1	5.7	4–8.8	0.7–18.9
Stage 2	4.3	3.8–7.3	1.2–15.7
Stage 3	1.7	1.3–2.8	0.5–12.7
Stage 4	0.9	0.5–1.4	0–3.5

Data presented as number of days. IQR, interquartile range.

systematic review of feeding protocols for gastroschisis[1] demonstrated the effectiveness of such feeding regimens in early initiation of enteral feeding. This review identified the likelihood of reduced rates of sepsis, shorter duration of parenteral nutrition, length of hospital stay and time to full enteral feeding; however, trends in these outcomes were statistically significant.[1]

Our study demonstrates practice compliance between the neonatal and surgical teams and within these teams by the adoption of a staged feeding protocol. This resulted in the introduction of early trophic feeds. The benefits of trophic and early enteral feeds have been found to significantly decrease the time to discharge following the repair of gastroschisis.[5,6] We found the combination of trophic feeds and breast milk reduced the time for the introduction of feeds as well as the first suck feed was significantly reduced.

The clinical outcomes of growth were improved in the pre-feeding group. The use of *Z*-scores enabled us to monitor growth for the duration of hospital admission. Given the earlier infants were discharged as malnourished (*Z*-score <2), though not statistically significant, the protocol may have helped with optimisation of nutrition intake with a streamlined approach rather than 'stop-start'.

Total parenteral nutrition is used frequently in neonates with gastroschisis. We found by using the protocol and establishing feeds early, to use of TPN was halved. Our findings are consistent with the findings of other studies[7] that reported shorter duration of TPN and hospitalisation. This is a benefit to the neonate, reducing the need for central catheters as well as reducing the overall cost of the hospital stay.[8] Studies also reported reduced infection rates following the early initiation of enteral feed,[1,7] similarly our study also found a reduction in the number of culture-proven infections by half.

As reported by a systematic review,[1] there are eight different guidelines to manage the feeding of babies with gastroschisis. Most of the feeding protocols aim to provide early onset of enteral feeding and progressive advancement of feed.[1] Similarly, our feeding protocol introduces trophic feed within 24 h of post-abdominal closure at Stage 1, guides early introduction of sucking feeds and reduction of TPN at Stage 2, followed by initiation of breastfeeding and cessation of TPN at Stage 3 and demand breastfeeding at Stage 4. The preferred choice of feeding was breastmilk in all the reported protocols; however, the decision to increment food was based on different factors, such as infants' bodyweight,[1] residual small bowel length[9] and feeding intolerance.[4]

We believe the use of the feeding protocol generates satisfaction from the nursing team as the baby's feeding plan is clearly established. The parents have expressed their approval of the protocol as it provides a guide for them to participate in their baby's feeding regime and an understanding of the need for caution.

Strength and limitations

The study utilised a retrospective design, relying on medical records for data collection, which may introduce inherent limitations. The focus of this study was short-term clinical outcomes, such as length of hospital stay and duration of total parenteral nutrition. Long-term outcomes, such as neurodevelopmental outcomes and growth beyond discharge, were not assessed. Despite these limitations, the study provides valuable insights into the implementation of a feeding protocol for neonates with gastroschisis and highlights the potential benefits. Further research is warranted to address these limitations and strengthen the evidence supporting the use of standardised feeding protocols in this patient population.

Conclusion

In conclusion, our study has provided valuable insights into the potential benefits of a systematic and staged feeding protocol for neonates with gastroschisis. We observed improvements in feeding practices, including earlier initiation of enteral feeds, first suck feeds. Furthermore, the protocol demonstrated a potential reduction in the need for total parenteral nutrition and a decrease in the length of hospital stay. By sharing our expertise and encouraging other health-care professionals to adopt similar feeding protocols, we aim to contribute to the advancement of care practices for neonates with gastroschisis. We hope that our study sparks further investigations in this field, addressing the identified limitations and exploring additional aspects of feeding protocols, such as long-term growth and neurodevelopmental outcomes.

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Ethics Statement

The approval for the study was obtained from the Sydney Children's Hospitals Network, Human Research Ethics Committee (HREC approval number: 2021/ ETH12358, STE approval number 2022/STE00040).

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