Research Square

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Continuous and Intermittent Enteral Feeding in Newborns Following Duodenal Atresia Surgery

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Abstract

Duodenal atresia is a rare condition characterized by bowel hypomotility and associated difficulties with enteral and oral feeding, the optimal postoperative feeding strategy remains controversial. Propose: We evaluated the impact of continuous versus intermittent postoperative feeding on neonatal intensive care unit (NICU) length of stay, nasogastric tube duration, time to initiation of enteral and oral feeding, catheter-related outcomes, and oral feeding difficulties up to two years of age. Methods: We conducted a single-center retrospective cohort study from 2014 to 2024, comparing neonates after duodenal atresia surgery by feeding mode. Results: Among 27 neonates, 13 were fed continuously and 14 intermittently. Intermittent feeding was associated with a shorter NICU stay ($p = 0.008$), reduced nasogastric tube duration ($p = 0.004$), and earlier initiation of oral feeding ($p < 0.001$). No differences were observed for the other outcomes. Conclusion: Intermittent postoperative feeding appears to be a beneficial strategy in duodenal atresia to reduce NICU stay and facilitate earlier oral feeding.

What is Known – What is New

Duodenal atresia is a rare condition associated with bowel hypomotility and well-known difficulties in enteral and oral feeding.

Optimizing postoperative nutritional management is essential to reduce hospitalization and associated complications.

Our study shows that bolus/intermittent feeding reduces NICU length of stay and facilitates the transition to oral feeding compared with continuous feeding, without increasing complications.

Introduction

Duodenal atresia is a rare congenital anomaly, with a reported incidence ranging from approximately 1 in 5,000 to 1 in 10,000 live births [1, 2]. More recent population-based data estimate an incidence of about 0.9 per 10,000 live births [3]. Duodenal atresia is a congenital interruption of the proximal bowel. Two mechanisms have been proposed. First, Tandler *et al.* [4] attribute the condition to failure of recanalization during the solid cord stage of intestinal development. The second hypothesis, from Louw and Barnard, suggests an intrauterine vascular insult as the underlying mechanism [5]. Overall, the observed pathophysiological features reflect failure of duodenal recanalization after the seventh week of gestation, potentially modulated by underlying genetic determinants [6]. Duodenal atresia is classically classified into four anatomical types [7]. Type I consists of an intraluminal mucosal diaphragm with an intact muscular and serosal layer, resulting in no true bowel discontinuity. Type II is characterized by a duodenal interruption with the two segments connected by a fibrous cord, and Type III by a complete interruption of the proximal and distal duodenal segments without any fibrous connection. Type IV involves multiple atretic segments, giving the appearance of a “string of sausages.”

The standard surgical treatment for duodenal atresia or stenosis, with or without an annular pancreas, is primary duodenoduodenostomy, which is considered a surgical emergency in the neonatal period. Primary duodenoduodenostomy provides a physiologic bypass, facilitates earlier restoration of intestinal function, and promotes effective duodenal emptying [8]. Postoperatively, the markedly dilated proximal duodenum is often

dysmotile, which can impair gastrointestinal function. Advances in surgical techniques and postoperative parenteral nutrition have significantly improved outcomes; however, prolonged postoperative dysmotility may still occur, even in the absence of mechanical obstruction [9–11]. Currently, there is no standardized postoperative feeding strategy for infants with duodenal atresia. Early enteral nutrition is increasingly adopted and appears feasible in this population, but the optimal feeding mode—intermittent (bolus) versus continuous—remains controversial. We therefore conducted a retrospective observational study to evaluate the impact of postoperative enteral feeding modality on short- and long-term outcomes after surgical repair of duodenal atresia.

Materials and methods

Study population. We conducted a single-center, retrospective observational study in a 32-bed tertiary neonatal intensive care unit (NICU) at Bicêtre Hospital, AP-HP Paris Saclay University. We included newborns over a 10-year period. All newborns with a prenatal or postnatal diagnosis of duodenal atresia, whether inborn or transferred to the center after diagnosis, were eligible for inclusion. Patients were classified into two groups based on postoperative feeding strategy: continuous enteral feeding or intermittent (bolus) enteral and/or oral feeding. Continuous postoperative feeding was defined as uninterrupted nasogastric infusion over 20–24 hours per day using an enteral feeding pump. Intermittent postoperative feeding was defined as bolus feeds administered every 2–3 hours via nasogastric tube or orally, with volumes starting at 10–20 mL/kg/day and increased by 10–20 mL/kg/day as tolerated. Feeding intolerance was defined as bilious or significant gastric residuals (> 50% of the previously fed volume), abdominal distension, or vomiting. The choice of feeding modality was based on attending physician preference and unit practice during the study period. The nasogastric tube was removed once the infants had achieved optimal oral feeding while maintaining full intake.

Analyzed data and outcomes. Collected demographic and clinical data, including gestational age, birth weight, Apgar scores at 0 and 5 minutes, lactates at birth, presence of Down syndrome, presence of associated congenital heart defects, median time to surgery, postoperative complications, anatomical site of duodenal atresia, presence of a duodenal diaphragm, annular pancreas, and Meckel’s diverticulum, type of postoperative enteral feeding, duration of catheter, presence of catheter complications, and death in NICU.

The primary outcome was the duration of NICU stay. Secondary outcomes included nasogastric tube duration, catheter duration during hospitalization, catheter-related complications, time to initiation of postoperative enteral and oral feeding, feeding disorders at discharge, and total length of hospital stay.

Data management and statistics. Categorical variables were presented as frequencies (percentages), and continuous variables were reported as medians with interquartile ranges (IQRs). Nonparametric tests, including the Wilcoxon rank-sum test or Fisher's exact test, were used to compare baseline characteristics between groups. Associations between postoperative feeding modality and primary and secondary outcomes were first tested using univariate analysis. Depending on the variable, univariate associations were assessed using the chi-squared test, Mann-Whitney test, or Spearman correlation. Significant variables were then included in multivariable linear or binary logistic regression analyses to assess their independent association with the primary and secondary outcome measures. Statistical analyses were performed using R software (version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria). A two-sided p-value < 0.05 was considered statistically significant.

Results

Between January 2014 and December 2024, 29 newborns were eligible. Of those, 27 (93%) were included. Thirteen neonates (48%) received continuous enteral feeding via a nasogastric tube, and 14 neonates (52%) received intermittent postoperative feeding (enteral or oral). Baseline neonatal and surgical characteristics were comparable between the two groups. No statistically significant differences were observed in gestational age, birth weight, Apgar scores at 1 and 5 minutes, presence of Down syndrome, associated congenital heart defects, median time to surgery, postoperative complications, anatomical site of duodenal atresia, presence of a duodenal diaphragm, annular pancreas, Meckel's diverticulum, type of postoperative enteral feeding, catheter duration, catheter-related complications, or NICU mortality. Only lactate levels at birth were significantly higher in the intermittent postoperative feeding group ($p = 0.043$) (Table 1).

Table 1
Characteristics of population

Characteristic	Overall, n=27[a]	Continuous postoperative feeding, n=13[a]	Intermittent postoperative feeding, n=14[a]	*p-value*[b]
Gestational age, weeks	37.14 (34.94, 38.57)	37.00 (34.87, 37.57)	38.21 (37.00, 38.57)	*0.3*
Birth weight, gr	2,480 (1,930, 2,760)	2,280 (1,890, 2,710)	2,655 (2,125, 2,778)	*0.4*
Apgar score at M0	9.00 (5.00, 10.00)	9.00 (7.00, 10.00)	9.00 (4.00, 10.00)	*0.8*
Apgar score at M5	10.00 (9.50, 10.00)	10.00 (10.00, 10.00)	10.00 (8.25, 10.00)	*0.2*
Lactates at birth (mmol/L)	5.00 (3.03, 7.45)	3.50 (1.88, 5.15)	7.25 (4.55, 8.00)	*0.043*
Down syndrome	5 (19%)	2 (15%)	3 (21%)	*> 0.9*
Cardiac malformation	3 (11%)	2 (15%)	1 (7.1%)	*0.6*
Days to surgery, days	2.00 (1.50, 3.00)	2.00 (1.00, 3.00)	2.00 (2.00, 3.00)	*> 0.9*
Postoperative complications	2 (7.4%)	1 (7.7%)	1 (7.1%)	*> 0.9*
Site of duodenal atresia [c]				*0.5*
1	5 (19%)	1 (7.7%)	4 (29%)	
2	13 (48%)	6 (46%)	7 (50%)	
3	5 (19%)	3 (23%)	2 (14%)	
4	4 (15%)	3 (23%)	1 (7.1%)	
Duodenal web	2 (7.4%)	1 (7.7%)	1 (7.1%)	*> 0.9*
Annular pancreas	6 (22%)	2 (15%)	4 (29%)	*0.6*
Meckel's diverticulum	2 (7.4%)	2 (15%)	0 (0%)	*0.2*
Type of enteral feeding				*0.15*
Mother's milk	20 (80%)	11 (100%)	9 (64%)	
Low protein milk	3 (12%)	0 (0%)	3 (21%)	

[a] *Médiane (IQR) ; n (%)*

[b] *Test de Wilcoxon (rang-somme) ; test exact de Fisher*

Characteristic	Overall, n=27[a]	Continuous postoperative feeding, n=13[a]	Intermittent postoperative feeding, n=14[a]	*p-value*[b]
Formula	2 (8.0%)	0 (0%)	2 (14%)	
Preterm formula	0 (0%)	0 (0%)	0 (0%)	
Catheter complications	1 (3.8%)	1 (7.7%)	0 (0%)	*> 0.9*
Days with catheter, days	16.0 (12.8, 19.3)	18.0 (13.3, 22.3)	15.0 (12.8, 16.3)	*0.3*
Death in NCIU	0 (0%)	0 (0%)	0 (0%)	
[a] *Médiane (IQR) ; n (%)*				
[b] *Test de Wilcoxon (rang-somme) ; test exact de Fisher*				

[c]The anatomical site of duodenal atresia is divided into 4 portions: 1 is the first portion of the duodenum, 2 is the second portion of the duodenum, 3 is the third portion of the duodenum, and 4 is the fourth portion of the duodenum.

Gr, gram; M, minutes; NICU, neonatal intensive care unit

Baseline neonatal and surgical characteristics of infants with duodenal atresia according to postoperative feeding mode (continuous vs intermittent feeding). Data are presented as median (interquartile range, IQR) for continuous variables and as number (percentage) for categorical variables. Group comparisons were performed using the Wilcoxon rank-sum test for continuous variables and Fisher's exact test for categorical variables.

The primary endpoint, NICU length of stay, differed between the two postoperative feeding groups. On univariate analysis, the NICU length of stay was significantly shorter in the intermittent feeding group (beta − 10, 95% CI [-17, -3.7], p = 0.004). Demographic factors associated with NICU length of stay were gestational age (beta − 1.7, 95% CI [-3.1, -0.29], p = 0.02), birth weight (beta − 0.01, 95% CI [-0.02, -0.01], p < 0.001), and catheter duration (beta 1, 95% CI [0.26, 1.8], p = 0.011) (Table 2). On multivariate analysis, factors associated with a shorter NICU length of stay were intermittent postoperative feeding (beta − 8, 95% CI [-14,-2], *p = 0.012*) and birth weight (beta − 0.01, 95% CI [-0.02, 0.02,0.00], *p = 0.022*) (Table 3, Fig. 1).

Table 2
NICU stay duration: univariate analysis

Characteristic	N	Beta	95% CI[a]	*p-value*
Postoperative feeding mode	26			
Continuous postoperative feeding		—	—	
Intermittent postoperative feeding		-10	-17, -3.7	0.004
Gestational age, weeks	26	-1.7	-3.1, -0.29	0.020
Birth weight, gr	26	-0.01	-0.02, -0.01	< 0.001
Apgar score at M0	26	-0.81	-2.2, 0.61	0.2
Apgar score at M5	26	0.20	-4.0, 4.4	> 0.9
Lactates at birth (mmol/L)	24	-0.33	-2.1, 1.4	0.7
Down syndrome	26			
No		—	—	
Yes		-7.7	-17, 2.1	0.12
Site of duodenal atresia [b]	26			
1		—	—	
2		-1.1	-12, 9.9	0.8
3		1.6	-12, 15	0.8
4		7.3	-7.9, 22	0.3
Duration of postoperative drain, days	23	0.27	-1.1, 1.6	0.7
Postoperative enteral feeding, days	26	1.0	-0.58, 2.6	0.2
Type of enteral feeding	24			
Mother's milk		—	—	
Low protein milk		-6.1	-19, 7.0	0.3
Formula		-8.5	-24, 7.2	0.3
Days with catheter, days	24	1.0	0.26, 1.8	0.011
Oral feeding disorders	24			
No		—	—	
Yes		7.5	-2.8, 18	0.14

[a] *CI = Confidence Interval*

[b] The anatomical site of duodenal atresia is divided into 4 portions: 1 is the first portion of the duodenum, 2 is the second portion of the duodenum, 3 is the third portion of the duodenum, and 4 is the fourth portion of the duodenum.

Gr, gram; M, minutes.

Univariate linear regression analysis of factors associated with NICU length of stay in neonates with duodenal atresia. Beta coefficients, 95% confidence intervals (CI), and p-values are reported for each variable. Continuous postoperative feeding was used as the reference category for postoperative feeding mode, and mother's milk as the reference category for enteral feeding type.

Table 3
Multivariate analysis of factors associated with NICU length of stay

Characteristic	**Beta**	**95% CI[a]**	***p-value***
Postoperative feeding mode			
Continuous postoperative feeding	—	—	
Intermittent postoperative feeding	-8.0	-14, -2.0	0.012
Birth weight, gr	-0.01	-0.02, 0.00	0.022
Gestational age, weeks	0.33	-1.3, 2.0	0.7
Days with catheter, days	0.39	-0.28, 1.1	0.2
[a] *CI = Confidence Interval*			

Table 4

A. Secondary outcomes, Univariate and multivariate linear logistic regression analysis

Characteristic	Univariate analysis			Multivariate analysis		
	Beta	**95% CI[a]**	***p-value***	**Beta**	**95% CI[a]**	***p-value***
Time to initiation of postoperative enteral feeding, days	-2.4	(-4.1, -0.72)	0.007	-2.4	(-4.1, -0.72)	0.007
Time to initiation of postoperative oral feeding, days	-13	(-18, -8.3)	< 0.001	-9.8	(-18, -1.5)	0.024
Nasogastric tube duration, days	-14	(-22, -5.3)	0.003	-11	(-19, -3)	0.01
Catheter duration during hospitalization, days	-2.3	(-6.6, 1.9)	0.3	-	-	-
Total length of hospital stay, days	-6.6	(-16, 3.3)	0.2	-	-	-

[a] *CI = Confidence Interval*

Univariate linear regression analysis of factors associated with secondary outcome. Significant variables were included in multivariate linear logistic regression analyses to assess their independent association with the secondary outcome measures.

Beta coefficients, 95% confidence intervals (CI), and p-values are reported for each variable.

Table 4B. Secondary outcomes, Univariate and multivariate binary logistic regression analysis

Characteristic	Univariate analysis		Multivariate analysis	
	OR (95% CI[a])	***p-value***	**OR (95% CI[a])**	***p-value***
Feeding disorders at discharge	0.6 (0.07, 4.44)	0.62	-	-

[a] *CI = Confidence Interval*

Univariate binary logistic regression analysis of factors associated with secondary outcome. Significant variables were included in multivariate binary logistic regression analyses to assess their independent association with the secondary outcome measures.

Odd ratio (OR), 95% confidence intervals (CI), and p-values are reported for each variable.

Discussion

Hereby, we showed that intermittent enteral feeding is associated with an 8-day reduction in NICU length of stay as well as earlier enteral and oral feeding, and removal of gastric tube.

Postoperative feeding difficulties occur across various neonatal surgical conditions, yet feeding tolerance after duodenal surgery has been poorly studied. The correlation between duodenal atresia-associated gastrointestinal dysmotility and postoperative feeding strategies remains largely underexplored. Duodenal atresia is associated with antenatal gastric and duodenal dilation, reflecting prolonged absence of enteral stimulation *in utero* and

often resulting in postoperative gastroparesis [12]. Physiologically, small-intestinal peristalsis typically recovers within 6–8 hours after surgical trauma, and absorptive function is preserved even without coordinated motility, allowing early nutrient infusion [13]. In newborns with intestinal atresia, proximal hypomotility after surgery delays the return of normal intestinal motility and prolongs fasting, with an incidence of 4%–11% [14]. This condition prolongs hospitalization and increases medical costs [15]. Duodenal dysmotility may persist until two years of age [16].

The extent to which early postoperative feeding strategies influence outcomes is of particular interest, yet the literature remains scarce. Escobar *et al.* described one of the largest duodenal atresia series, identifying 169 patients. The study focused on surgical approaches and long-term gastrointestinal complications, without addressing nutritional outcomes [17]. Peng *et al*., in a series including duodenal atresia, annular pancreas, intestinal duplication, and intestinal stenosis, demonstrated that the time to first enteral feeding was significantly shorter in the early enteral nutrition group than in the conventional management group, but no differences were observed in time to full feeds, postoperative morbidity, or length of postoperative hospital stay [9].

Advancement to oral feeding after repair of congenital duodenal atresia, however, may be limited by persistent bilious gastric aspirates and vomiting, presumed to result from dysfunction of the dilated proximal duodenum [18, 19]. The mechanism underlying oral feeding may involve the physiological stimulation of gastric motility patterns that more closely mimic normal neonatal feeding behavior. Although no studies directly compare continuous and intermittent feeding in duodenal atresia, several reports document variability in the time to oral feeding. In newborns treated with laparoscopic or laparotomy repair for duodenal atresia, initiation of oral feeding is reported to occur between 4 and 24 days after surgery, whereas full oral feeding is achieved in 6 to 200 days [3, 20].

In duodenal atresia, a fast-feeding strategy is thought to advance feed volumes more rapidly than slow-feeding, with comparable gastric residuals [21]. In our study, we confirm that intermittent enteral feeding enables faster achievement of full oral intake than continuous feeding. In addition, we demonstrate a direct impact on NICU length of stay without increasing the risk of central line-associated adverse events. Furthermore, similar rates of feeding-related complications between groups indicate that intermittent bolus feeding, when properly monitored, does not increase the risk of aspiration, vomiting, or abdominal distension compared with continuous feeding**.** We observed no differences in oral feeding disorders at the two-year follow-up. This long-term follow-up is a strength of our study and suggests that the choice of early postoperative feeding modality does not have lasting effects on oral-motor development or feeding behavior.

This study has several limitations. Its retrospective, single-center design introduces selection bias and limits adjustment for potential confounders. Feeding modality was not randomized and was based on physician preference and unit practice, potentially reflecting unmeasured factors such as clinical stability, severity of duodenal dilation, or expected feeding tolerance. The small sample size of 27 patients, although consistent with the rarity of duodenal atresia and comparable to published series, reduced statistical power and precluded multivariable analysis. Detailed data on daily feeding volumes, caloric intake, and weight trajectories were unavailable, and physicians defined feeding intolerance based on clinical documentation, which may have varied. At 2 years, we assessed oral feeding difficulties without standardized swallowing evaluations or validated questionnaires. In addition, the 10-year study period may have included changes in NICU practices

beyond feeding protocols. Nevertheless, the cohort was homogeneous, all patients underwent duodenoduodenostomy, and the sample size was consistent with the literature. The availability of 2-year follow-up data is an important strength. In conclusion, this study suggests that rapid intermittent enteral feeding is feasible and appears to facilitate progression to oral feeding while reducing both the duration of parenteral nutrition and NICU length of stay. This approach is further supported by the concept that intestinal dysmotility in duodenal atresia is predominantly physiological rather than pathological, and that early enteral nutrition may promote progressive digestive tolerance. However, given the retrospective nature of this study and its inherent limitations, prospective randomized controlled trials are required to confirm these findings and establish evidence-based postoperative feeding protocols for neonates with duodenal atresia.

Declarations

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

The study conception and design were performed by Marion Perrine, Khadidja Khadir Soumeya, Pierre Tissières, and Silvia Foligno. Methodology, investigation, and data curation were performed by Marion Perrine and Silvia Foligno, with Sandra Rodrigues contributing to investigation and resources. The first draft of the manuscript was written by Marion Perrine, Silvia Foligno, and Luca Pio. Narjes Ghali and Diane Carriere contributed to manuscript review and editing. Supervision was provided by Pierre Tissières, Silvia Foligno, and Luca Pio. All authors read and approved the final manuscript.

Ethics approval

In accordance with local regulatory requirements for retrospective studies, parents received an information letter approved by the institutional regulatory authorities; written informed consent was not required. The study was approved by the institutional ethics committee of AP-HP Paris Saclay University (approval number: 2024-IRB-20250908155253).

Consent to participate

Not applicable

Consent to publish

Not applicable

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Figures

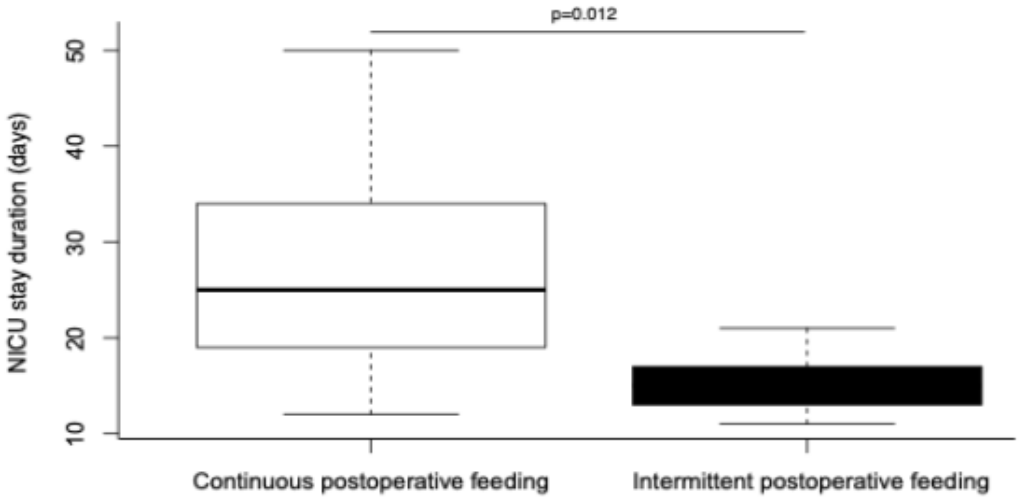


Figure 1

Comparison of NICU length of stay according to postoperative enteral feeding modality. Box plots show NICU stay duration (days) for infants receiving continuous postoperative enteral feeding versus intermittent (bolus) postoperative feeding. The median NICU stay was significantly longer in the continuous feeding group than in the intermittent feeding group (25 vs. 15 days; p = 0.008). Boxes represent the interquartile range; the horizontal line indicates the median, and whiskers denote the minimum and maximum value.