

Chyme refeeding therapy in pediatric patients with double enterostomy

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Abstract. Double enterostomy is a common surgical procedure performed in children that may result in a notable loss of nutrients, fluids and electrolytes from the proximal stoma, predisposing patients to malnutrition and intestinal failure-associated complications. Chyme refeeding therapy (CRT) is a nutritional intervention that reinfuses chyme from the proximal stoma into the distal gut, aiming to preserve intestinal integrity and enhance nutritional status. However, it is still greatly underutilized in pediatric patients in developing countries. Therefore, in the present study, a combined retrospective-prospective cohort study was conducted, which included 20 pediatric patients (aged 0-12 years) who underwent CRT following double enterostomy. At the time of admission, the majority of the patients were suffering from wasting malnutrition. Following CRT, the weight gain velocity, weight-for-height Z-score and body mass index-for-age Z-score increased significantly and more than half of the patients were able to discontinue parenteral nutrition (PN). Infection was the leading indication for temporary CRT cessation; however, the association between infection and CRT was unclear. On the whole, the present study demonstrates that CRT may be an effective treatment that improves nutritional status and

reduces PN requirement in children who have undergone a double enterostomy. However, further research with a larger sample size is required to further demonstrate the benefits of this therapy and promote its implementation in clinical practice.

Introduction

Chyme refeeding therapy (CRT) redirects effluent chyme from the proximal stoma into the distal intestine. Hence, by utilizing the downstream bowel, it facilitates enteral nutrient absorption and physiological stimulation of the intestine, and also reduces dependence on parenteral nutrition (PN). In addition, CRT restores the enterohepatic circulation of bile salts, thereby limiting bile salt hypersecretion and potentially mitigating intestinal failure-associated liver disease (IFALD) (1). Despite these potential benefits, however, CRT remains underutilized, particularly in children from developing countries.

According to the European Society for Clinical Nutrition and Metabolism (ESPEN), intestinal failure is defined as a reduction in gut function below the minimum necessary for the absorption of macronutrients and/or water and electrolytes, such that intravenous supplementation is required to maintain health and growth (2). By contrast, a reduction in intestinal absorptive capacity that does not require intravenous supplementation is defined as intestinal insufficiency. ESPEN further classifies intestinal failure into three types, of which type II intestinal failure (prolonged acute condition, often in metabolically unstable patients, which requires complex multi-disciplinary care and intravenous supplementation over periods of weeks or months) is typically observed in patients with high-output enterostomy (3). In this context, CRT may play a role in partially or completely restoring intestinal function, thereby contributing to the resolution of intestinal failure.

In recent years, interest in CRT for the treatment of pediatric populations with prolonged enterostomy has increased. The study by Wong *et al* (4) has shown that CRT is safe among children, can prevent disuse atrophy in the distal loop, promote weight gain and reduce dependence on PN. Other more recent research from Lau *et al* (5) and Lim *et al* (6) has shown similar results. However, there remains a paucity of data from low and middle-income countries, where the burden

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Abbreviations: CRT, chyme refeeding therapy; IFALD, intestinal failure-associated liver disease; PN, parenteral nutrition; VNCH, Vietnam National Children's Hospital

Key words: chyme refeeding therapy, parenteral nutrition, intestinal insufficiency, intestinal failure, children, double enterostomy

of enterostomy-related malnutrition is substantial and access to PN, as well as novel CRT devices is limited or unaffordable. Moreover, there are minimal details available regarding its use among children outside of the neonatal period.

The practice of CRT in children at Vietnam National Children's Hospital (VNCH; Hanoi, Vietnam), a selected tertiary center with a multidisciplinary team dedicated to caring for children with nutritional complications following gastrointestinal surgery, has been applied since 2021. The present study aimed to describe the characteristics, methodology and nutritional outcomes of CRT in 20 pediatric patients (both neonates and older children) who had undergone double enterostomies treated at VNCH. By presenting this clinical experience, the authors hope to contribute to the growing body of evidence supporting CRT as an effective strategy for improving nutritional status and reducing PN dependence in children who have undergone a double enterostomy.

Patients and methods

Ethics approval and study design. The present study was approved by the Ethics Committee of VNCH (approval no. 3697/BVNTW-HDDD; dated November 26, 2024) prior to data collection and analysis. For the prospective cohort, written informed consent was obtained from the parents or legal guardians of the patients after they were informed of the study. All data were anonymized and participant information was kept strictly confidential.

The present combined retrospective-prospective cohort study was conducted at the Clinical Nutrition Department of VNCH. The department is a leading center in Northern Vietnam specializing in managing children with nutritional complications following gastrointestinal surgery. The retrospective cohort included patients who had completed treatment and follow-up between January 1, 2021 and November 26, 2024 (the date of ethics approval). Data for the retrospective cohort were extracted from medical records between November 27, 2024 and June 30, 2025. The prospective cohort comprised patients who began CRT on or after November 27, 2024 (after ethics approval) and completed follow-up before June 30, 2025.

Study population. Eligible participants were patients aged <18 years who had undergone a double enterostomy and subsequently received CRT for any indication between January 1, 2021 and June 30, 2025. Patients who received all CRT methods (bolus or continuous, manual or automated) were eligible for inclusion. Patients who succumbed prior to enterostomy closure (intestinal anastomosis) or those who received CRT for ≤ 1 day in total were excluded from the study. Due to the rarity of CRT among Vietnamese children, the present study employed convenience sampling and did not perform a formal sample size calculation. A total of 20 patients met the inclusion criteria, comprising 13 children in the retrospective cohort and 7 children in the prospective cohort.

Study process. For the retrospective cohort, patients were identified through the systematic screening of databases at VNCH, including the surgical logs and records from the Clinical Nutrition Department. All pediatric patients who

underwent double enterostomy during the study period were initially screened. Among these, patients who received CRT prior to enterostomy closure were selected. These cases were then assessed against predefined inclusion and exclusion criteria to determine eligibility for inclusion in the present study. Data for the retrospective cohort were extracted from medical records between November 27, 2024 and June 30, 2025.

A standardized CRT protocol had been established and routinely applied in the Clinical Nutrition Department prior to the study period. For patients receiving bolus CRT, chyme was manually collected from the proximal stoma bag and refeed into the distal stoma using either a gastric tube or a Foley catheter, as determined by the attending gastrointestinal surgeon. A small opening was created in the stoma bag to allow the insertion of the tube, which was then secured with medical tape. The collected chyme was refeed as a bolus over a period of 15-20 min, either manually or using an electronic syringe. To minimize the risk of contamination, refeeding was performed within 1 h of chyme collection. The frequency of refeeding was initially set at twice daily and subsequently increased based on patient tolerance and clinical judgment. For patients receiving continuous CRT, two gastric tubes or Foley catheters were inserted into the proximal and distal stomas and connected via a three-way connector, allowing chyme to pass continuously from the proximal to the distal bowel.

For the retrospective cohort, the clinical management was reviewed to ensure that CRT was performed according to this protocol. For the prospective cohort, the same protocol was applied prospectively without modification. During the entire study period, no major changes were made to the core principles of CRT indication, refeeding techniques or nutritional management. Surgical management followed the standard pediatric surgical practices at VNCH and did not differ between study phases.

Data were collected using a standardized data collection form. The collected baseline demographic and clinical variables included the indication for a double enterostomy, stoma site and ileocecal-valve preservation status. Each patient was monitored from the time of surgery until enterostomy closure. For the retrospective cohort, these variables were retrieved from the existing records; for the prospective cohort, data were collected prospectively following the same protocol. Data were obtained at three predefined time points: Admission to the Clinical Nutrition Department (T0), the initiation of CRT (T1) and the final day of CRT prior to enterostomy closure (T2).

Characteristics of the CRT data. The interval from stoma formation to the initiation of CRT was measured in weeks, from the date of stoma creation to T1. The duration of CRT was defined as the period (weeks) from T1 to T2. The CRT method was classified as either bolus or continuous. The number of CRT episodes per day referred to the number of chyme refeeding sessions delivered to the distal stoma per day, as indicated by clinicians. Time to stool passage was measured in days from T1 to the first time stool passed via the anatomical anus and rounded to the nearest day (for example, ≤ 24 h = 1 day). The proportion of patients who underwent

temporary cessation of CRT was calculated, with documented reasons for each case.

Clinical outcomes of patients receiving CRT. Weight and length/height were routinely measured and recorded by trained nurses or physicians following standardized anthropometric procedures. Body weight was measured using a calibrated mechanical pediatric scale with a precision of 0.1 kg. Recumbent length (for patients <2 years) or standing height (for patients ≥2 years) was measured to the nearest 0.1 cm using a length board or stadiometer, respectively. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m²). Weight-for-height Z-scores (WHZs) were calculated for children aged <59 months and BMI-for-age Z-scores (BMIZs) were calculated for children aged ≥60 months. Z-score calculations were performed using AnthroCalc (version 3.1.6), a growth assessment application developed and supplied by Daniel L. Metzger, which applies World Health Organization (WHO) growth reference algorithms to compute standardized anthropometric indices. The nutritional status was classified as wasting when the WHZ or BMIZ was ≤-2 SD relative to the WHO 2007 growth reference standards (7). To account for variability in the baseline weight and duration of CRT, the weight-gain velocity before vs. after CRT (g/kg/week) was compared using the following formula: Weight-gain velocity before CRT=[(W1-W0) x1,000]/[W0 x (T0-T1)] and weight-gain velocity after CRT=[(W2-W1) x1,000]/[W1 x (T1-T2)], where W0, W1 and W2 denote the weight (kg) measured at the T0, T1 and T2 time points, respectively, and (T0-T1) and (T1-T2) denote the corresponding time intervals in weeks.

PN was defined as the administration of intravenous amino acids or lipids alone or any combination of at least two macronutrient components, excluding glucose-only infusions (8). A total of 17 patients required complete or partial PN at time point T1. Changes in PN requirement were classified as follows: Cessation (no PN required at T2), reduction (any measurable decrease in PN requirement from T1 to T2) or no change. The interval from CRT initiation to PN cessation was recorded in weeks. The number of patients analyzed before and after CRT were exactly the same.

Data processing and statistical analysis. Statistical analyses were conducted using SPSS Statistics v27 (IBM Corp.). Continuous variables were tested for normality using the Shapiro-Wilk test. Non-normally distributed data are summarized as the median [interquartile range (IQR)] or median (range) and were compared using the Wilcoxon signed-rank test. A two-sided P-value <0.05 was considered to indicate a statistically significant difference. Given the small sample size, results were interpreted descriptively and no multivariable modeling was attempted.

Results

The present study included 20 pediatric patients with a median age of 0.1 years (range, 0.0-12.9 years). The majority of the patients were male, with a male-to-female ratio of 1.5:1. The most common indication for double enterostomy was intestinal atresia (30.0%), followed closely by necrotizing

Table I. Patient demographics and clinical characteristics.

Characteristic	Value
Sex, n (%)	
Male	12 (60)
Female	8 (40)
Age, years; median (IQR)	0.1 (0.0-12.9)
Indications of double-enterostomy, n (%)	
Intestinal atresia	6 (30)
Necrotizing enterocolitis	5 (25)
Intestinal obstruction	4 (20)
Intestinal volvulus	4 (20)
Intestinal perforation	1 (5%)
Site of ostomy, n (%)	
Duodenostomy	2 (10)
Jejunostomy	8 (40)
Ileostomy	10 (50)
ICV preserved, n (%)	19 (95)
WHZ or BMIZ before CRT, median (IQR)	-2.9; (-3.8-2.1)
Wasting malnutrition at admission, n (%)	17 (85)

IQR, interquartile range; ICV, ileocecal valve; BMIZ, BMI-for-age Z-score; WHZ, weight-for-height Z-score; CRT, chyme refeeding therapy.

Table II. Characteristics of chyme refeeding therapy.

Characteristics	Value
Duration from stoma formation to CRT initiation, weeks; median (IQR)	7 (4.3-10.8)
Duration of CRT, weeks; median (range)	5 (2.0-16.0)
CRT method, n (%)	
Bolus	18 (90)
Continuous	2 (20)
CRT episodes per day; median (range)	4 (1-8)
Time to stool passage, days; median (range)	1 (1-3)

IQR, interquartile range; CRT, chyme refeeding therapy.

enterocolitis, intestinal obstruction and intestinal volvulus. A total of 18 patients (90.0%) underwent either jejunostomy or ileostomy, whereas 2 underwent duodenostomy. At baseline, 85.0% of the cohort suffered from wasting malnutrition with a median WHZ or BMIZ of -2.9 SD (Table I).

CRT was initiated at a median of 7 weeks following stoma formation and was maintained for a median duration of 5 weeks (range, 2-16 weeks). In total, 18 patients (90.0%) received CRT via the bolus method, whereas the remaining 2 were managed with continuous infusion. The median number of chyme refeeding sessions was 4 per day and stool passage via the anatomical anus occurred within a median of 1 day (Table II).

Among the 17 patients who required PN prior to CRT initiation, 9 (52.9%) were able to discontinue PN following the

Table III. Change in parenteral nutrition dependence after chyme refeeding therapy.

Outcomes	Value
PN required prior to CRT initiation, n (%) (n=20)	17 (85)
Change in PN requirement, n (%) (n=17)	
Cessation	9 (52.9)
Reduction	3 (17.6)
No change	5 (29.4)
Time to PN cessation after CRT initiation (weeks), median (IQR) (n=9)	2 (1.0-4.0)

IQR, interquartile range; CRT, chyme refeeding therapy; PN, parenteral nutrition.

procedure following a median duration of 2 weeks; 3 patients (17.6%) exhibited a reduction in PN requirement, whereas 5 (29.4%) patients exhibited no change (Table III). The weight-gain velocity per week improved significantly from a median of 15 g/kg/week before CRT to 26.9 g/kg/week after CRT ($P=0.04$; Fig 1). Similarly, the WHZ/BMIZ increased from -2.4 to -1.8 following CRT, a difference that was statistically significant ($P=0.02$; Fig. 2). The temporary cessation of CRT occurred in 40.0% of cases, which was primarily due to infection (Table IV). Of note, 1 patient had pneumonia, and 6 patients were diagnosed with infection of unknown origin; 1 patient had to discontinue CRT due to distal gut prolapse.

Discussion

To the best of our knowledge, the present study is the first to describe CRT in a pediatric population that is not limited to the neonatal period and is in a low-to-middle income country setting. The present study included 20 patients and aimed to describe the characteristics and outcomes of children treated with CRT.

Double enterostomy is performed in children with gastrointestinal conditions, such as intestinal atresia or necrotizing enterocolitis, when primary anastomosis is not feasible due to inflammation, poor tissue perfusion or a high risk of anastomosis leakage. However, this procedure may lead to a substantial loss of fluids, electrolytes and nutrients through the proximal stoma, placing patients at risk of developing post-operative malnutrition. In the present study cohort, 85% of the pediatric patients presented with wasting or acute malnutrition at admission, with a median WHZ/BMIZ of -2.9 SD. Since the present study included children of various ages assessed at the acute stage following stoma formation, it was considered that examining the WHZ or BMIZ would be more appropriate than the weight-for-age Z-score. Nonetheless, malnutrition following enterostomy has also been reported in another study. The study by Chong *et al* (9) on 74 infants demonstrated that 42% of the infants developed severe underweight malnutrition at the time of stoma closure, with a median weight-to-age Z-score of -2.8 SD.

Several strategies can improve the nutritional status of patients who have undergone a double enterostomy. Enteral

Table IV. Complications during CRT.

Parameter	Value
Rate of complications (n=20)	n (%)
Infection	7 (35)
Stoma prolapse	1 (5)
Intestinal bleeding	0 (0)
CRT cessation rate due to complications (n=20)	8 (40)

CRT, chyme refeeding therapy.

nutrition can facilitate intestinal adaptation; however, increasing the feeding volume is limited by the reduced absorption surface area and increased stoma losses, particularly in patients with high-output enterostomy (defined as a stoma output ≥ 20 ml/kg/day for 2 consecutive days) (10). When enteral nutrition is insufficient or not tolerated, PN is required; however, PN is associated with complications, such as central line infection, thrombosis or liver injury (11,12). To overcome these limitations, CRT is a complementary nutritional intervention that is expected to restore intraluminal stimulation, improve nutrient and fluid reabsorption, as well as reduce reliance on PN by redirecting chyme from the proximal to the distal stoma.

The present study observed a significant improvement in both weight-gain velocity and WHZ/BMIZ following CRT initiation. These findings are consistent with those of the prior study by Ludlow *et al* (13), in which a positive weight gain from a mean of 68.8 ± 37.4 to 197 ± 25.0 g/week after CRT ($P=0.024$) was reported. Although weight-gain velocity expressed as g/kg/day has not been previously applied in pediatric CRT research, it was previously used in a study on children with acute malnutrition to evaluate nutritional status improvement after medical interventions (14). Thus, the present study expressed weight change as g/kg/week, which was considered more appropriate than absolute g/day or g/week, since the majority of the cohort suffered from wasting malnutrition and had varying ages, initial weights and CRT durations compared with the majority of other research, which has been limited to infants (4-6,12,15). The 'per week' unit was selected instead of 'per day' as CRT is typically maintained for several weeks until enterostomy reversal (at least 2 weeks in the present study). The improvement in weight gain observed in the present study may partly reflect recovery from acute illness or regression toward the mean. However, in the present cohort, CRT was initiated relatively late (median of 7 weeks after stoma formation) compared with other studies, a time point at which a number of patients had generally passed the acute post-operative phase and had already received other forms of nutritional support with limited weight gain (5,6). The subsequent improvement in weight-gain velocity following CRT initiation may indicate a possible contribution from CRT to these changes.

In the present study, CRT also facilitated PN weaning as over half of the cohort discontinued PN after a median of 2 weeks following CRT, while an additional 17.6% experienced a reduction in PN. This cessation rate is comparable to that reported by in the study by Elliott and Walton (15), in which

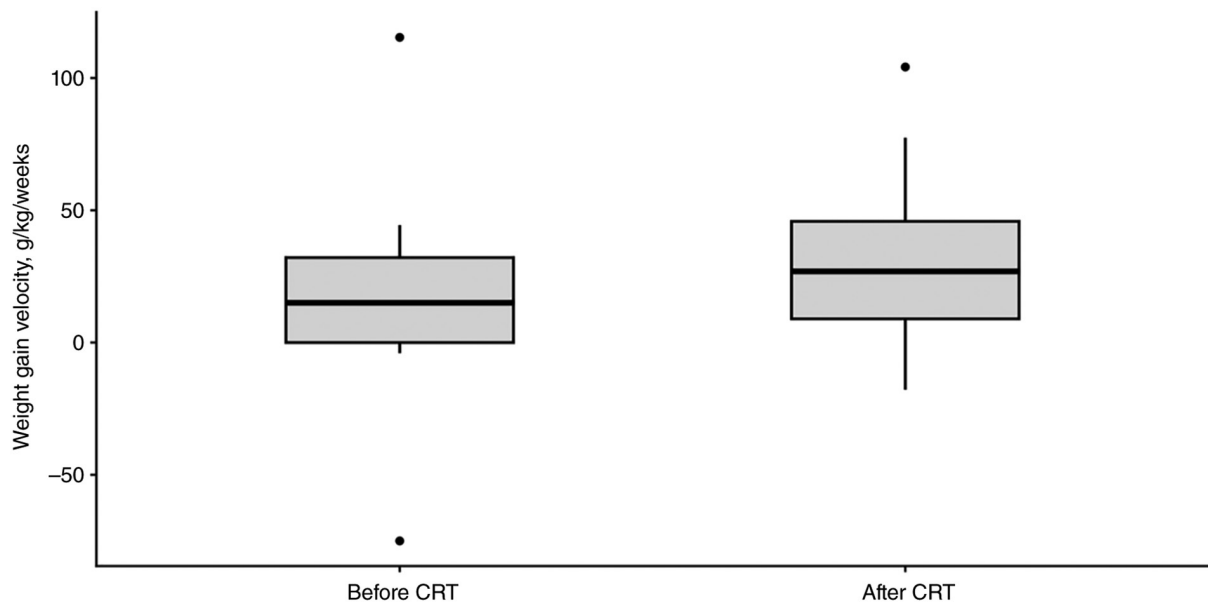


Figure 1. Weight-gain velocity before and after CRT. Paired comparisons were performed using the Wilcoxon signed-rank test (P=0.02). CRT, chyme refeeding therapy.

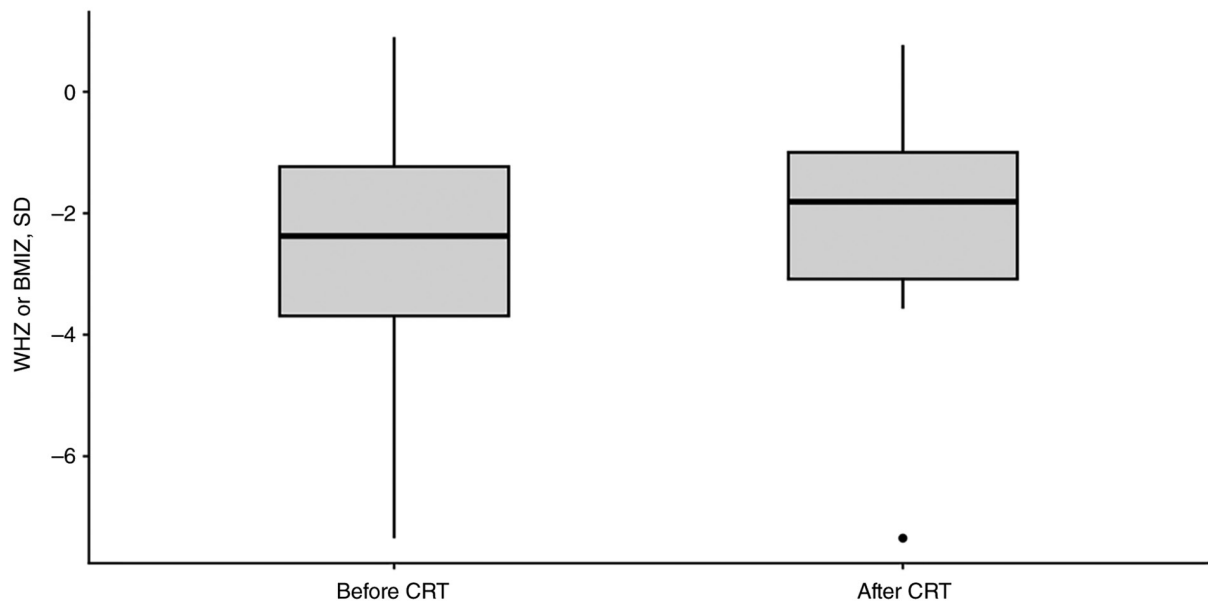


Figure 2. WHZ or BMIZ before and after CRT. Paired comparisons were performed using the Wilcoxon signed-rank test (P=0.04). BMIZ, body mass index-for-age Z-score; CRT, chyme refeeding therapy; SD, standard deviation; WHZ, weight-for-height Z-score.

48% of cases were able to withdraw from PN. CRT utilizes the chyme from the proximal stoma, thereby enhancing nutritional status, reducing PN requirement and stimulating the release of several gut hormones, particularly glucagon-like peptide 2, which accelerates enteral mucosal growth and intestinal adaptation (16). Reducing PN dependence is essential due to the risks associated with long-term PN use (11,12). CRT may also decrease hospitalization duration and healthcare costs, particularly in settings where home PN is not available, such as Vietnam.

In the present study, CRT was initiated at a median of 7 weeks (IQR, 4.3-10.8 weeks) following stoma formation, which is later than the median of 28.7 days (range,

15.0-140.0 days) reported by Lau *et al* (5) and 17 days (range, 13.0-27.5 days) reported by Lim *et al* (6). This delay may reflect the limited clinical awareness and familiarity with CRT among Vietnamese pediatricians, as a number of patients were only referred to the Clinical Nutrition Department when they developed severe malnutrition, failed to discontinue PN or exhibited signs of IFALD. In the present study, the median CRT duration was 5 weeks, which is longer than that reported by Lim *et al* (6), who reported a median of 19 days (6), but shorter than the mean of 76.5 days described by Lau *et al* (5). Since CRT is maintained until enterostomy closure, these variations may reflect a lack of consensus regarding the optimal timing of re-anastomosis surgery. A previous systematic review

indicated that there was no significant difference in complications between early and late closure and that decisions can vary by center as well as multidisciplinary assessment (17). At VNCH, closure is largely based on the preference of the surgeon and is typically deferred until at least 12 weeks after stoma formation and the patient has reached a minimum weight of 2 kg if they were born preterm. In the present study, the majority of patients (90%) received CRT via the bolus method due to limited technical resources and staffing constraints.

Despite its benefits, CRT is not without challenges. In the present study, 8 patients (40%) had to cease CRT temporarily due to complications. Infection was the leading cause of this, followed by 1 case of distal stoma prolapse; however, no patients experienced intestinal bleeding or intestinal perforation. The infection rate (35%) was comparable to that reported by Lim *et al* (6), which was 44%. In the present study, among the 7 cases of infection observed following CRT initiation, 1 patient was diagnosed with pneumonia based on clinical and radiological findings. The remaining 6 patients had episodes of fever accompanied by elevated inflammatory markers (leukocytosis and increased C-reactive protein) occurring 1 week to 1 month after initiation of CRT. Microbiological investigations, including blood and/or stool cultures, were negative in all of these cases and no definitive infectious source could be identified. These episodes were managed conservatively and none resulted in intensive care admission or mortality. Additionally, 1 patient with distal gut prolapse after CRT initiation had to stop CRT definitively after 2 weeks and subsequently underwent stoma closure.

The present study has several limitations that should be acknowledged. First, the sample size was small (n=20), which limits the generalizability of the findings. Although this sample size reflects the rarity of CRT in pediatric populations and its early implementation at VNCH, the results should be interpreted cautiously as preliminary observational evidence rather than definitive evidence of efficacy. Second, the combined retrospective-prospective design is subject to incomplete documentation and potential selection bias among the retrospective cohort; however, the routine anthropometric measurements performed by trained medical staff at VNCH likely mitigated measurement error. Moreover, as the Clinical Nutrition Department is currently the only unit implementing CRT at VNCH, the present study cohort may represent a subset of children with who had undergone double enterostomy who had more severe nutritional impairment or greater clinical complexity than those managed in other departments, such as the Surgery or Gastroenterology departments. Such a referral pattern may have influenced both the baseline characteristics and observed outcomes in the present study and should therefore be considered when interpreting the results. Third, since the present cohort was inherently predisposed to infection due to malnutrition and the use of a central venous line, the association between infection and CRT should be interpreted with caution. The high baseline risk of infection makes it difficult to determine whether infections were related to CRT or to pre-existing vulnerabilities. Fourth, subgroup analysis was not performed as we considered it substantially underpowered and likely to yield unreliable or potentially misleading results. In particular, several subgroups were

very small, including patients with duodenostomy (n=2) and those receiving continuous CRT (n=2), which would limit meaningful interpretation and increase the risk of spurious findings. Fifth, although the observed weight gain may plausibly be attributable to CRT rather than recovery alone in our cohort, the independent effect of CRT cannot be definitively established and residual confounding cannot be completely excluded given the observational design of the present study. Finally, liver function and stoma discrepancy following CRT were not assessed in the present study due to limited data availability. Despite these limitations, the findings of the present study are consistent with those of previous reports, suggesting that CRT may serve as a beneficial adjunctive therapy, with potential improvements in nutritional outcomes and facilitation of PN weaning in children following a double enterostomy (4-6,12,15). However, larger and well-designed prospective studies are required to confirm these observations and evaluate the long-term outcomes of CRT.

In conclusion, CRT may be an effective treatment strategy in pediatric patients who have undergone a double enterostomy, as demonstrated by the improved weight gain and reduced PN dependence observed in the present study. While the observed results are encouraging, they should be interpreted with caution. Broader clinical adoption of CRT and further research are required to establish the effectiveness and optimal implementation of CRT.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

All authors (HTTN, NTH, NTKB, DTT, HMT, DQL, LTTN and TTML) contributed to the conception and design of the present study. The patient data collection was performed by NTH. The first draft of the manuscript was written by NTH, HTTN and TTML, and all authors commented on previous versions of the manuscript. HTTN, NTH and TTML confirm the authenticity of all the raw data. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of Vietnam National Children's Hospital (approval no. 3697/BVNTW-HDDD; dated November 26, 2024). The parents or guardians of the pediatric patients were informed of the purpose of the present study and signed the consent forms for participation in the study.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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