

Outcomes of infant development following intestinal surgery at a national children's hospital

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Abstract. The aim of the present study was to describe the physical and psychomotor development of infants following bowel resection surgery, and to determine the factors effecting psychomotor development post-surgery. The present prospective descriptive study followed the development of infants who underwent bowel resection surgery prior to 3 months of age. The infants were monitored from 1 week to 6 months post-surgery. The present study included 60 infants (58.3% males). Post-operative intestinal failure occurred in 28.6% of the infants. Psychomotor delay was observed in 56.7% of the infants, primarily in gross motor skills. Developmental delay was more prevalent in infants with a small head circumference, and in those who were underweight and had intestinal failure ($P<0.05$). On the whole, the present study demonstrates that bowel resection surgery not only affects the physical growth of children, but may also affect their psychomotor development.

Introduction

Bowel resection in infants involves the removal of a segment of the bowel or creating an opening in the intestine to create an enterostomy to establish the normal circulation of the digestive tract. Infants who undergo intestinal resection may develop short bowel syndrome (SBS), leading to marked changes in gastrointestinal absorption and various complications. Infants with SBS absorb nutrients poorly and often rely on long-term intravenous nutrition. The study by Ubesie *et al* (1) found that

56% of patients were deficient in at least one mineral and 35.4% were deficient in at least one vitamin during combined intravenous and enteral nutrition (EN), compared to 25 and 42.5% during complete EN. The study by Olieman *et al* (2) reported that 53% of children with SBS were shorter than their healthy peers. It has been demonstrated that the physical and psychomotor development of children is significantly influenced by their diet and micronutrient deficiencies; severe malnutrition, including stunting and underweight, is strongly associated with negative impacts on neurological development (3). A low intake of micronutrients can result in disease, disability, and increased risks of morbidity and mortality (4). A number of nutrients, including protein, iron, zinc, iodine, selenium, vitamin A, folate, choline and long-chain polyunsaturated fatty acids influence nervous system function, and have a particularly pronounced effect during the late fetal and newborn stages (5). The enteric nervous system (ENS) originates from the vagal segment of the neural crest, extends to the proximal part of the gut and radiates throughout the gastrointestinal tract. For this reason, the ENS is considered part of the central nervous system (6). The intestinal tract not only plays a role in absorbing nutrients, but also secretes substances that affect the nervous system, regulating emotions, behavior and neurotransmitter activity. As a result, intestinal surgery can affect both the nutritional status and psychomotor development of children. According to the study by Dwyer *et al* (7) involving 135 children (68 patients and 67 controls), children with a history of surgery in the first 90 days after birth were assessed for psychomotor development at 3 years of age by the Baley scale version III. The results of their study revealed that although both groups had average developmental scores, the surgical group lagged behind the healthy group in cognitive ($P<0.002$) and receptive language ($P<0.001$), and fine motor skills ($P=0.03$). Additionally, around 4-9% of children in the surgical group exhibited mild to moderate developmental delays in one or more cognitive domains, including expressive language, receptive language, fine motor skills and/or gross motor skills (7).

Numerous studies worldwide have examined the nutritional status and psychomotor development outcomes of children who have undergone gastrointestinal malformation surgery. However, the majority of these studies are retrospective with small sample sizes, and there are a limited number

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Abbreviations: EN, enteral nutrition; SBS, short bowel syndrome; HC, head circumference

Key words: bowel resection, psychomotor retardation, stunted malnutrition, wasting, malnutrition

of longitudinal studies that track development immediately following surgery (8). In Vietnam specifically, research in this area is limited, with the majority of studies being cross-sectional and focused on nutritional status, and lacking any monitoring or evaluation of psychomotor development in children. Given the varying medical conditions and advancements across countries, it is critical to investigate how these differences affect developmental outcomes in children following gastrointestinal surgery. Thus, the present study was conducted to describe the physical and psychomotor development outcomes in infants at 6 months post-bowel surgery.

Patients and methods

Ethics approval and study location. The present study was conducted following the approval of the Ethics Committee of the Vietnam National Children's Hospital, Hanoi, Vietnam (Approval no. 1807/BVNTW-HDDD). All guardians/parents of the children were informed of the purpose of the study and were required to sign the consent forms. The children's information was kept completely confidential and used for research purposes only. The study was conducted at the National Children's Hospital from 2023 to 2024. This is the leading center for surgery and treatment of pediatric diseases in the country.

Study methodology and participants. For the purposes of the present study, 60 children who had indications for gastrointestinal surgery (bowel resection or enterostomy) at <3 months of age were included and followed-up for 6 months following the first surgery. Children with congenital abnormalities of the nervous system, nervous system infections, or other congenital malformations outside the digestive tract were excluded.

The present study included all infants who met the study criteria and whose parents/legal guardians agreed to participate in the study. There were 60 eligible infants participating in the study. The study commenced in February, 2023 and included all children who met the criteria to participate in the study. In total, 120 infants were included in the study and followed-up; however, only 60 infants had sufficient research data. Of these 60 children, 12 children succumbed due to severe infections, and 38 patients did not continue to participate in the study for various reasons (such as no funds for re-examination, no time to take their children to the hospital, or they prefer to visit a hospital closer to their home). Certain other patients did not have sufficient data for 6 months of follow-up.

The inclusion criteria were as follows: All children <3 months of age who were indicated to have bowel resection or enterostomy to establish normal circulation of the digestive tract. The exclusion criteria were the following: Children >3 months of age at the time of the first surgery, children with other congenital malformations outside the digestive tract (nervous system abnormalities, congenital heart disease, genetic abnormalities and diseases related to developmental delay in children) and children with nervous system infections during the research follow-up. Infants were continuously monitored from the start of the surgery to 6 months post-operatively. Anthropometric data were recorded at three time points [at 1 week following surgery (T0), at 3 months following surgery (T1) and at 6 months following surgery (T2)]. The time points T0, T1 and T2 are calculated from the first surgery. At T0, 100%

of the infants were receiving intravenous nutrition and fasting or drinking only sugar water. At T1, 16 (26.7%) of the infants were hospitalized and were receiving a combination of oral and intravenous nutrition. At T2, 100% of the infants were receiving complete oral nutrition and were not hospitalized. The children were examined and evaluated at the National Children's Hospital at the study points (T0, T1 and T2). Anthropometric measurements [weight, length, head circumference (HC)] were measured at T0, T1 and T2, and classified for malnutrition levels according to the WHO 2006 (9) and WHO 2007 (10) criteria, and corrected for gestational age. For premature children, malnutrition levels were classified according to the Fenton growth chart (11). Additionally, blood was drawn from the children for the testing of certain nutrients (zinc, iron and hemoglobin) at T2. Blood test results were classified (decrease or no decrease) according to the reference table of the National Children's Hospital laboratory (2021) (iron deficiency <7.2 $\mu\text{mol/l}$; zinc deficiency <10 $\mu\text{mol/l}$, anemia hemoglobin <10.5 g/dl). At the same time, infants were screened for psychomotor development at the Department of Rehabilitation of the Vietnam National Children's Hospital using the ASQ-3 developmental scale. Infants were assessed for development when their health was stable. The ASQ-3 test results were assessed according to the established threshold scores for each developmental area (12). Infants were diagnosed with intestinal dysfunction according to the Aspen criteria and infants with SBS. According to the Aspen criteria, intestinal failure in children is a condition of severe reduction in intestinal function below the level that can sustain life, resulting in dependence on parenteral nutrition support for a minimum of 60 days within a 74-day period (13). According to the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN), SBS in children is defined as 'the need for parenteral nutrition (PN) more than 60 days after bowel resection or bowel length less than 25% of estimated length for gestational age' (14). A premature baby is one born at <37 weeks of gestation.

The parents/legal guardians of all the infants participating in the present study received nutritional advice and were supplemented with micronutrients, including multivitamins [hydrosol 20 ml contains: Vitamin A, 50,000 UI; vitamin D2, 10,000 UI; vitamin E, 20 mg; vitamin B1, 20 mg; vitamin B2, 15 mg; vitamin B6, 20 mg; vitamin PP, 100 mg; vitamin C, 500 mg; vitamin B5, 40 mg), vitamin D (dedrolyl:calcifediol: 1.5 mg/10 ml) and zinc (Zinco: 15 mg elemental zinc/5 ml)]. Doses were individualized based on the clinical condition of each child and blood test results. One course of treatment: hydrosol dose 10 drops/day, lasting 30 days. dedrolyl 4 drops/day, lasting 30 days, zinco 2 ml/day, lasting 30 days. Children were given 2 additional courses of treatment after 1 and 6 months post surgery. 100% infants were supplemented with hydrosol, the remaining micronutrient supplementation rate was based on the deficiency rate of each deficient micronutrient. No children received iron supplements. The micronutrient supplementation is prescribed by other doctor, not me. Micronutrient supplementation is based on test results.

Data processing and statistical analysis. Data processing for the present study involved the use of Stata version 16.0 statistical software (StataCorp LLC) for the analysis of the collected data. Anthropometric measurements (weight, height and head circumference) were taken at three distinct time points: At

Table I. General characteristics of the infants in the present study.

General characteristics	Total	Sex, n (%)	
		Male	Female
Number of surgeries			
<2 times	31	17 (48.6)	14 (56)
≥2 times	29	18 (51.4)	11 (44)
Gestational age (weeks)			
Medium	37.3 (29-40)		
Full-term, ≥37 weeks	43	26 (74.3)	17 (68)
Birth weight (kg)			
Medium	2.8 (1.1-4.3)		
<2.5 kg	14	8 (22.9)	6 (24)
≥2.5 kg	46	27 (77.1)	19 (76)
Enterostomy (first postoperative period)			
Yes	42	27 (77.1)	15 (60)
No	18	8 (22.9)	10 (40)
Function of remaining intestine			
Intestinal failure	16	10 (28.6)	6 (24)
No intestinal failure	44	25 (71.4)	19 (76)
Location of the resected intestine			
Small intestine	49	26 (74.3)	23 (92)
No cutting of the small intestine	11	9 (25.7)	2 (8)
Surgical cause			
Necrotizing enterocolitis	11	9 (25.7)	2 (8)
Peritonitis	11	7 (20)	4 (16)
Megacolon	13	10 (28.6)	3 (12)
Intestinal atresia	15	6 (17.1)	9 (36)
Other cause ^a	10	3 (8.6)	7 (28)
Zinc (at 6 months post-surgery)			
Deficient	28	14 (40)	14 (56)
Not deficient	32	21 (60)	11 (44)
Iron (at 6 months post-surgery)			
Deficient	20	14 (40)	6 (24)
Not deficient	40	21 (60)	19 (76)
Hemoglobin (at 6 months post-surgery)			
Anemic	18	9 (25.7)	9 (36)
Not anemic	42	26 (74.3)	16 (64)

^aIntestinal perforation, duodenal septum, intestinal volvulus, intestinal pseudo-obstruction syndrome.

1 week after surgery (T0), at 3 months after surgery (T1) and at 6 months after surgery (T2). Nutritional deficiencies, such as zinc, iron and hemoglobin levels were also recorded at T2. Psychomotor development was assessed using the ASQ-3 developmental scale. Statistical tests, including descriptive statistics and significance testing (P-values), were employed to explore associations between malnutrition, psychomotor delays and factors, such as birth weight, head circumference and intestinal dysfunction. The Chi-squared test and Fisher's exact test were used to compare the differences in risk factors that may affect the psychomotor development of the children. A P-value $P < 0.05$ was considered to indicate a statistically significant difference.

Results

The present study included 60 infants (58.3% male), with a mean gestational age of 37.3 weeks (28.3% premature) and a mean birth weight of 2.8 kg (23.3% <2.5 kg). In total 42 (70%) infants had an enterostomy and 16 (26.7%) infants had intestinal failure. At 6 months following surgery, 28 (46.7%) of the infants had a zinc deficiency, 20 (33.3%) had an iron deficiency and 18 (30%) had anemia (low hemoglobin levels) (Table I).

Post-operatively, the rate of malnutrition in the children increased significantly. The rate of infants who were underweight (thus malnourished) was 20% at T0. At 3 and 6 months

Table II. Anthropometric characteristics of the infants in the present study.

Anthropometric index	Mean and SD	Time point following surgery		
		T0, n (%)	T1, n (%)	T2, n (%)
Weight (kg)	Mean	2.8 (1-6.5)	4.6 (2.2-8)	6.1 (3.2-9)
Normal	≥-2 SD	48 (80)	33 (55)	31 (51.7)
Moderately underweight	<-2 SD	9 (15)	6 (10)	9 (15)
Severely underweight	<-3 SD	3 (5)	21 (35)	20 (33.3)
Height (cm)	Mean	48.5 (35-59)	57.1 (44-70)	63.5 (54.5-74)
Normal	≥-2 SD	56 (93.3)	38 (63.3)	41 (68.3)
Moderately stunted	<-2 SD	1 (1.7)	10 (16.7)	9 (15)
Severely stunted	<-3 SD	3 (5)	12 (20)	10 (16.7)
HC (cm)	Mean	33.4 (26.4-40.8)	37.6 (30-42)	40 (35-45)
Normal	≥-2 SD	51 (85)	34 (56.7)	39 (65)
Moderately slow HC	<-2 SD	9 (15)	15 (25)	11 (18.3)
Severely slow HC	<-3 SD	0 (0)	11 (18.3)	10 (16.7)
Weight/length (kg/cm)				
Normal	≥-2 SD		39 (65)	37 (61.7)
Moderately wasted	<-2 SD		6 (10)	12 (20)
Severely wasted	<-3 SD		15 (25)	11 (18.3)

T0, at 1 week following surgery (T0); T1, at 3 months following surgery; T2, at 6 months following surgery; HC, head circumference.

following surgery, the rate of infants who were underweight at T1 increased by >2-fold compared with T0 (T1, 45%; T2, 48.3%). Stunting (caused by malnutrition) was observed in 6.7% of the infants at T0. At 3 and 6 months following surgery, the number of infants who suffered from stunting increased by >5-6-fold compared with T0 (T1, 36.7%; T2, 31.7%). The number of infants with a small head circumference was 15% at T0. At 3 months following surgery, this increased by almost 3-fold compared with T0 (T1, 43.3%). At 6 months following surgery, this increased by almost 2-fold compared with T0 (T2, 35%). The rate of wasting (caused by malnutrition) at 3 months following surgery was 35%. At 6 months following surgery, this slightly increased to 38.3% (Table II).

At 6 months post-surgery (T2), the velocity of weight gain, height gain and head circumference growth was observed a significantly more rapid rate than at 3 months post-surgery (T1). The rate of slow velocity weight gain was 55% in the first 3 months after surgery, decreasing to 23.3% in the 3-6 months after surgery. The rate of slow velocity height gain was 50% in the first 3 months following surgery, decreasing to 23.3% at 3-6 months following surgery. The rate of slow velocity head circumference growth was 53.3% at 3 months following surgery, decreasing to 18.3% at 3-6 months following surgery (Table III).

Of note more than half of the infants had developmental delay in at least one domain (56.7%), with the rate of gross motor skill delay being the highest (45%). The rate of delay in other domains was <25% and >16% (Table IV).

The results of the present study demonstrated that the rate of psychomotor developmental delay in children was the highest in infants who were underweight (with malnutrition) (77.8 and 79.3%), in those with a small head circumference group (80.8

and 81%) and in those with intestinal failure (81.2%). However, the rate of psychomotor developmental delay in infants in the present study exhibited no significant difference between the pairs of groups (premature or full-term birth, the presence or absence of enterostomy and birth weight). In the surgical cause, the rate of infants with psychomotor retardation was the highest in the peritonitis group (72.7%), while the remaining groups had similar rates of infants with developmental retardation, >50% (Table V).

Discussion

Bowel resection surgery may have an effect on both growth and psychomotor development, rendering the long-term monitoring of these aspects essential to enhance the treatment efficacy and support comprehensive child development. The present study was conducted at the National Children's Hospital in Vietnam from 2023 to 2024 to describe the physical and psychomotor development of infants from their first bowel resection surgery up to 6 months post-surgery.

The results of the present study demonstrated that following bowel resection, the rate of malnutrition increased, and there was a slow growth rate in head circumference. A low weight, small head circumference and intestinal dysfunction are the risk factors which may affect psychomotor development in children (3,15). Malnutrition increases in infants following intestinal surgery, as the function of their digestive system has not yet fully recovered and is thus not able to absorb nutrients sufficiently. In particular, infants who have undergone long intestinal resections develop intestinal dysfunction which is often severe and the infants suffer from prolonged malnutrition (2).

Table III. Growth velocity.

Anthropometric index	Mean and SD	Period of time	
		T0-T1, n (%)	T1-T2, n (%)
Weight gain velocity post-operative each 3 months (cm)	Mean	1.8 (0.2-3.5)	1.4 (-0.2-3.2)
Normal	≥ -2 SD	27 (45)	46 (76.7)
Moderately slow	< -2 SD	11 (18.3)	6 (10)
Severely slow	< -3 SD	22 (36.7)	8 (13.3)
Height increase velocity postoperative each 3 months (cm)	Mean	8.6 (1-15.5)	6.3 (1-13)
Normal	≥ -2 SD	30 (50)	46 (76.7)
Moderately slow	< -2 SD	13 (21.7)	9 (15)
Severely slow	< -3 SD	17 (28.3)	5 (8.3)
Head circumference growth velocity post-operative each 3 months (cm)	Mean	4.1 (0.8-8)	3.1 (0-7)
Normal	≥ -2 SD	28 (46.7)	49 (81.7)
Moderately slow	< -2 SD	8 (13.3)	1 (1.7)
Severely slow	< -3 SD	24 (40)	10 (16.6)

T0, at 1 week following surgery (T0); T1, at 3 months following surgery; T2, at 6 months following surgery.

Table IV. Psychomotor development screening results by ASQ-3.

Domain of development	ASQ-3 test results at 6 months post-surgery, no. of infants	%
Slow development	34	56.7
Suspect	16	26.7
No slow development	10	16.6
Communication skills		
Slow	11	18.3
Suspect	13	21.7
Normal	36	60
Gross motor skills		
Slow	27	45
Suspect	15	25
Normal	18	30
Fine motor skills		
Slow	10	16.7
Suspect	13	21.7
Normal	37	61.7
Problem solving skills		
Slow	10	16.7
Suspect	14	23.3
Normal	36	60
Social individual skills		
Slow	14	23.4
Suspect	11	18.3
Normal	35	58.3

Compared to numerous studies on children with a history of bowel resection, the present study found that the rate of underweight malnourished children accounted for almost half of the cases at 3-6 months post-surgery, primarily due to the reduced absorption capacity of the digestive tract (Table II). In the study by Tran *et al* (16), the rate of malnourished children was (52%). In the study by Olieman *et al* (2), the rate of stunted children was 53%. The study by McLaughlin *et al* (17) specifically also demonstrated that the mean weight, height, head circumference and weight/length of children post-surgery remained lower than those of healthy children for 2 years. Thus, despite post-operative monitoring, dietary guidance and appropriate nutrient supplementation, the ability of children to absorb nutrients remained poor at 6 months post-surgery.

Children's psychomotor development in the first years of life is influenced by a number of factors: Nutrition, living environment, education, disease (12,13,18-20). However, intestinal resection (intestinal dysfunction) is one of the factors that is considered to affect the development of children, as proven by previous studies (7,21). So *et al* (22) reported that 88% of infants with intestinal failure exhibited signs of psychomotor retardation when assessed at 12-15 months of age using the Prechtl's Assessment of General Movements, Movement Assessment of Infants, Alberta Infant Motor Scale and Mullen Scales of Early Learning tool. In the present study, as shown in Table V, the rate of psychomotor retardation in the intestinal failure group was almost 2-fold higher than that of the infants without intestinal failure ($P < 0.020$). Although only 28.6% of the children had intestinal failure, 56.7% exhibited psychomotor retardation (Table IV). Thus, following intestinal surgery, even if children do not have intestinal failure, they are still at risk of psychomotor retardation. Compared with the results of the study by Batta *et al* (23), the present study found that only 16.4% of children had developmental delay following surgery for digestive malformations, although the screening assessment results were performed at 1 following after surgery.

Table V. Psychomotor retardation and some related factors.

Characteristic	Slow in at least 1 a domain		Not slow in at least 1 a Domain		OR (95% CI)	P-value
	n	%	n	%		
Gestational age						0.429 ^a
<37 weeks	11	64.7	6	35.3	1.59 (0.50-5.1)	
≥37 weeks	23	53.5	20	46.5		
Birth weight						0.967 ^a
<2.5 kg	8	57.1	6	42.9	1.03 (0.31-3.43)	
≥2.5 kg	26	56.5	20	43.5		
HC at 3 months post-surgery						0.01^a
≥-2 SD	13	38.2	21	61.8	6.78 (2.05-22.4)	
<-2 SD	21	80.8	5	19.2		
HC at 6 months post-surgery						0.005^a
≥-2 SD	17	43.6	22	56.4	5.5 (1.56-19.3)	
<-2 SD	17	81	4	19		
HC increase velocity at the first 3 months after surgery						0.043^a
≥-2 SD	12	42.9	16	57.1	2.93 (1.01-8.45)	
<-2 SD	22	68.8	10	31.2		
HC increase velocity at 3-6 months after surgery						0.742 ^b
≥-2 SD	27	55.1	22	44.9	1.43 (0.37-5.51)	
<-2SD	7	63.6	4	36.4		
Weight at 3 months post-surgery						0.003^a
≥-2 SD	13	39.4	20	60.6	8.91 (1.71-16.9)	
<-2 SD	21	77.8	6	22.2		
Weight at 6 months post-surgery						0.001^a
≥-2 SD	11	35.5	20	64.5	6.97 (2.18-22.2)	
<-2 SD	23	79.3	6	20.7		
Weight gain velocity in the first 3 months following surgery						0.001^a
≥-2 SD	9	33.3	18	66.7	6.25 (2.02-19.3)	
<-2 SD	25	75.8	8	24.2		
Weight gain velocity 3-6 months following surgery						0.203 ^a
≥-2 SD	24	52.2	22	47.8	2.29 (0.63-8.37)	
<-2 SD	10	71.4	4	28.6		
Enterostomy						0.909 ^a
Yes	24	57.1	18	42.9	1.07 (0.35-3.25)	
No	10	55.6	8	44.4		
Intestinal failure						0.020^a
Yes	13	81.2	3	18.8	4.75 (1.18-19.0)	
No	21	47.7	23	52.3		
Surgical cause (n=50)						
Exclude other cause ^c (n=10)						0.798 ^b
Necrotizing enterocolitis	6	54.5	5	45.5		
Peritonitis	8	72.7	3	27.3		
Megacolon	7	53.8	6	46.2		
Intestinal atresia	8	53.3	7	46.7		

Table V. Continued.

Characteristic	Slow in at least 1 a domain		Not slow in at least 1 a Domain		OR (95% CI)	P-value
	n	%	n	%		
Zinc in blood (6 months post-surgery)						0.265 ^a
Deficient	18	64.3	10	35.7	1.80 (0.63-5.08)	
Not deficient	16	50	16	50		
Iron in blood (6 months post-surgery)						0.713 ^a
Deficient	12	60	8	40	1.23 (0.41-3.65)	
Not deficient	22	55.5	18	45		
Hemoglobin (6 months post-surgery)						0.071 ^a
Anemic	6	37.5	10	62.5	0.34 (0.11-1.12)	
Not anemic	28	63.6	16	36.4		

Data were analyzed using the ^aChi-squared test or ^bFisher's exact test. Values in bold font indicate statistically significant differences (P<0.05).

^cIntestinal perforation, duodenal septum, intestinal volvulus, intestinal pseudo-obstruction syndrome.

Therefore, children who undergo surgery need time to recover. Long-term monitoring may accurately diagnose any issues with the development of a child following surgery.

A slow growth rate is a key risk factor that can impair the cognitive development of children (4,24). The present study also found an association between delayed brain development and factors, such as a small head circumference and a low weight. Infants with a small head circumference had a rate of psychomotor retardation which was ~2-fold higher than that of infants with a head circumference within the normal limits (P<0.02). Moreover, infants who were underweight (had malnutrition) had a rate of psychomotor retardation which was ~2-fold higher than that of infants who were not malnourished. Thus, good nutritional support for children following surgery helps reduce risk factors that affect the later psychomotor development of children.

The results of the present study also demonstrated that the rate of infants with psychomotor retardation did not differ between the groups with and without enterostomy. Some studies have found an association between prematurity and a delay in psychomotor development (22,25). However, in the present study, premature infants had a slightly higher rate of developmental delay than full-term infants (64.7 and 53.5%; P<0.429).

A number of studies have shown that nutritional deficiencies affect the mental development of children, particularly zinc and iron, which are critical micronutrients (5,26). As demonstrated in Table V, the group of infants with zinc deficiency and anemia had a higher rate of slow development than the other groups; however, the difference was not statistically significant.

The present study had certain limitations, which should be mentioned. These include the small sample size and the fact that the duration of the follow-up period was not sufficient in

order to determine whether the children had fully recovered. All the children in the present study were <2 years of age and were not representative of older groups. This was not sufficient to determine long-term developmental outcomes. Nevertheless, the present study serves as a first step towards establishing a framework for monitoring and evaluating the development of children following bowel resection in Vietnam.

In conclusion, infants undergoing gastrointestinal surgery are not only at risk of growth retardation, but are also at risk of psychomotor retardation. In particular, the later development of the child depends greatly on factors affecting the first 2 years of life. Therefore, it is necessary to have long-term monitoring and nutritional support for the child following surgery in order to help the child develop comprehensively.

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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 (HTL, HTTN, NTKT, MTKL, HTTN and HTN) were involved in the conception and design of the study. HTL and HTN performed the statistical analysis of the data. HTL, HTN, HTTN, NTKT, MTKL and HTTN were involved in the

investigative aspects of the study. HTL and HTN were involved in the interpretation of the data. HTL and HTN were involved in the writing of the original draft of the manuscript. HTL, HTN and HTTN were involved in the writing, reviewing and editing of the manuscript. All authors have read and agreed to the published version of the manuscript. HTL and HTN confirm the authenticity of all the raw data.

Ethics approval and consent to participate

The present study was conducted after the research protocol was approved by the Vietnam National Hospital of Pediatrics (decision no. 1807/BVNTW-HDDD). All guardians/parents of the children were informed about the purpose of the study and were required to sign consent forms. The childrens' information was kept completely confidential and used for research purposes only.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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