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Clinical predictors of readmission after surgery for Hirschsprung disease

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Abstract

The reasons for readmission of children with Hirschsprung disease (HD) are multiple. The study aims to predict the relevant factors for the readmission of children with HD by collecting and analyzing the relevant data of the child's admission to the hospital at the time of surgery.

A retrospective review was performed including all patients with surgical treatment of HD at our institution between the years of 2011 to 2020. Univariate and multivariate Logistic regression analysis were performed to obtain the independent risk factor for this study. The receiver operating characteristic curve (ROC) were used to assess the performance of derived models.

A total of 162 patients were identified. The average presurgery weights were 6.93 ± 1.78 kg in the readmission group and 8.38 ± 3.17 kg in the non-readmission group. Six children were classified as a low-weight in the readmission group, and 11 children classified as low-weight in the non-readmission group. The length of the intestinal tube after resection was 25.25 ± 15.21 cm in the readmission group, and 16.23 ± 4.10 cm in the non-readmission group. The ROC for the prediction model of readmission after HD surgery (AUC = 0.811).

In children undergoing the HD surgery, we showed preoperative low body weight and long intra-operative bowel resection significantly increase the probability of readmission due to complications.

Abbreviations: HAEC = Hirschsprung-associated enterocolitis, HD = Hirschsprung disease, ROC = receiver operating characteristic curve.

Keywords: Hirschsprung disease, low-weight, pediatric, predictor, readmission

1. Introduction

Hirschsprung disease (HD) is a congenital condition characterized by an absence of ganglion cells in the distal hindgut resulting from failed cranial-caudal neural crest cell migration.[1,2] Common complications of HD include intestinal obstruction, intestinal perforation, gastroenteritis, Hirschsprung-associated enterocolitis (HAEC), etc. HAEC remains the greatest cause of morbidity and mortality in children with HD who present with clinical manifestations including abdominal distention, fever and foul-smelling stools. Usually, HD requires surgical intervention to remove the affected bowel segment. Most children recovered well after surgery. However, postoperative complications such as long-term constipation, abdominal distension, and fecal incontinence[3] may occur, resulting in longer-term consequences on future quality of life and mental health.[4]

Readmission is a typical prognostic indicator following surgery that accurately reflects the postoperative recovery of children. Increased readmissions not only affects patient quality of life, but are also a major social burden. A deeper understanding of the reasons for readmission due to surgical complications may lead to the development of more targeted and successful interventions.[5]

There is a current lack of information regarding the most important factors causing readmission after the surgery. As readmission following HD surgery may occur for multiple reasons, this study aimed to predict the relevant factors for readmission by analyzing data regarding admissions of children at the time of surgery. This data presented in this study could potentially inform clinical diagnosis and treatment, and also reduce the readmission rates of children with HD.

2. Materials and methods

1. Children who underwent surgery at the Children's Hospital of Soochow University between 2011 and 2020 with complete clinical datasets;
2. Postoperative pathological diagnosis of HD, and
3. Patients who met the criteria for discharge and readmission.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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The exclusion criteria of this study were as follows:

1. Children associated with major anomalies;
2. Children readmitted to hospital with non-HD direct complications.

Patients were divided into readmission and non-readmission groups depending on whether they were readmitted after surgery.

2.1. Strategies for surgical methods

All children underwent barium enema examination before surgery. After radiological examination by an experienced physician, the modified Soave surgical technique was used for patients with suspected short-segment type disease in which the diseased bowel is limited to the distal part of the rectum. Laparoscopic examination and open pull-through operations were used for patients who did not definitively have long-segment type disease in which the diseased bowel includes the descending colon, the splenic flexure and most of the transverse colon, or total-colon type disease in which the diseased bowel includes the entire colon and terminal. For the typical types of disease in which the diseased bowel includes the anus and the distal sigmoid colon),[6] the surgical method was determined according to the preoperative auxiliary examination and the general conditions of the patient.

2.2. Follow-up

Children who had surgical treatment completed the first telephone follow-up within 7 days after discharge, and completed the first outpatient follow-up within 30 days. Follow-up mainly included obtaining details relating to general postoperative conditions, postoperative defecation and anal dilatation. As the outcomes of this study were designated as readmission to the hospital due to complications, some children who required readmission for the first time for ostomy were excluded. This study did not require approval from the institutional review board.

2.3. Readmissions and complications

All patients were evaluated by an outpatient or emergency specialists and met the admission criteria. Children with related complications such as intestinal obstruction, constipation, gastroenteritis, and HAEC occurring 1 year after surgery were included in the readmission group. Children with no history of readmission after surgery were included in the non-readmission group.

2.4. Statistical methods

Multiple patient variables were analyzed including age, sex, birth weight, pregnancy, preoperative weight, surgical method, duration of operation, the length of bowel resected during the operation, classification, the number of days after hospitalization and plasma markers of basic status during hospitalization. SPSS 21.0 software was used to analyze the data in this study. Different statistical methods were used for data analysis. Specifically, a *T*-test was used to analyze the measurement data, a Chi-Squared test was used to analyze the count data and multi-categorical variables were analyzed using a non-parametric test. All statistical tests were two-sided and *P* values $<.05$ were considered statistically significant. The collected relevant risk factors were subjected to univariate Logistic regression analysis. To exclude confounding factors and include all relevant risk factors, all factors with $P<.1$ were included in the multivariate Logistic regression analysis. The final statistically significant ($P<.05$) factor was the independent risk factor for this study. Receiver operating characteristic curves (ROCs) were used to assess the performance of derived models.

3. Results

3.1. General information comparisons

In total, 49 patients were recruited to the readmission group (38 males and 11 females) and 113 patients were recruited to the non-readmission group (90 men and 23 women). The average age of patients at the time of surgery in the study was 4 months in the readmission (3.0–5.5 months) and non-readmission (3.0–9.0 months) groups. The average presurgery weights were 6.93 ± 1.78 kg in the readmission group, and 8.38 ± 3.17 kg in the non-readmission group. Based on the numerical table of height and weight percentiles (standard deviation units) for children and adolescents (0–18 years of age) in China, children were divided into low- and non-low-weight groups before surgery. Six children were classified as a low-weight in the readmission group, and 11 children classified as low-weight in the non-readmission group.

3.2. Comparison of surgery characteristics

The length of hospitalization during the current operation was 22.55 ± 12.91 days in the readmission group, and 20.93 ± 8.94 days in the non-readmission group. 30 patients underwent the modified Soave procedure in the readmission group and 86 children underwent this procedure in the non-readmission group. The length of bowel resection was 25.25 ± 15.21 cm in the readmission group, and 16.23 ± 4.10 cm in the non-readmission group. The operation time was 146.20 ± 63.98 minutes in the readmission group, and 131.23 ± 37.30 minutes in the non-readmission group.

Intra-operative observations of morphological changes in the intestine combined with preoperative imaging data were used to classify children with megacolon. One patient in the readmission group. And 9 patients in the non-readmission group had short-segment type disease. Twenty three patients in the readmission group and 86 patients in the non-readmission group had typical type disease, 18 patients in the readmission group and 17 patients in the non-readmission group had long segment type disease, and 7 patients in the readmission group and 1 patient in the non-readmission group had total colon type disease.

The clinical characteristics and specific operations of each group are summarized in Table 1 (the Table 1 has been adopted a correction for multiple testing). No statistically significant differences were detected between the groups relating to age, sex, operation method, length of hospitalization, duration of operation, the use of blood products after surgery, time to recommencing regular diet, anal tube placement time after surgery, and plasma markers of basic status during hospitalization between 2 groups ($P>.05$). Statistically significant differences ($P<.05$) were observed in the length of bowel resection during surgery, preoperative weight classification and clinical classification of HD.

To exclude confounding factors and include all relevant risk factors, the length of bowel resection, low body weight before

Table 1

Summary of clinical characteristics and specific operations of each patient group.

	Non-readmission group	Readmission group	P	Z/χ^2 /T
Total number of patients	113	49	——	
Sex				
Males	90	38	>.05	0.090
Females	23	11		
Low-weight children				
Yes	6	11	<.05	10.689
No	107	38		
Weight (kg)	8.38±3.17	6.93±1.78	<.001	3.685
Age (mo)	4.0 (3.0, 9.0)	4 (3.0, 5.5)	>.05	1.611
Number of days in hospital (d)	20.93±8.94	22.55±12.91	>.05	−0.800
Plasma markers of basic status at admission				
WBC count (10^9/L)	9.53±2.89	8.91±2.05	>.05	0.947
Hemoglobin (g/l)	112.42±11.53	110.40±9.55	>.05	0.756
Albumin (g/l)	42.23±3.15	41.73±2.23	>.05	0.705
Surgical procedures				
Laparoscopic-assisted pull-through operations	22	15	>.05	3.775
Modified soave	86	30		
Open pull-through operations	5	4		
Length of bowel resection (cm)	16.23±4.10	25.25±15.21	<.001	−4.088
The operation time (mins)	131.23±37.309	146.20±63.98	>.05	−1.529
Concentration of plasma markers of basic status at 24h after surgery				
WBC count (10^9/L)	11.54±4.42	10.25±3.62	>.05	1.252
Hemoglobin (g/l)	100.63±14.34	97.32±13.61	>.05	0.955
Number of days in hospital after surgery (d)	10.47±5.00	11.88±6.06	>.05	−1.540
Use of blood products				
Yes	66	35	>.05	2.469
No	47	14		
Maximum number of defecate per day after surgery (times)	3.8±2.03	4.33±1.59	>.05	−1.618
Time to regular diet (d)	3.85±1.813	3.58±1.672	>.05	0.871
Anal tube placement time after surgery (d)	4.15±1.546	4.00±1.522	>.05	0.540
Plasma markers of basic status before discharge				
WBC count (10^9/L)	8.75±2.54	9.60±2.15	>.05	−1.421
Hemoglobin (g/l)	111.42±16.59	114.76±14.96	>.05	−0.844
Clinical classification				
Short segment type	9	1	<.001	26.137
Typical type	86	23		
Long segment type	17	18		
Total-colon type	1	7		

surgery, clinical classification of HD, and the maximum number defecate per day after surgery ($P<.1$) were included in the multivariate analysis (Table 2). Data showed that the length of bowel resection and low body weight before surgery were independent risk factors for readmission. Finally, ROC curves for the prediction model of readmission after HD surgery (AUC= 0.811) are shown in Figure 1.

4. Discussion

Recent advances in the diagnosis and treatment of HD have significantly improved the survival rates for children with the disease. However, clinicians remain highly concerned about outcomes following treatment and the recovery of children after surgical treatment. Studies have reported that the long-term recovery of intestinal function in adult patients with HD could be further improved.[7–9] There is a critical need for improved strategies to reduce the occurrence of postoperative complications in children after treatment.

Most studies have reported recovery of intestinal function and quality of life in children following HD surgery through long-term follow-up. This study aimed to predict the relevant factors associated with hospital readmission in children following surgery for HD by analysing relevant clinical data at the time of admission to the hospital and during the surgical procedure or regimen

Studies have reported that poor nutritional status before surgery can increase the risk of complications and even death to around 3 times higher than normal.[10] After consulting with nutritionists, we chose to use the weight-for-age measure to assess preoperative malnutrition in children recruited to the study. Preoperative weights were compared to the numerical table of the height and weight percentile (standard deviation unit) of children and adolescents (0–18 years old) developed in China in 2009, to determine whether children's weights were before surgery. The results showed that the preoperative readmission rate of children with low birth weights was significantly higher than those with higher birth weights. This may be explained as most children are diagnosed with congenital megacolon at the neonatal period, and so clinicians recommend that in the absence of other complications occur, surgery should be performed in older children. During this period, children need long-term rectal lavage, special

Table 2

Summary of factors included in the logistic regression analysis.

	Univariate regression			Multivariate analysis		
	OR	95% CI	*P*	OR	95% CI	*P*
Length of bowel resection (cm)	1.189	1.1–1.286	<.001	1.163	1.069–1.265	<.001
Low-weight children	5.162	1.786–14.920	<.05	8.619	2.686–27.660	<.001
Maximum number of defecate per day after surgery (times)			>.05			
Clinical classification						
Typical type						
Short segment type	0.415	0.050–3.449	>.05			>.05
Long segment type	3.959	1.767–8.872	<.05			>.05
Total-colon type	26.174	3.063–223.626	<.05			>.05

formula milk powder for feeding, and other treatments to prevent weight loss. Furthermore, the number of goblet cells in the intestinal segment of HD is significantly reduced compared to normal intestinal tissue. These changes in goblet cell function may cause intestinal barrier dysfunction which affects the intestinal absorption of proteins and vitamins.[11] Evidence from a previous related study also found that complications such as iron deficiency and growth retardation after surgery were higher in patients diagnosed with HD.[12] This may also be a major reason explaining why the preoperative weights of children with readmission were lower than those of children without readmission of the same age.

Poor nutritional status in children before surgery is likely to cause a reduced ability to tolerate and recover from surgery. Moreover, although the method of HD surgery is relatively mature, the operation and the postoperative fasting time are relatively long. Children who have insufficient protein and fat content which are partially consumed during and after the operation are therefore more likely to be susceptible to intestinal infections and more serious complications such as HAEC. It should be recommended that children are well-nourished through a balanced diet before surgery. Also, children should have strong nutritional management after surgery to facilitate recovery and reduce complications. These measures should form part of parental education and nutritional guidance, regular outpatient visits, telephone follow-up and collaboration with nutritionists to develop a personalized plan for children to reduce postoperative readmissions.

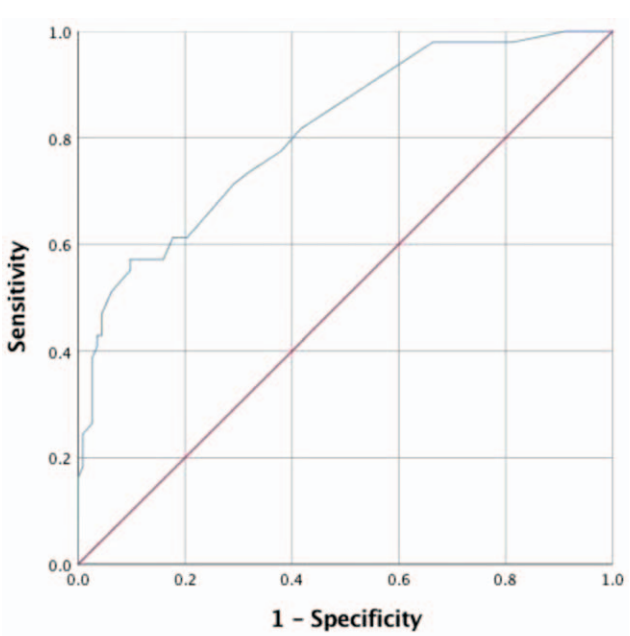

Figure 1. Receiver operating characteristics (ROC) curves for the prediction model of readmission after HD surgery (AUC=0.811).

Our study showed that the length of bowel resection during surgery is also an independent risk factor for readmission. According to guidelines, a frozen pathological examination should be performed during the operation to determine the presence of mature ganglion cells which can assist in the assessment of surgical margins. However, the accurate determination of surgical margins remains a persistent problem in pediatric surgery. Previous studies have suggested that the extended length of ganglion segments may be an important risk factor for complications after surgery.[13–15]

Alnajar et al, previously found differences between the clinical and pathological characteristics of long- and short-segment megacolon.[16] Also, Jamieson et al, found inconsistencies between imaging and histological results (approximately 62.5%), where the length of the intestinal canal from imaging lesions was much longer than that based on histological evaluation.[17] In contrast, Georgeson et al, showed that 10 to 15 cm of the ganglion colon edge should be removed before deciding bowel anastomosis during surgery.[16] Coyle et al, postulated that for evidence-based medicine, it is recommended that the resection site should be at the farthest normal ganglion intestinal canal during surgery.[18] Previously, clinicians believed that intestinal anastomosis should be used at least 2 cm adjacent to the distal end of the biopsy showing ganglion cells. However, studies now suggest that the length of the transition zone is variable, and may even extend to more than 10 cm. The current recommended margin range is 1 to 2 cm above the normal frozen section biopsies to 10 to 15 cm.[19–23]

Based on the results of our study, surgical margins should be determined by combining pathological changes in the intestinal tract with fast-frozen pathological results during surgery. This approach should preserve the length of the intestinal canal as far as possible, which is conducive to the recovery of postoperative intestinal function and reduced rates of hospital readmission. However, our study did not evaluate the length and location of the specific surgical margins which may limit these conclusions.

Based on the epidemiological characteristics of HD, typical type disease was more prevalent than other disease types. The number of patients with short and long-segment disease types were lower than those with typical type disease, and the number of patients of total-colon type disease was least frequent. These findings are consistent with our data. Based on our observations, the classification of HD was shown to impact on postoperative readmission. However in this study, we did not conclude the classification of HD to be an independent risk factor for readmission. Finally, a number of limitations associated with our study should be noted. Firstly, of all factors that were compared across the patients recruited to our study, the classification of HD remains highly subjective. Secondly, the sample size of our study was small and may have selection bias. A study concluded that short-segment prognosis is better than in other types of HD,[24] with the prognosis of the total-colon type disease being relatively poor, which is also consistent with our data. Based on our findings, we believe that shorter intestinal tubes removed during surgery can also lower the probability of postoperative readmission. However, further research is needed to draw more accurate conclusions, and to better understand the correlation between HD classification and prognosis.

5. Conclusions

In children undergoing HD surgery, we showed that preoperative low body weight and long intra-operative bowel resection significantly increase the probability of readmission due to direct complications. Ensuring the nutritional status before the operation and precise surgery should be widely implemented to improve surgical outcomes in children with HD.

Author contributions

Data curation: Jie Min.
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Funding acquisition: Bin Wu.
Investigation: Peng Cai, Bin Wu.
Methodology: Peng Cai.
Software: Jie Min.
Writing – original draft: Jie Min.
Writing – review & editing: Zhicheng Gu, Shungen Huang, Jian Wang.

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