

Laparoscopic-aided transanal pull-through procedure for the management of Hirschsprung's disease: an observational prospective study for children older than 12 months

Mohamed Rabea^{a,b}

^aDepartments of General and Pediatric Surgery, ^bPediatric Surgery, Faculty of Medicine, El-Minia University, El-Minia, Egypt

Correspondence to Mohamed Rabea, MD, Department of Pediatric Surgery, Faculty of Medicine, El-Minia University, El-Minia, Egypt, Tel: 01067045041; fax: 0862296734; e-mail: mrabea177@gmail.com

Received 24 March 2016

Accepted 15 April 2016

The Egyptian Journal of Surgery
2016, 35:348–356

Objective

The aim of the present study was to evaluate the surgical and functional outcome of the laparoscopic-aided transanal pull-through procedure for the management of Hirschsprung's disease (HD).

Patients and methods

The study included 17 patients older than 12 months. Diagnosis of HD relied on the inability of the patients to relax the anal internal sphincter in response to colonic extension on anorectal manometry. The laparoscopic part entailed transition zone identification, seromuscular biopsy for fresh frozen histopathology, and sigmoid and rectal mobilization up to 1 cm down the peritoneal reflection. The transanal part included mobilization of the rectal lower by 2 cm, resection till the ganglionic segment, and anastomosis. Patient outcome included evaluation of fecal consistency, frequency of soiling, and presence of perianal skin excoriation at 1, 3, and 6 months after the procedure. Colonic manometry and functional outcome evaluation according to qualitative clinical Hirschsprung scoring were carried out at 1 and 6 months after the procedure.

Results

One (5.9%) patient required open conversion for dissection of thick adhesions. Frequency of patients that passed formed stool and free of soiling increased progressively till the end of 6 months after the procedure. At 1 month after the procedure, six patients developed perianal skin excoriation, but all were free by the sixth postoperative (PO) month. Manometric pressure measures at 3 and 6 months after the procedure were significantly higher compared with the preoperative measures, with significant difference in favor of 6-month measures. At 6 months after the procedure, Hirschsprung scoring was significantly higher compared with that at 1 month, and 10 patients had a score of 14. No surgery-related complications were detected.

Conclusion

Laparoscopic-aided transanal pull-through is a feasible procedure for the management of children older than 12 months and who have HD. The procedure is safe with minimal PO complications, which are gradually resolved within 6 months PO.

Keywords:

anorectal manometry, functional outcome, Hirschsprung's disease, laparoscopic-aided transanal pull-through procedure

Egyptian J Surgery 35:348–356
© 2016 The Egyptian Journal of Surgery
1110-1121

Introduction

Hirschsprung's disease (HD) is a severe congenital anomaly of the enteric nervous system characterized by the absence of parasympathetic ganglion cells in the submucous and myenteric plexuses of the intestine, usually affecting the rectosigmoid portion of the large bowel. Distal innervation deficiency results from incomplete colonization of the bowel by enteric neural crest cells and results in functional intestinal obstruction [1].

HD remains the commonest cause of functional intestinal obstruction in children and contributes significantly to high morbidity and mortality. The

majority of patients present late, when the disease becomes complicated. Early diagnosis and timely definitive pull-through procedure are essential to decrease the morbidity and mortality associated with this disease [2].

Treatment of HD consists of surgical resection of the abnormal section of the colon, followed by reanastomosis. Definitive surgery for HD has been

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work noncommercially, as long as the author is credited and the new creations are licensed under the identical terms.

performed for many years using one of the techniques developed by Swenson, Duhamel, or Soave [3]. However, management of HD is still progressing due to application of minimally invasive procedures, minimizing the need for diversion stomas, reducing hospital stay, and postoperative (PO) morbidities and mortalities. Transanal endorectal pull-through (TERPT) for HD is a relatively safe and feasible procedure for neonates and infants. However, overstretching the anal sphincter and mesentery of the sigmoid colon might cause potential risk for impaired defecation function [4].

Introduction of laparoscopy as a part of the armamentarium for the management of HD permits obtaining biopsies so as to assure the level of aganglionosis, allows an adequate mobilization of the bowel with less trauma and bleeding, and, in addition, is cosmetically superior [5].

Various pull-through techniques, both open and laparoscopic, have been performed for HD and were compared for outcome; in Britain, the primary pull-through, using an open Duhamel or laparoscopic-assisted Soave–Boley technique, has become the operative strategy of choice for rectosigmoid HD, but marked variation in practice remains for the right-sided HD [6]. Open and laparoscopic Duhamel pull-through techniques were found to have similar outcomes with comparable operative times and hospital stay [7]. Laparoscopic-assisted endorectal pull-through procedure has become the standard treatment for HD in many centers around the world [8].

Recently, single-incision laparoscopic techniques have drawn more attention for their better cosmetic result. However, it is stressful for the surgeon in view of its low manipulability and poor visualization, causing clashing of instruments, especially in older children or patients with long-segment aganglionosis [4]. Clinical outcomes and ergonomic analysis of three laparoscopic approaches in the management of HD yielded the finding that laparoscopic approach should be selected according to the age, transition zone, and desired cosmetic result [9].

The current study aimed to evaluate the surgical and functional outcome of the laparoscopic-aided transanal pull-through procedure for the management of HD in children older than 12 months.

Patients and methods

The current prospective, observational study was conducted at El-Minia University Hospital (Egypt)

and Al-Eman Hospital (Riyadh, KSA) from June 2012 to March 2015 so as to allow a minimum follow-up period of 6 months for the last case operated upon. The study protocol was approved by the local ethical committee. An informed consent was obtained from the parents. All children with manifestations of chronic colonic obstruction were enrolled for clinical examination and investigations. Diagnosis of HD relied on the inability of the patients to relax their anal internal sphincter in response to colonic extension on anorectal manometry [10]. Inclusion criteria included age older than 12 months, chronic constipation secondary to HD, and no history surgical interference.

Collected clinical data included age, sex, weight, and frequency of presenting symptoms. Weight deficit, if any, was calculated versus the ideal weight-for-age using the US Center for Disease Control charts intended for babies and toddlers with an age range of 0–3 years [11]. All patients underwent abdominal radiograph in erect and supine positions and also barium studies to determine the site of probable aganglionic segment. Then, all patients underwent preoperative bowel preparation, including digital rectal stimulations and rectal irrigations using saline solution 20 ml/kg twice daily. All patients received prophylactic preoperative antibiotics as amoxicillin and clavulanic acid.

Operative procedure

All surgeries were conducted under general endotracheal anesthesia. Total body preparation was done for intraoperative change of position from laparoscopic to transanal part. Broad-spectrum antibiotic was given before skin incision. Operative procedure included two parts: a laparoscopic part and a transanal part. In the laparoscopic part, after placement of ports, the transition zone was identified (Fig. 1) and a seromuscular biopsy (Fig. 2) was obtained about 5 cm proximal to the transition zone for fresh frozen section histopathological examination so as to decide the level of pull-through. A window was made in the sigmoid mesentery and the sigmoid was mobilized. Proximal ganglionic bowel was mobilized, preserving the marginal arcade. The peritoneal reflection was incised sharply to facilitate dissection and mobilization of the aganglionic rectum. The rectum below the peritoneal reflection was minimally mobilized within 1 cm of peritoneal reflection (Fig. 3). After completion of laparoscopic dissection and assurance of hemostasis, the ports were left in situ and the patient's position was changed for transanal

Figure 1



The transition zone was identified.

Figure 2



Laparoscopic seromuscular biopsy.

Figure 3



Laparoscopic sigmoid and rectal mobilization.

dissection of the remaining rectum. In the transanal part, as most of the rectal dissection was conducted laparoscopically, only the lower 2 cm of the rectum were mobilized transanally (Fig. 4). The anastomosis

Figure 4



Transanal dissection of lower rectal 2 cm.

Figure 5



Anastomosis was complete.

Figure 6



Anastomosis was complete.

was performed about 5 mm above the dentate line (Figs 5 and 6). The level of pull-through was at the biopsy-proven ganglionic segment. Once the anastomosis was completed, laparoscopy was performed again to check for the orientation of the

pull-through bowel. Drain was placed and the port sites were closed.

Postoperative care

All patients received their immediate PO care in the neonatal intensive care unit (NICU). Patients were maintained on intravenous fluid therapy with continuous nasogastric decompression for at least 24 h. Broad-spectrum intravenous antibiotics were given for at least 48 h. Oral feeding was initiated when bowel sounds returned.

A patient was discharged when he or she could tolerate a full oral diet. Parents were taught to perform home dilatation with Hegar dilators. Rectal examination was performed 1 month PO. Patient's outcome was evaluated for fecal consistency, the frequency of soiling, and presence of perianal skin excoriation; the three items were evaluated at 1, 3, and 6 months after the procedure. Colonic manometry and functional outcome evaluation were carried out at 1 and 6 months after the procedure. Functional outcome was evaluated according to qualitative clinical Holschneider scoring [12], which included seven parameters scored on a three-point scale (Table 1), with a collective score of 14 points meaning normal bowel habits, 10–13 points meaning good (i.e. social continence with few limitation in social life), 5–9 points meaning fair (i.e. marked limitations in social life), and 0–4 points meaning poor bowel habits (i.e. total incontinence).

Statistical analysis

Obtained data were presented as mean \pm SD, numbers, and percentages. Results were analyzed using the one-way ANOVA with post-hoc Tukey's HSD test and the χ^2 -test. Statistical analysis was conducted using the SPSS (version 15 for Windows, 2006; SPSS Inc., Chicago, Illinois, USA) statistical package. A *P*-value less than 0.05 was considered statistically significant.

Results

The study included 17 patients fulfilling the inclusion criteria (12 boys and five girls), with a mean age of

19.8 \pm 6.5 years (range: 13–34 months). Mean body weight of the studied infants was 8.9 \pm 1.3 kg (range: 7–11 kg). Their weight deficit was 2.1 \pm 1.2 kg (range: 1–6 kg). Details of demographic data are shown in Table 2. All infants presented with chronic constipation, abdominal distension, and occasional passage of watery stool. However, all infants were accustomed to evacuating bowel once or twice weekly using enema. None of studied infants had previous operative interference.

Barium enema showed the typical picture of HD in 15 (88.2%) cases and demonstrated transition zone in the rectosigmoid region in 10 (58.8%) cases, in the sigmoid in three (17.6%) cases, and in the rectum in two (11.8%) cases. Two (11.8%) cases showed no transition zone on barium enema, but there was a marked rectocolic dilatation consistent with juxta-anal forms. Mean resting anorectal pressure and maximum internal sphincter pressure estimated on preoperative anorectal manometry were consistent

Table 2 Demographic data of studied patients

Data	Findings
Age (months)	
Strata	
12–18	8 (47.1)
19–24	4 (23.5)
25–30	4 (23.5)
>30	1 (5.9)
Total	19.8 \pm 6.5
Sex	
Male	12 (70.6)
Female	5 (29.4)
Weight (kg)	
Strata	
<10	12 (70.6)
\geq 10	5 (29.4)
Total	8.9 \pm 1.3
Deficit from ideal weight	
<2	6 (35.3)
2–4	10 (58.8)
>4	1 (5.9)
Total	2.1 \pm 1.2

Data are presented as *n* (%) and mean \pm SD.

Table 1 Holschneider score for clinical evaluation of continence [12]

Scores	Parameters						
	Frequency of defecation	Fecal consistency	Soiling	Sensitivity	Anorectal RP (mmHg)	Maximum squeezing MP (mmHg)	Adaptation reaction
2	Normal (1–2/day)	Normal	No	Normal	\geq 20–24	\geq 30	Normal
1	Often (3–5/day)	Soft	Stress/diarrhea	Reduced	14–19	20–29	Small amplitude, shortened
0	Very often (>5/day)	Liquid	Constant	Missing	\leq 13	<20	Not detectable

MP, maximum pressure; RP, resting pressure.

with the diagnosis of HD and assured radiological findings.

All surgeries were conducted uneventfully without anesthesia or surgery-related mortalities. All patients underwent successful laparoscopic biopsy-taking, which were then examined by using the frozen section for assurance of the limit of the aganglionic part.

Laparoscopic part of the procedure was conducted free of complications, but one patient required open conversion for thick adhesions that hindered laparoscopic dissection, which consumed 25 min; the open procedure was completed uneventfully within a total operation theater time of 175 min and was considered a procedural failure with a rate of 5.9%. Mean total theater time for the remaining 16 patients was 159.3 ±15.5 min (range: 122–180 min). Intraoperative blood loss was minimal, with a mean amount of 30±11 ml (range: 20–60 ml). Mean length of resected colonic segment was 19.3±3.5 cm (range: 15–25 cm). Details of operative data are shown in Table 3.

All patients received their immediate PO care at the NICU. Mean time till resumption of oral intake was 32.9 ±7.5 h (range: 20–48 h). Mean NICU stay was 46±11 h (range: 30–70 h). All patients completed their NICU stay uneventfully. Mean total hospital stay was 4.9±1.5 days (range: 3–6 days) for patients with successful laparoscopic part of the procedure, whereas the hospital stay for the patient who required conversion to open surgery was prolonged for 9 days. Details of operative data are shown in Table 4.

The frequency of patients who passed formed stool and free of soiling increased progressively till the end of 6 months after the procedure, with significant ($P<0.05$) difference compared with frequency determined at 1 and 3 months after the procedure, and significantly ($P<0.05$) higher frequency of formed stool passers at 6 months after the procedure

Table 3 Operative data of studied patients

Data	Findings
Operative laparoscopy	
Successful	16 (94.1)
Failed	1 (5.9)
Operative time (min)	
Successful two part procedure	159.3±15.5
Open procedure	175
Total	160.3±15.5
Operative blood loss (ml)	30±11
Length of resected colonic segment (cm)	19.3±3.5

Data are presented as *n* (%) and mean±SD.

compared with at 3 months after the procedure. Six patients developed perianal skin excoriation, detected at 1 month after the procedure; three were still excoriated at 3 months after the procedure, but none still had excoriation at the sixth PO month (Table 5).

Mean resting anorectal pressure and maximum internal sphincter pressure at maximum squeeze estimated at 3 and 6 months PO were significantly ($P<0.05$) higher compared with the preoperative pressure estimates, with significantly ($P<0.05$) higher pressure measures at 6 months compared with the measures estimated at 3 months PO (Fig. 7).

Qualitative clinical Holschneider scoring of studied patients at 6 months PO was significantly higher compared with the 1-month scoring (Table 6 and Fig. 8). Patients' distribution among the strata of Holschneider scoring was significantly higher at 6 months compared with the 1-month distribution and 10 patients at 6 months, whereas only one patient at 1 month had a score of 14 (Fig. 9). No surgery-related complications or wound dehiscence were detected.

Discussion

The current selective study included children with HD older than 12 months to allow anorectal manometric diagnosis and follow-up depending on the fact that anorectal manometry was carried out only in patients at least 12 months old because the relax reflex of the anal internal sphincter may not be developed in younger infants [13]. Selection of such an age-group aimed also

Table 4 Immediate postoperative data of studied patients

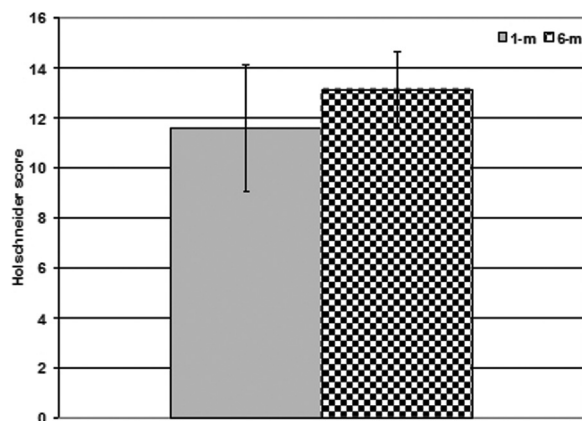
Data	Findings
Time till resumption of oral intake (h)	
<24	2 (11.9)
24–35	8 (47.1)
36–48	7 (41)
Total	32.9±7.5
NICU stay (h)	
<36	2 (11.9)
36–48	12 (70.3)
>48–60	1 (5.9)
>60	2 (11.9)
Total	46±11
Hospital stay (days)	
3–4	5 (29.4)
5–6	11 (64.7)
>6	1 (5.9)
Total	5.2±1.3

Data are presented as *n* (%) and mean±SD. NICU, neonatal intensive care unit.

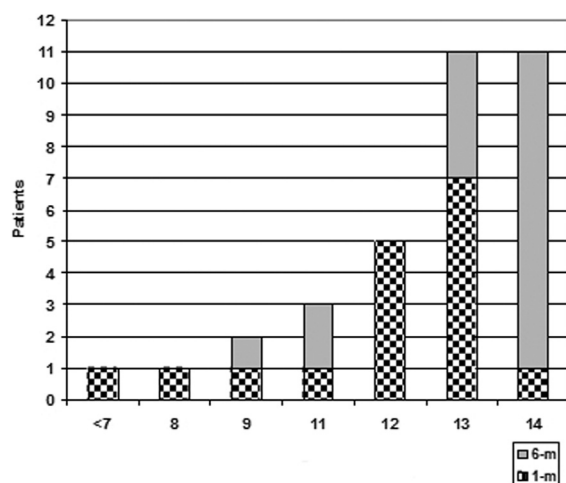
Table 6 Holschneider score for studied patients determined at 1 month and 3 months

Time	Frequency of defecation	Fecal consistency	Soiling	Sensitivity	Anorectal RP	Maximum squeezing MP	Adaptation reaction	Total
1 month	1.5±0.7	1.7±0.6	1.8±0.5	1.7±0.6	1.3±0.7	1.8±0.4	1.8±0.6	11.6±2.5
6 months	1.9±0.3	1.9±0.2	1.9±0.2	1.9±0.2	1.6±0.6	1.9±0.2	1.9±0.3	13.1±1.5*

MP, maximum pressure; RP, resting pressure. *Significant difference.

Figure 8

Mean±SD of qualitative clinical Holschneider scoring of studied patients determined at 1 month and 6 months.

Figure 9

Patients' distribution among strata of Holschneider scoring determined at 1 and 6 months postoperatively.

be dissected. Laparoscopy also assured hemostasis and, finally, helped in checking for orientation of the pull-through bowel.

Thus, the major part of the surgical burden was applied laparoscopically and was completed uneventfully in all cases apart from one case in which dense adhesions hindered dissection and was converted to laparotomy with a conversion rate of 5.9%. These data indicated the feasibility and safety of

the laparoscopic part of the procedure. In addition, meticulous under-vision dissection and minimal tissue trauma reduced the PO catabolic stage, thus allowing short duration of NICU stay and time till resumption of oral intake.

The reported advantages of laparoscopy for the management of HD cases were in agreement with those reported by Ksia *et al.* [18], who retrospectively studied 20 patients older than 2 years who underwent a transanal Soave one-stage endorectal pull-through procedure for HD, and concluded that laparoscopy may be necessary whenever there are difficulties in the pull-through.

In their study, van de Ven *et al.* [19] reported resection of significantly longer colon by using the TERPT within significantly shorter operative time compared with laparoscopically-assisted transanal endorectal pull-through (L-TERPT), but found a significant association between length of resection and PO obstructive symptoms, and also reported non-significantly higher frequency of colonic torsion after TERPT compared with L-TERPT. In addition, Gosemann *et al.* [20] documented that L-TERPT represents a valid option in the treatment of HD and might have some advantages over the open techniques. Moreover, Mathur *et al.* [21] found that the extent of laparoscopic mobilization of rectum does not appear to be a factor deciding the outcomes, but laparoscopic assistance can be used to maximize the benefits of Swenson type of operation and a transanal pull-through.

The advent of laparoscopic application for the management of HD could be another support for the advantages reported by the current study, whereas Tang *et al.* [22] retrospectively documented that in selected HD patients, the single-incision laparoscopic endorectal pull-through (SILEP) was safe and technically feasible in experienced hands, with similar operative results compared with conventional laparoscopic endorectal pull-through, but SILEP is more difficult if the transition zone is higher than the rectosigmoid. Moreover, Aubdoollah *et al.* [4] reported no major intraoperative complication for hybrid SILEP; PO,

perianal excoriation was the main early complication, which occurred in nine patients, and enterocolitis in two patients, but no anastomotic leak occurred.

As another form of support for advantages of laparoscopy, Tang *et al.* [23] compared laparoscopic surgery with traditional perioperative management versus fast-track management for infants with HD and reported no significant differences in intraoperative blood loss and operative time, and despite the earlier recovery of bowel movement with fast-track management, the difference was not statistically significant, with similar PO complications and recovery conditions during 4 weeks of follow-up.

In addition, Thomson *et al.* [24] conducted a meta-analysis for the outcomes following totally TERPT versus TERPT with any form of laparoscopic assistance for infants with uncomplicated HD, and found no significant differences concerning PO enterocolitis, fecal incontinence, or constipation. Recently, Scholfield and Ram [25] conducted a meta-analysis including 11 articles comparing open and versus laparoscopic Duhamel procedures for HD and reported significantly greater incidence of soiling/incontinence, further surgery, longer hospital stay, and time to oral feed, but significantly shorter operative time with open procedure compared with the laparoscopic procedure, whereas the incidence of enterocolitis and constipation was nonsignificant.

Conclusion

The obtained results and review of the literature allowed concluding that laparoscopic-assisted transanal pull-through is a feasible procedure for the management of children older than 12 months and with uncomplicated HD. The procedure is safe with minimal PO complications that are gradually but progressively resolved within 6 PO months. However, wider-scale randomized comparative studies are mandatory for establishing such outcome.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

- Mabula JB, Kayange NM, Manyama M, Chandika AB, Rambau PF, Chalya PL. Hirschsprung's disease in children: a five year experience at a university teaching hospital in northwestern Tanzania. *BMC Res Notes* 2014; 7:410.
- Soret R, Mennetrey M, Bergeron KF, Dariel A, Neunlist M, Grunder F *et al.* Ente-Hirsch Study Group. A collagen VI-dependent pathogenic mechanism for Hirschsprung's disease. *J Clin Invest* 2015; 125:4483–4496.
- Fukuzawa M. Progress in the treatment of and research on Hirschsprung's disease. *Nihon Geka Gakkai Zasshi* 2014; 115:312–316.
- Aubdoollah TH, Tang ST, Yang L, Li S, Lei HY, Zhang X. Hybrid single-incision laparoscopic approaches for endorectal pull-through in Hirschsprung's disease. *J Laparoendosc Adv Surg Tech A* 2015; 25:595–598.
- Antao B, Roberts J. Laparoscopic-assisted transanal endorectal coloanal anastomosis for Hirschsprung's disease. *J Laparoendosc Adv Surg Tech A* 2005; 15:75–79.
- Bradnock TJ, Walker GM. Evolution in the management of Hirschsprung's disease in the UK and Ireland: a national survey of practice revisited. *Ann R Coll Surg Engl* 2011; 93:34–38.
- Nah SA, de Coppi P, Kiely EM, Curry JI, Drake DP, Cross K *et al.* Duhamel pull-through for Hirschsprung disease: a comparison of open and laparoscopic techniques. *J Pediatr Surg* 2012; 47:308–312.
- Zhu T, Feng J, Zhang W, Wei M, Yu D, Zhang X *et al.* Subtotal colectomy with a single-incision laparoscopic surgery technique in children with long-segment Hirschsprung disease and allied disorders. *Pediatr Surg Int* 2013; 29:197–201.
- Aubdoollah TH, Li K, Zhang X, Li S, Yang L, Lei HY *et al.* Clinical outcomes and ergonomics analysis of three laparoscopic techniques for Hirschsprung's disease. *World J Gastroenterol* 2015; 21: 8903–8911.
- Stewart DR, von Allmen D. The genetics of Hirschsprung disease. *Gastroenterol Clin North Am* 2003; 32:819–837.
- Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). National health and nutrition examination survey data. Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2008. Available at: <http://www.cdc.gov/growthcharts/>.
- Holschneider AM. Treatment and functional results of anorectal continence in children with imperforate anus. *Acta Chir Belg* 1983; 82:191–204.
- López-Alonso M, Ribas J, Hernández A, Anguita FA, Gómez de Terreros I, Martínez-Caro A. Efficiency of the anorectal manometry for the diagnosis of Hirschsprung's disease in the newborn period. *Eur J Pediatr Surg* 1995; 5:160–163.
- Sun X, Ren H, Chen S, Wu X, Zhao B, Jin Y, Chen L. Complication analysis of endorectal pull-through radical operation for Hirschsprung disease. *Zhonghua Wei Chang Wai Ke Za Zhi* 2015; 18:459–462.
- Takawira C, D'Agostini S, Shenouda S, Persad R, Sergi C. Laboratory procedures update on Hirschsprung disease. *J Pediatr Gastroenterol Nutr* 2015; 60:598–605.
- Takahashi T, Kato Y, Okazaki T, Koga H, Lane GJ. Patchy innervation confirmed in pull-through bowel with normal conventional biopsy results in Hirschsprung's disease – the benefit of circumferential biopsying. *Hepatogastroenterology* 2013; 60:1014–1017.
- Bonnard A, Terrasa JB, Viala J, Aizenfisz S, Berrebi D, Ghoneimi AE. Abdominal cellulitis following a laparoscopic procedure: a rare and severe complication. *Eur J Pediatr Surg Rep* 2014; 2:67–70.
- Ksia A, Yengui H, Saad MB, Sahnoun L, Maazoun K, Rachida L *et al.* Soave transanal one-stage endorectal pull-through in the treatment of Hirschsprung's disease of the child above two-year-old: a report of 20 cases. *Afr J Paediatr Surg* 2013; 10:362–366.
- van de Ven TJ, Sloots CE, Wijnen MH, Rassouli R, van Rooij I, Wijnen RM, de Blaauw I. Transanal endorectal pull-through for classic segment Hirschsprung's disease: with or without laparoscopic mobilization of the rectosigmoid? *J Pediatr Surg* 2013; 48:1914–1918.
- Gosemann JH, Friedmacher F, Ure B, Lacher M. Open versus transanal pull-through for Hirschsprung disease: a systematic review of long-term outcome. *Eur J Pediatr Surg* 2013; 23:94–102.
- Mathur MK, Aggarwal SK, Ratan SK, Sinha SK. Laparoscopic-assisted transanal pull-through for Hirschsprung's disease: comparison between partial and near total laparoscopic mobilization of rectum. *J Indian Assoc Pediatr Surg* 2014; 19:70–75.
- Tang ST, Yang Y, Li SW, Cao GQ, Yang L, Huang X *et al.* Single-incision laparoscopic versus conventional laparoscopic endorectal pull-through for Hirschsprung's disease: a comparison of short-term surgical results. *J Pediatr Surg* 2013; 48:1919–1923.

1 Mabula JB, Kayange NM, Manyama M, Chandika AB, Rambau PF, Chalya PL. Hirschsprung's disease in children: a five year experience at a

- 23 Tang W, Geng Q, Zhang J, Chen H, Lyu X, Lu C *et al*. Fast track surgery combined with laparoscopy in the treatment of infant Hirschsprung disease. *Zhonghua Wei Chang Wai Ke Za Zhi* 2014; 17:805–808.
- 24 Thomson D, Allin B, Long AM, Bradnock T, Walker G, Knight M. Laparoscopic assistance for primary transanal pull-through in Hirschsprung's disease: a systematic review and meta-analysis. *BMJ Open* 2015; 5:e 006063.
- 25 Scholfield DW, Ram AD. Laparoscopic Duhamel procedure for Hirschsprung's disease: systematic review and meta-analysis. *J Laparoendosc Adv Surg Tech A* 2016; 26:53–61.