Epidemiology of small-bowel obstruction beyond the neonatal period

Christoph H. Houben, Kristine K. Pang, Wai Cheung Mou, Kin Wai Chan, Yuk Him Tam and Kim Hung Lee

Background **The aim of this study was to evaluate the etiologies causing intestinal obstruction beyond the neonatal period.**

Patients and methods **An observational study was conducted on children between 1 month and 17 years of age who underwent surgery for small-bowel obstruction (SBO) at this tertiary referral center between 1 January 2004 and 31 December 2013.**

Results **In total, 133 patients (38 female) with a median age of 3.4 (range 0.16–15.8) years were included in the study group. Forty-four patients (18 female) had intussusception, of whom seven presented with a pathological lead point. Thirty-nine individuals (12 female) had a postoperative SBO. The median formation time for the SBO was 1.75 years, and neonatal anomalies represented the most frequent cause of initial surgery. Primary SBO with no previous surgery was observed in 30 children (eight girls), including 12 (9%) with Meckel's diverticulum, nine (7%) with congenital bands, and three (2%) with bezoars. Twenty patients (15%), all boys, presented with an irreducible inguinal hernia. During the surgery, a total of 43 (32%) patients underwent bowel resection or enterotomy. Five patients (3.8%) died, four as a result of sepsis and one following parenteral nutrition-related liver failure.**

Conclusion **Nearly a quarter of this cohort had a primary SBO. SBO in children is more prevalent among boys (M : F ratio, 2.5 : 1). Intussusception, postoperative adhesions, and irreducible inguinal hernias are the most common pathologies for SBO, followed by Meckel's diverticulum and congenital adhesive bands.** *Ann Pediatr Surg* **12:90–93**

Annals of Pediatric Surgery 2016, **12**:90–93

Keywords: congenital band, inguinal hernia, intussusception, Meckel's diverticulum, postoperative adhesion, small bowel obstruction

Department of Surgery, Division of Paediatric Surgery & Paediatric Urology, Prince of Wales Hospital, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China

Correspondence to Christoph H. Houben, Department of Surgery, Division of Paediatric Surgery & Paediatric Urology, Prince of Wales Hospital, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China
Tel: +852 26 323 936; fax: +852 26 324 669; e-mail: chhouben@web.de

Received 2 February 2015 **accepted** 19 January 2016

Introduction

The frequency of pathologies responsible for small-bowel obstruction (SBO) in children beyond the neonatal period is often based on assumptions or is deduced from small cohorts of selected patients – adhesive intestinal obstruction, for example, is excluded from consideration [1,2]. This study aimed to identify all factors responsible for SBO, quantify their occurrences, and analyze their outcomes.

Patients and methods

Children between 1 month (corrected for gestation) and 17 years of age who underwent surgery for SBO at our tertiary referral center between 1 January 2004 and 31 December 2013 were included in the study group.

Cases of intussusception were included into the cohort after pneumatic reduction failed or a direct surgical approach was deemed necessary for an acute abdomen or a pathological lead point.

Cases of incarcerated inguinal hernia were only included in the cohort after reduction under sedation by the attending surgeon had failed and surgery showed small-bowel entrapment in the hernia sac – for example, a trapped omentum or prolapsed ovary was not a part of our analysis [3].

Surgical interventions ranging from adhesiolysis to reduction of intussusception and from bowel resection to hernia repair were performed according to established surgical practice [4,5]. When appropriate, laparoscopic approaches were given preference in the management of the intestinal obstruction.

The charts and computer records of the study group were reviewed, with approval from the local clinical research ethical committee (CREC Ref. No.: 2014.296). The electronic patient administration system allowed for a seamless follow-up evaluation.

Results

A total of 133 individuals (38 female), with a median age of 3.4 years (range 2 months to 15.8 years), had undergone surgery for intestinal obstruction between 1 January 2004 and 31 December 2013.

Of the 208 pneumatic reductions, 36 required surgical intervention and eight required direct surgery for intussusception. A total of 44 individuals (18 female) had undergone surgery for intussusception at a median age of 9 months (range 2.5 months to 15.75 years). Seven had a pathological lead point (Table 1): three patients with Meckel's diverticula, two with polyps, one with Henoch–Schoenlein purpura, and one patient with an accessory spleen [6].

1687-4137 © 2016 Annals of Pediatric Surgery DOI: 10.1097/01.XPS.0000481055.24776.db

Table 1 Breakdown of the various etiologies

Etiology	Subgroup	Frequency [*n* (%)]
Intussusception		44 (33)
	Idiopathic	37
	Path lead point	7
Postoperative SBO		39 (29)
	Multiple/dense adhesions	28
	Single-band adhesion	8
	Mesenteric defect	2
	Anastomotic stricture	1
Primary SBO		30 (23)
	Meckel's diverticulum	12 (9)
	Congenital band and inflammatory adhesions	9 (7)
	Malrotation volvulus	4 (3)
	Bezoar	3 (2)
	Midgut volvulus	1
	CIPO	1
Irreducible inguinal hernia		20 (15)

CIPO, chronic intestinal pseudo-obstruction; SBO, small bowel obstruction.

Table 2 Conditions leading to adhesions

Pathology	Frequency ($N=39$)
Neonatal index case	11
Intestinal atresia	3
Malrotation volvulus	2
Diaphragmatic hernia	2
Exomphalos/gastroschisis	2
Hiatal hernia	1
Necrotizing enterocolitis	1
Liver and gallbladder	5
Choledochal cyst	3
Liver tumor	1
Liver transplant	1
Tumor	4
Kidney	2
Adrenal gland	1
Ovary	1
Intussusception	4
Appendicitis	4
Perforated A	2
Gangrenous A	1
Acute A	1
Hirschsprung's disease	2
Bleeding duodenal ulcer	2
Bladder augmentation	2
Miscellaneous	5

A, appendicitis.

Postoperative SBO was observed in 39 individuals (12 female) presenting at a median age of 6.5 years (range 3 months to 15.5 years). The median time for a postoperative intestinal obstruction to develop was 1.75 years (range 0.5 months to 15.6 years). The most frequent initial procedure was surgery for a congenital neonatal anomaly (Table 2).

The median time for the presentation of adhesions after neonatal procedures was 3.8 years (range 4 months to 10.6 years).

The most common intraoperative finding was multiple/dense adhesions ($N=28$), followed by single-band adhesions ($N=8$).

Two patients required correction for a mesenteric defect following surgery for a choledochal cyst, and one patient had an anastomotic stricture (Table 1).

Primary SBO with no previous surgery was observed in 30 children (eight female), representing 23% of the total sample(median age of 4.4 years, range 3 months to 14.8 years). Of these children, 12 had Meckel's diverticula (9%), nine had congenital band/inflammatory adhesions (7%), four had malrotation volvuli (3%), three had bezoars (2%), one had a midgut volvulus, and one had chronic intestinal pseudo-obstruction (Table 1). Of the nine children with congenital bands and adhesions, five presented with a single mesenteric/fibrous band, two of whom had an additional incomplete rotation, and four patients had multiple adhesions throughout the gastrointestinal tract, two of whom had evidence of an inflammatory response in the abdominal cavity, but only one had primary peritonitis secondary to a proven infection by *Corynebacterium* spp.

In 20 boys, an irreducible inguinal hernia (15%) was identified; they presented at a median age of 1.25 years (range 2 months to 15.6 years). All had an obstructed small bowel within the hernial sac, one of which was Meckel's diverticulum (Littré hernia).

Apart from treatment for the underlying condition (e.g. reduction of intussusception, freeing of adhesions, herniotomy, etc.), a total of 47 (35%) bowel procedures were required: 37 small-bowel resections, six hemicolectomies, and four enterotomies. In addition, four Ladd's procedures were performed. A laparoscopic approach was completed in 51 patients (38%).

The following complications were observed during a median observation period of 6.1 (range 1–10.5) years: four umbilical wound infections, four hypertrophic scars, one abdominal abscess requiring open drainage and resection of a segment of the small bowel, one anastomotic leak requiring a temporary ileostomy, and one atrophic testis 6 years postoperatively for an irreducible inguinal hernia.

A total of five deaths (3.7%) were recorded. Four patients died as a result of sepsis and subsequent multiorgan dysfunction syndrome: one died after a midgut volvulus secondary to an internal hernia, one due to a malrotation volvulus, one following a perforation during pneumatic reduction for intussusception, and one after release of a necrotic closed loop after repair of an exomphalos major in the neonatal period.

The fifth person died of total parenteral nutrition-related liver failure; initially, he underwent corrective surgery for an ileal atresia, which was followed by surgery for an adhesive obstruction.

Discussion

The etiologies of SBO in adults are dominated by postoperative adhesive SBO (60–75% of cases), followed by neoplasms (20%) and hernias (10%) [7,8].

The results of this study show that for children older than 1 month the etiologies of SBO are more evenly distributed. The most common pathologies ranged from intussusception (33%) to postoperative obstruction (29%) and from primary SBO (23%) to irreducible inguinal hernia (15%) (Table 1). Only one study is available for comparison, albeit with a much smaller investigated cohort [2].

Pneumatic reduction is the main treatment option for idiopathic intussusception. In a survey, Daneman and Navarro [9] concluded that currently available technology allows for a reduction rate of ~85% . The success rate of 83% in our study is in line with this expectation. Pathological lead points ($N = 7$) were observed in 16% of the surgically managed intussusceptions. Overall, intussusceptions represented a third of all SBOs. In a survey by Ikeda and colleagues, more than half of the cohort presented with intussusception, requiring surgical correction; however, it is not clear whether all patients underwent a trial hydrostatic reduction [2].

Postoperative obstruction was observed in 39 individuals, representing approximately 30% of this cohort; SBOs occurred at a median of 1.75 years after the initial surgery. In the 1970s, Festen [10] identified the majority of postoperative obstructions (> 80%) among his patients within 3 months after the initial operation. It is possible that improved surgical techniques and aftercare as well as better suture material might contribute to the later presentation of adhesive SBOs.

In this series, postoperative adhesive obstructions were most commonly observed after surgery for neonatal anomalies; this finding is similar to Festen's observation [10]. The median time for the development of adhesions in neonates was 3.8 years. This is in contrast to the findings by Wilkins and Spitz [11], who, in the 1980s, observed more than 75% of adhesive SBOs after neonatal surgery to have occured within 6 months after the initial surgery. Choudhry and Grant [12] reported that more than 80% of their SBOs after neonatal surgery occurred within the first postoperative year. Some of the most frequent neonatal conditions in the above-mentioned studies were meconium ileus and gastroschisis [10–12].

Meconium ileus is only rarely observed in Asian populations. Likewise, gastroschisis among neonates is only occasionally encountered; this is most likely a result of the high rate of abortion associated with this condition in our region.

Nearly a quarter of the individuals undergoing surgery for intestinal obstruction had a primary SBO. In adults, intestinal obstructions of unknown origin with no previous surgery are most frequently caused by adhesions (75%), followed by newly diagnosed malignancies (~10%) [13].

In this study of children, the two dominant pathologies causing primary intestinal obstruction were Meckel's diverticulum and congenital band(s)/inflammatory adhesions (Table 1).

Although case series on obstructed Meckel's diverticula and primary band adhesions, even in adults, exist, comparative studies, such as this one, that examine the quantitative relationship between primary SBO and all causes of SBO in children have not been reported [14–16].

Diagnosing Meckel's diverticulum directly continues to be a considerable challenge more than 200 years after Meckel correctly identified the omphalomesenteric duct as the origin of midileum diverticulum [17]. ^{99m}Tc-Na-pertechnetate scintigraphy has only limited accuracy in locating a diverticulum unless it contains associated gastric mucosa [14,18]. Intestinal obstruction remains the second most common presentation of Meckel's diverticulum [19].

Together with the three Meckel's diverticula in the subgroup of intussusception and one Littré hernia in the irreducible hernia group, Meckel's diverticula ($N = 16$) represented 12% of all SBOs in this cohort.

Primary adhesion(s) as a result of congenital anomalies or inflammatory processes were observed either as an isolated band or as multiple adhesions in nine patients, representing 7% of the total sample.

Large postmortem studies on more than 700 individuals each identified primary abdominal adhesions ranging in frequency from 28 to 33%, although they were clinically silent during the lifetime of the individuals [20,21]. Diebold [20] identified an overwhelming majority of these spontaneous adhesions to be in the region of the gallbladder and duodenum, whereas Weibel and Majno [21] found most spontaneous adhesions to be in the omentum and large bowel region. The frequency of spontaneous small-bowel adhesions varied in the two studies (2 and 17%, respectively). In a large clinical study encompassing more than 1000 individuals with adhesional intestinal obstruction requiring adhesiolysis, de-novo adhesions were observed at a rate of just 3.3%; almost all primary adhesions were single-band adhesions [22].

Both postmortem studies attribute the increase in spontaneous adhesions, mostly later in life, to inflammatory processes [20,21]. Although two spontaneous adhesions in this cohort were almost certainly associated with an inflammatory process (primary peritonitis), two other band adhesions might have had a congenital origin because the intraoperative findings showed an associated incomplete rotation.

Irreducible inguinal hernias secondary to small-bowel entrapment were another frequent occurrence in this cohort. All patients within this subgroup were boys; this is a finding confirmed by Ikeda and colleagues in their much smaller cohort [2]. In a recently published review, we have shown that irreducible hernias in girls are almost exclusively observed with prolapsed ovaries [3].

Overall, SBOs were predominant in boys; the male-to-female (M : F) ratio was 2.5 : 1. This finding is partially explained by the aforementioned group of irreducible hernias ($N = 20$, 15%), which included only boys. Meckel's diverticulum is another factor contributing to the male dominance in this cohort; a large series analyzing Meckel's diverticulum reported a M : F ratio of 2.8 : 1 for this anomaly [19,23].

Even the subgroup of postoperative SBO has a similar M : F ratio of 2.25 : 1. In the adult population, adhesive obstructions requiring surgery appear to be more often observed in female patients, considering that the vast

majority (70–80%) of SBOs in adults are related to previous surgery [24,25].

We did not encounter mesenteric or duplication cysts presenting as primary SBOs; Ikeda and colleagues identified four duplication cysts, representing 12.5% of their cohort [2]. We think that most of these conditions are now identified on antenatal scans and operated upon before symptoms of intestinal obstruction develop.

In summary, nearly a quarter of children with SBOs beyond the neonatal period presented with a primary SBO. SBO was predominant in boys in this series, with a male-to-female ratio of 2.5 : 1. The most frequent causes of SBOs requiring surgical correction were intussusception, postoperative adhesions, and irreducible inguinal hernias with a strangulated small bowel.

Meckel's diverticulum had various manifestations, including intussusception and Littré hernia in 12% of the cohort.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Ginalewski CA. Other causes of intestinal obstruction. In: Grosfeld JC, editor. *Pediatric surgery*, **Vol. 2**. 6th ed. Philadephia, PA: Mosby Elsevier; 2006. pp. 1358–1368.

2 Ikeda H, Matsuyama S, Suzuki N, Takahashi A, Kuroiwa M, Hatakeyama S. Small bowel obstruction in children: review of 10 years experience. *Acta Paed Jap* 1993; **35**:504–507.

3 Houben CH, Chan KW, Mou JW, Tam YH, Lee KH. Irreducible inguinal hernia in children: how serious is it? *J Pediatr Surg* 2015; **50**:1174–1176.

4 Spitz L, Coran AG. *Operative pediatric surgery*, 7th ed. Boca Raton, FL: CRC Press; 2013.

5 Tam YH, Lee KH, Sihoe JD, Chan KW, Wong PY, Cheung ST, Mou JW. Laparoscopic hernia repair in children by the hook method: a single-center series of 433 consecutive patients. *J Pediatr Surg* 2009; **44**:1502–1505.

6 Houben Christoph H, Wong Hei Y, Lacambra M, Tam Yuk H. Accessory spleen as lead point in intussusceptions. *Annals of Pediatric Surgery* 2014; **10**:136–138.

7 Townsend CM Jr, Beauchamp RD, Evers BM, Mattox KL, Evers BM. *Small intestine: Sabiston Textbook of Surgery*, 18th ed. Philadelphia: WB Saunders; 2007.

8 Tavakkoli A, Ashley SW, Zinner MJ. Small intestine. In: Brunicardi FC, editor. *Schwartz's principles of surgery*, 10th ed. New York, USA: Mc Graw Hill Education Medical; 2015. pp. 1137–1174.

9 Daneman A, Navarro O. Intus-susception. Part 2: an update on the evolution of management. *Pediatr Radiol* 2004; **34**:97–108.

10 Festen C. Postoperative small bowel obstruction in infants and children. *Ann Surg* 1982; **196**:580–583.

11 Wilkins BM, Spitz L. Incidence of postoperative adhesion obstruction following neonatal laparotomy. *Br J Surg* 1986; **73**:762–764.

12 Choudhry MS, Grant HW. Small bowel obstruction due to adhesions following neonatal laparotomy. *Pediatr Surg Int* 2006; **22**:729–732.

13 Beardsley C, Furtado R, Mosse C, Gananadha S, Fergusson J, Jeans P, Beenen E. Small bowel obstruction in the virgin abdomen: the need for a mandatory laparotomy explored. *Am J Surg* 2014; **208**:243–248.

14 Menezes M, Tareen F, Saeed A, Khan N, Puri P. Symptomatic Meckel's diverticulum in children: a 16-year review. *Pediatr Surg Int* 2008; **24**: 575–577.

15 Akgür FM, Tanyel FC, Büyükpamukçu N, Hiçsönmez A. Anomalous congenital bands causing intestinal obstruction in children. *J Pediatr Surg* 1992; **27**:471–473.

16 Habib E, Elhadad A. Small bowel obstruction by a congenital band in 16 adults. *Ann Chir* 2003; **128**:94–97.

17 Meckel JF. Ueber die Divertikel am Darmkanal. [On diverticula in the gastrointestinal tract]. *Reil's Arch Physiol* 1809; **9**:421–453.

18 Poulsen KA, Qvist N. Sodium pertechnetate scintigraphy in detection of Meckel's diverticulum: is it usable? *Eur J Pediatr Surg* 2000; **10**:228–231.

19 Kusumoto H, Yoshida M, Takahashi I, Anai H, Maehara Y, Sugimachi K. Complications and diagnosis of Meckel's diverticulum in 776 patients. *Am J Surg* 1992; **164**:382–383.

20 Diebold O. Über Bauchfellverwachsungen. Leichenbefunde bei 700 Sektionen [On peritoneal adhesions. Postmortem studies on 700 sections]. *Arch Klin Chir* 1930; **158**:737–757.

21 Weibel MA, Majno G. Peritoneal adhesions and their relation to abdominal surgery. A postmortem study. *Am J Surg* 1973; **126**:345–353.

22 Butt MU, Velmahos GC, Zacharias N, Alam HB, de Moya M, King DR. Adhesional small bowel obstruction in the absence of previous operations: management and outcomes. *World J Surg* 2009; **33**:2368–2371.

23 Huang CC, Lai MW, Hwang FM, Yeh YC, Chen SY, Kong MS, *et al*. Diverse presentations in pediatric Meckel's diverticulum: a review of 100 cases. *Pediatr Neonatol* 2014; **55**:369–375.

24 Hashimoto D, Hirota M, Matsukawa T, Yagi Y, Baba H. Clinical features of strangulated small bowel obstruction. *Surg Today* 2012; **42**:1061–1065.

25 Springer JE, Bailey JG, Davis PJ, Johnson PM. Management and outcomes of small bowel obstruction in older adult patients: a prospective cohort study. *Can J Surg* 2014; **57**:379–384.