Pediatr Surg Int (2018) 34:177–182
DOI 10.1007/s00383-017-4186-0

ORIGINAL ARTICLE

Laparoscopy or laparotomy for adhesive bowel obstruction in children: a systematic review and meta-analysis

Hiromu Miyake[1,2] · Shogo Seo[1] · Agostino Pierro[1]

Accepted: 21 September 2017 / Published online: 10 October 2017

Abstract
Purpose Adhesive small bowel obstruction (ASBO) is one of the most important cause of postoperative morbidity in children who underwent abdominal surgery. Laparoscopic management for ASBO in pediatric patients has been reported. However, its safety and efficacy has not been evaluated in details. The aim of this study is to compare the outcomes of laparoscopy and laparotomy for the treatment of ASBO in children.
Methods A systematic review and meta-analysis were performed following the Cochrane Handbook for systematic reviews of intervention and the preferred reporting item for systematic reviews and meta-analysis (PRISMA) and a protocol registered in PROSPERO (CRD42017067914). The primary outcome was the number of intraoperative and postoperative complications. The secondary outcome was length of hospital stay. The risk of bias in non-randomized studies of interventions (ROBINS-I) tool was used to assess the risk of bias. Quality of evidence was summarized using the grades of recommendation, assessment, development and evaluation (GRADE) approach.
Results We identified three observational studies and no randomized controlled trials. The meta-analysis was done only for the primary outcome. Complications were significantly fewer after laparoscopy compared to laparotomy (Odds ratio = 0.51; 95% CI 0.40–0.66; $p < 0.01$; I^2: 0%). The overall risk of bias was considered serious.
Conclusions Our results, based on observational studies, indicate that laparoscopy for ASBO was associated with less postoperative complications compared to conventional laparotomy. However, the quality of evidence is very low. A well-controlled study is needed to assess the efficacy of laparoscopy for pediatric patients with ASBO.

Keywords Small bowel obstruction · Laparoscopy · Pediatrics · Postoperative adhesion

Introduction

Postoperative adhesive small bowel obstruction (ASBO) is one of the major complications of abdominal surgery in children [1–4]. Although the incidence of postoperative ASBO varies according to the type of operation performed, its incidence of in children has been estimated between 1 and 5% in children [1–4]. An operation is often needed for the management of ASBO in children (35–45%) to avoid the risk of developing intestinal perforation and gangrene [1]. In recent years laparoscopic surgery has been utilized for the treatment of ASBO and a good outcome has been reported after this minimally invasive approach in children [5–7]. However, many surgeons are concerned about a laparoscopic approach in patients with ASBO for the risk of causing a iatrogenic injury to the obstructed and distended bowel. There is no consensus in both adult and pediatric literature on which approach is preferable: laparoscopic or traditional laparotomy. The aim of this study is to review the current evidence in children comparing the safety and efficacy of laparoscopy versus laparotomy for the surgical treatment of ASBO.

✉ Agostino Pierro
agostino.pierro@sickkids.ca

[1] Division of General and Thoracic Surgery, The Hospital for Sick Children, University of Toronto, 1526-555 University Avenue, Toronto, ON M5G 1X8, Canada

[2] Department of Pediatric Surgery, Shizuoka Children's Hospital, 860 Urushiyama, Aoi-ku, Shizuoka 4208660, Japan

Materials and methods

This systematic review and meta-analysis was performed following the Cochrane handbook for systematic reviews of intervention and the preferred reporting item for systematic reviews and meta-analysis (PRISMA) [8, 9]. The protocol of the systematic review was registered on the PROSPERO online database (PROSPERO 2017:CRD42017067914) on June 6, 2017 [10]. We searched MEDLINE, EMBASE and Cochrane Central database using the combination of following terms: "pediatric", "children", "laparoscopy", "laparoscope", "ileus" and "bowel obstruction". In addition, a manual search of the references of retrieved articles was performed. The date of the last search was June 13, 2017. We planned to include all published randomized controlled trials (RCTs) and observational studies. Intraoperative and postoperative complications were the primary outcomes for this meta-analysis. We considered length of postoperative length of stay (LOS) as secondary outcome. We included all studies comparing the above outcomes in children less than 18-year-old who underwent laparoscopy or laparotomy for ASBO. There was no language restriction.

Two reviewers (HM and SS) independently screened all retrieved abstracts with a low threshold for selecting studies for full-text review. Full texts were then independently reviewed to identify the included studies. In this step, we extracted the following data from each article: first author and year of publication, study design, country, years of study, sample size, age of patients, conversion rate in laparoscopy group and outcomes. Disagreement regarding inclusion were resolved through a discussion between reviewers, reaching consensus at each stage of the screening process.

We performed the meta-analysis using Review manager 5.3. We estimated statistical significance using a two-sided p value of 0.05. Effect sizes were calculated and presented as pooled odds ratio (OR) along with a 95% confidence interval (CI). A random-effects model was implemented using the Inverse Variance method.

The grading of recommendations and assessment, development and evaluation (GRADE) system was used to assess the quality of the evidence [11–18]. Quality of evidence was rated as high, moderate, low and very low for each outcome. Observational studies start with a low quality of evidence. The quality of evidence was rated down in the presence of risk of bias, inconsistency, indirectness, imprecision and publication bias. For assessment of risk of bias in observational studies, we used the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool [19]. The following domains were assessed for each outcome: bias due to confounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes and bias in selection of the reported result. Each domain was scored as low, moderate, serious and critical risk of bias. Overall risk of bias was then scored. Inconsistency was determined according to heterogeneity. I^2 statistics was used to determine heterogeneity. I^2 value of 0–40, 30–60, 50–90, and 75–100% were considered as low, moderate, substantial, and considerable heterogeneity, respectively. Imprecision was assessed using optimal information size (OIS), which was based on 25% relative risk reduction, 0.05 of α error and 0.20 of β error [20]. We planned to assess publication bias using funnel plots if 10 or more studies were available. The quality of evidence was upgraded in the presence of large magnitude of effects, dose–response gradient and plausible confounders. Large magnitude of effect was present if relative risk (RR) was greater than 2 or less than 0.5. We summarized the results of the meta-analyses and the assessment of quality of evidence for each outcome using GRADEpro GDT [21].

Results

We identified 880 articles after removing duplicates. 850 articles were excluded during title and abstract screening.

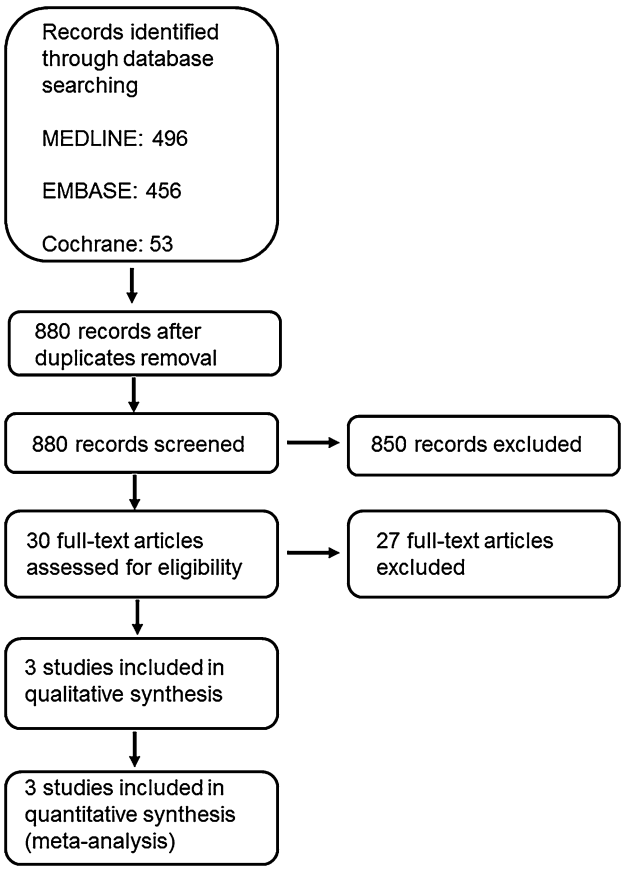

Fig. 1 Flow diagram for data extraction according to PRISMA statement

Full-text screening was performed and there was no RCT. Three retrospective cohort studies were selected for meta-analysis (Fig. 1) [22–24]. As no RCT was found, the meta-analysis was performed only for observational studies. The characteristics of included studies are shown in Table 1. Of the three included studies, two were single center cohorts and the remaining was a multicenter cohort study. In one study, median age was significantly higher in laparoscopy group compared to laparotomy [23]. In the remaining two studies, mean age at surgery was reported but differences between study group were not statistically analyzed [22, 24]. In laparoscopy group, the conversion rate to laparotomy ranged from 13 to 33% (Table 1). Our meta-analysis performed for the primary outcome of postoperative complications showed that the incidence of complications was 5.7% (66/1148) in laparoscopy group compared with 10.4% (915/8771) in laparotomy group. This indicates that the incidence of complications was significantly lower after laparoscopy compared to laparotomy (OR 0.51, 95% CI 0.40–0.66, $p < 0.00001$, $I^2 = 0\%$) (Fig. 2). Extracted data for LOS are shown in Table 2. All three analyzed studies reported LOS but we couldn't get enough information to perform a meta-analysis on this secondary outcome. In two out of three studies, LOS was significantly shorter after laparoscopy compared to laparotomy [23, 24]. In the remaining study, no statistical analysis of LOS was performed [22]. In the laparoscopic group, conversion rate to laparotomy ranged from 13 to 33% (Table 1).

Evidence for GRADE assessment is shown in Table 3. Outcomes from the 3 included studies had serious risk of bias according to ROBINS-I (Table 4). Inconsistency was not considered to be serious as heterogeneity was low ($I^2 = 0\%$). Indirectness was also considered not serious. Overall OIS was 9720. Thus, our result met OIS, and imprecision was considered not serious. As this meta-analysis included only 3 studies, we did not perform funnel plot analysis. There was no evidence to support publication bias. Because of serious risk of bias (Table 4), we rated down the quality of the evidence. Overall, the quality of the evidence in this systematic review was considered "very low" (Table 3).

Discussion

This systematic review and meta-analysis indicate that the available evidence for the use of laparoscopy in children with ASBO is based on retrospective studies. Although the

Table 1 Characteristics of included studies in the meta-analysis

Study	Study design	Country	Years of study	Sample size	Age (year)	Conversion to laparotomy during laparoscopy
van der Zee [22]	Single center Retrospective cohort	Netherland	1993–1998	Laparoscopy 9 Laparotomy 11	Laparoscopy 7.6 Laparotomy 2.2 (mean)	33% (3/9)
Lee [23]	Multicenter Retrospective cohort	US	1997, 2000, 2003, 2006, 2009	Laparoscopy 1126 Laparotomy 8736	Laparoscopy 13 Laparotomy 10 (median)*	17% (191/1126)
Albertos Mira-Marcelí [24]	Single center Retrospective cohort	Spain	2004–2012	Laparoscopy 15 Laparotomy 22	Laparoscopy 6.31 Laparotomy 4.32 (mean)	13% (2/15)

NA not available

*$p < 0.001$ comparing laparoscopy and laparotomy

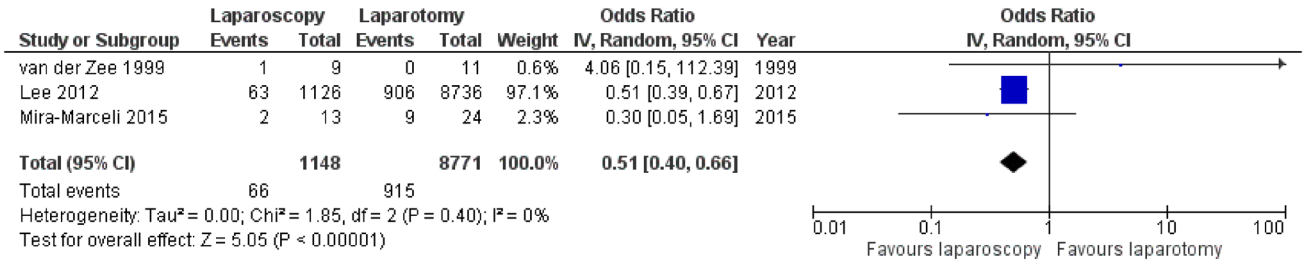

Fig. 2 Forest plot of complications after laparoscopy versus laparotomy

Table 2 Length of stay in analyzed studies

Study	Laparoscopy	Laparotomy	*p* value
van der Zee [22]	3.9[a]	10[a]	NA
Lee [23]	6[b]	8[b]	< 0.001
Albertos Mira-Marcelí [24]	7.77 ± 4.19[a]	13.05 ± 8.93[a]	0.027

NA not available

[a]Mean (± SD)

[b]Median

incidence of complications seems to favor the use of laparoscopy compared to laparotomy, the quality of evidence is very low and a prospective well-controlled study is needed.

Development of ASBO is a serious complication of abdominal surgery. A population-based study from Scotland revealed that the incidence of readmissions after surgery due to intestinal adhesions was 5.3% (if appendectomy was excluded) and 1.1% (if appendectomy was included) [4]. *Festen* reported that 2.2% of patients with previous abdominal surgery needed re-laparotomy due to ASBO [2]. From these reports, the incidence of postoperative ASBO is estimated between 1 and 5% [1]. Although conservative management is selected in some cases, majority of children with ASBO undergo surgery at the end [25].

Systematic reviews and meta-analyses revealed that laparoscopic surgery has better outcome for adult patients with ASBO [26–28]. Li et al. reported that laparoscopic surgery had lower complication rate for patients with ASBO, compared to laparotomy [27]. Wiggins et al. also reported shorter LOS in laparoscopy compared to laparotomy [28]. A recent cohort study from a single center in Finland also reported that laparoscopy was associated with lower morbidity and shorter length of stay [29]. These studies suggest that laparoscopy has beneficial effects on safety and efficacy for adult patients with postoperative ASBO, compared to laparotomy. However, a large population-based cohort study in Canada reported that laparoscopy for adult ABSO was associated with greater likelihood of intervention for bowel injury and/or repair. The authors speculate that this increase might be due to challenges inherent with laparoscopic approaches in patients with distended small bowel [30]. These opposed results suggest that the indication of laparoscopy for adult ASBO is still controversial.

Similarly, the evidence in children to support the use of laparoscopy in children with ASBO appears suboptimal and controversial. Recent report from population-based survey in US from 1997 to 2009 revealed that 11.4% (1126/9862) of children with ASBO underwent laparoscopy [23]. The continuing increase in the use of laparoscopy in children is likely to result in a greater proportion of children undergoing laparoscopy for ASBO [31]. Therefore, it is important to assess systematically the literature

Table 3 Evidence profile of complications using GRADE assessment

Quality assessment								Number of patients		Effect		Quality
Number of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		Laparoscopy	Laparotomy	Relative (95% CI)	Absolute (95% CI)	
Complications												
3	OS	Serious	Not serious	Not serious	Not serious	None		66/1148 (5.7%)	915/8771 (10.4%)	OR 0.51 (0.40 to 0.66)	48 fewer per 1000 (from 33 fewer to 60 fewer)	⨁◯◯◯ very low

OS observational study, *CI* confidence interval, *OR* odds ratio

Table 4 Risk of bias assessment using ROBINS-I

	van der Zee [22]	Lee [23]	Albertos Mira-Marcelí [24]
Domain			
Bias due to confounding	Serious	Serious	Serious
Bias in selection of participants into the study	Low	Low	Low
Bias in classification of interventions	Low	Low	Low
Bias due to deviations from intended interventions	Low	Low	Low
Bias due to missing data	Low	Low	Low
Bias in measurement of outcomes	Low	Low	Low
Bias in selection of the reported result	Low	Low	Low
Overall	*Serious*	*Serious*	*Serious*

to evaluate the safety and efficacy of laparoscopic surgery in children with postoperative ASBO. To our knowledge, this is first systematic review and meta-analysis regarding this condition. We assessed safety and efficacy of laparoscopy by analyzing the incidence of postoperative complication and LOS. Our meta-analysis revealed that the incidence of complications was significantly lower after laparoscopic surgery compared to laparotomy, suggesting that laparoscopy can be safe in children. Unfortunately, we could not obtain a pooled effect size of LOS due to the quality of the reported data. Two of the three included study reported significantly shorter LOS after laparoscopic repair [23, 24]. In the remaining study [22], the mean LOS was described as shorter after laparoscopy, but no statistical analysis was available. These results indicate that laparoscopic surgery compared to laparotomy seems to shorten the LOS after surgery.

The present systematic review reveals limitations in the current evidence. Because of the nature of the retrospective cohort studies, patients' characteristics in each group (laparoscopy versus laparotomy) were dissimilar in all three included studies. Age at surgery appeared to be higher in laparoscopy group compared to laparotomy group making the interpretation of results difficult. *Eeson* et al. reported that in children with ASBO a younger age was associated with bowel compromise and need for bowel resection [25]. Therefore, age can be confounder for the development of ASBO related complications.

For GRADE assessment, we considered the risk of bias as serious due to confounding factors. The quality of the evidence for the primary outcome of complications is scored as "very low" (Table 3). To obtain more reliable results with higher quality of evidence, prospective studies are needed.

The indications for laparoscopy need to be carefully evaluated to conduct a future well-designed controlled study in children with ASBO. In addition, the risk factors for failure of laparoscopy highlighted in previous reports [5, 32–34] need to be considered. The conversion rate from laparoscopy to open ranged from 23 to 33% in the above studies which is similar to the rate reported in the three studies included in our meta-analysis. *Shalaby* et al. reported that the most frequent cause for conversion was inadequate visualization due to bowel distension (6/10), multiple adhesions (2/10) and gangrenous bowel (2/10) [33]. Apelt et al. reported the reasons for the conversion to laparotomy from three pooled studies: the most frequent reason was "technical difficulty", including failed pneumoperitoneum, bad visualization and insufficient working space [5]. The requirement of intestinal resection and enterotomy were also important reasons for conversion (resection: 7/41, enterotomy: 6/41). Although it may be difficult to predict failure of laparoscopy before surgery, potential risk factors for failure should be considered in future prospective studies.

Conclusion

This meta-analysis seems to indicate that in children with ASBO laparoscopy is associated with lower incidence of complications compared to laparotomy. However, there is a severe risk of bias in confounder and the quality of evidence is very low. The current evidence is insufficient to evaluate the efficacy of laparoscopy in children with ASBO and a well-controlled study is needed.

Acknowledgements Dr. Agostino Pierro was supported by the endowment of the Robert M. Filler Chair of Surgery, The Hospital for Sick Children, and by the Canadian Institutes of Health Research (CIHR) Foundation Grant. The authors thank the following individuals who have assisted us with foreign language articles: Dr. Yuriy Kolivoshka (Russian), Dr. Bo Li (Chinese), Ms. Daniela Dominguez (Spanish) and Ms. Alison Hock (French).

Compliance with ethical standards

Conflict of interest The authors report no conflicts of interest.

References

1. Lautz TB, Barsness KA (2014) Adhesive small bowel obstruction-acute management and treatment in children. Semin Pediart Surg 23:349–352
2. Festen C (1982) Postoperative small bowel obstruction in infants and children. Ann Surg 196:580–583
3. Grant HW, Parker MC, Wilson MS et al (2006) Population-based analysis of the risk of adhesion-related readmissions after abdominal surgery in children. J Pediatr Surg 41:1453–1456
4. Grant HW, Parker MC, Wilson MS et al (2008) Adhesions after abdominal surgery in children. J Pediatr Surg 43: 152–157
5. Apelt N, Featherstone N, Giuliani S (2013) Laparoscopic treatment for adhesive small bowel obstruction: is it the gold standard in children too? Surg Endosc 27:3927–3928
6. Anderson SA, Beierle EA, Chen MK (2014) Role of laparoscopy in the prevention and in the treatment of adhesions. Semin Pediatr Surg 23:353–356
7. Alemayehu H, David B, Desai AA et al (2015) Laparoscopy for small bowel obstruction in children-An update. J Laparoendosc Adv Surg Tech A 25:73–76
8. Higgins JPT, Green S (2011) Cochrane handbook for systematic reviews of intervention. http://www.handbook.cochrane.org. Accessed 7 Oct 2017
9. Moher D, Liberati A, Tetzlaff J et al (2009) Preferred reporting items for systematic reviews and meta-analysis: the PRISMA statement. J Clin Epidemiol 62:1006–1012
10. Miyake H, Seo S, Pierro A (2017) Laparoscopic surgery for infants and children with postoperative bowel obstruction: a systematic review and meta-analysis. International prospective register of systematic reviews, PROSPERO, CRD42017067914
11. Guyatt GH, Oxman AD, Schunemann HJ et al (2011) GRADE guidelines: a new series of articles in the Journal of Clinical Epidemiology. J Clin Epidemiol 64:380–382
12. Balshem H, Helfand M, Schunemann HJ et al (2011) GRADE guidelines: 3. Rating the quality of evidence. J Clin Epidemiol 64:401–406
13. Guyatt GH, Oxman AD, Vist G et al (2011) GRADE guidelines: 4. Rating the quality of evidence-study limitations (risk of bias). J Clin Epidemiol 64:407–415
14. Guyatt GH, Oxman AD, Montori V et al (2011) GRADE guidelines: 5. Rating the quality of evidence-publication bias. J Clin Epidemiol 64:1277–1282
15. Guyatt GH, Oxman AD, Kunz RE et al (2011) GRADE guidelines: 6. Rating the quality of evidence-imprecsion. J Clin Epidemiol 64:1283–1293
16. Guyatt GH, Oxman AD, Kunz R et al (2011) GRADE guidelines: 7. Rating the quality of evidence-inconsistency. J Clin Epidemiol 64:1294–1302
17. Guyatt GH, Oxman AD, Kunz R et al (2011) GRADE guidelines: 8. Rating the quality of evidence-indirectness. J Clin Epidemiol 64:1303–1310
18. Guyatt GH, Oxman AD, Sultan S et al (2011) GRADE guidelines: 9. Rating up the quality of evidence. J Clin Epidemiol 64:1311–1316
19. Sterne JAC, Hernan MA, Reeves BC et al (2016) ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 355:i4919
20. Dupont WD, Plummer WD (1990) Power and sample size calculations: a review and computer program. Control Clin Trials 11:116–128
21. The GRADE working group (2004) https://gradepro.org. Accessed 28 July 2017
22. van der Zee DC, Bax NMA (1999) Management of adhesive bowel obstruction in children is changed by laparoscopy. Surg Endosc 13:925–927
23. Lee J, Tashjian DB, Moriarty KP (2012) Surgical management of pediatric adhesive bowel obstruction. J Laparoendosc Adv Surg Tech A 22:917–920
24. Albertos Mira-Marcelí N, Gallego Mellado N, Deltell Colomer P et al (2015) Treatment of the postoperative bowel obstructions in children: laparoscopic vs. open adhesiolysis. Cir Pediatr 28:123–127
25. Eeson GA, Wales P, Murphy JJ (2010) Adhesive small bowel obstruction in children: should we still operate? J Pediatr Surg 45:969–974
26. O'Connor DB, Winter DC (2012) The role of laparoscopy in the management of acute small-bowel obstruction: a review of over 2,000 cases. Surg Endosc 26:12–17
27. Li MZ, Lian L, Xiao L et al (2012) Laparoscopic versus open adhesiolysis in patients with adhesive small bowel obstruction: a systematic review and meta-analysis. Am J Surg 204:779–786
28. Wiggins T, Markar SR, Harris A (2015) Laparoscopic adhesiolysis for acute small bowel obstruction: systematic review and pooled analysis. Surg Endosc 29:3432–3442
29. Hackenberg T, Mentula P, Leppaniemi A et al (2017) Laparoscopic versus open surgery for acute adhesive small-bowel obstruction: a propensity score-matched analysis. Scand J Surg 106:28–33
30. Behman R, Nathens AB, Byrne JP et al (2017) Laparoscopic surgery for adhesive small bowel obstruction is associated with a higher risk of bowel injury. Ann Surg 266:489–498
31. Sattarova V, Eaton S, Hall NJ et al (2016) Laparoscopy in pediatric surgery: implementation in Canada and supporting evidence. J Pediatr Surg 51:822–827
32. Becmeur F, Besson R, GECI (1998) Treatment of small-bowel obstruction by laparoscopy in children multicentric study. Eur J Pediatr Surg 8:343–346
33. Shalaby R, Desoky A (2001) Laparoscopic approach to small intestinal obstruction in children: a preliminary experience. Surg Laparosc Endosc Percutan Tech 11:301–305
34. Aguayo P, Fraser JD, Ilyas S et al (2011) Laparoscopic management of small bowel obstruction in children. J Laparoendosc Adv Surg Tech A 21:85–88