Observational Study

Medicine® OPEN

Abdominal tumors in children

Comparison between minimally invasive surgery and traditional open surgery

Chaeyoun Oh, MD, Joong Kee Youn, MD, Ji-Won Han, MD, Hyun-Young Kim, MD, PhD*, Sung-Eun Jung, MD, PhD

Abstract

The use of minimally invasive surgery (MIS) in pediatric patients has been steadily increasing in recent years. However, its use for diagnosing and treating abdominal tumors in children is still limited compared with adults, especially when malignancy is a matter of debate. Here, we describe the experience at our center with pediatric abdominal tumors to show the safety and feasibility of MIS.

Based on a retrospective review of patient records, we selected for study those pediatric patients who had undergone diagnostic exploration or curative resection for abdominal tumors at a single center from January 2010 through August 2015.

Diagnostic exploration for abdominal tumors was performed in 32 cases and curative resection in 173 cases (205 operations). MIS was performed in 11 cases of diagnostic exploration (34.4%) and 38 cases of curative resection (21.9%). The mean age of the children who underwent MIS was 6.09 ± 5.2 years. With regard to diagnostic exploration, patient characteristics and surgical outcomes were found to be similar for MIS and open surgery. With regard to curative resection, however, the mean age was significantly lower among the patients who underwent open surgery (4.21 ± 4.20 vs 6.02 ± 4.99 for MIS, $P = 0.047$), and the proportion of malignancies was significantly higher (80% vs 39.4% for MIS, $P < 0.001$). MIS compared favorably with open surgery with respect to the rate of recurrence (6.7% vs 35.1%, $P = 0.035$), the rate of intraoperative transfusions (34.2% vs 58.5%, $P = 0.01$), the median amount of blood transfused (14 vs 22 mL/kg, $P = 0.001$), and the mean number of hospital days (4.66 ± 2.36 vs 7.21 ± 5.09, $P < 0.001$). Complication rates did not differ significantly between the MIS and open surgery groups. The operation was converted to open surgery in 3 cases (27.2%) of diagnostic MIS and in 5 cases (13.1%) of curative MIS.

MIS was found to be both feasible and effective for the diagnosis and curative treatment of pediatric abdominal tumors. However, to determine the surgical role and guidelines for MIS for each specific tumor, a multicenter prospective study with a long-term follow-up is warranted.

Abbreviation: MIS = minimally invasive surgery.

Keywords: abdominal tumor, laparoscopic surgery, minimally invasive surgery, pediatric abdominal tumor, pediatric solid tumor

1. Introduction

Recently, minimally invasive surgery (MIS) has become the standard procedure for various types of pediatric surgery, particularly appendectomy, cholecystectomy, fundoplication, splenectomy, and nephrectomy.[1–4] Since 2000, numerous reports have discussed the safety and feasibility of using MIS for diagnosing and treating pediatric abdominal/thoracic tumors.[1,5–9] However, MIS is not generally accepted as an option in such cases, and its use for solid tumors in this population remains limited.[5,10] Therefore, we compared MIS and open surgery for diagnostic exploration and curative resection to determine the safety and feasibility of MIS in pediatric patients with abdominal tumors seen at our center.

Editor: Johannes Mayr.

The authors have no conflicts of interest to disclose.

Department of Surgery, Seoul National University College of Medicine, Seoul, Korea.

* Correspondence: Hyun-Young Kim, Department of Pediatric Surgery, Seoul National University, Children's Hospital, 101 Daehang-ro, Yeongeon-dong, Jongro-gu, Seoul 03080, Korea (e-mail: spkhy02@snu.ac.kr)

Medicine (2016) 95:46(e5181)

Received: 5 June 2016 / Received in final form: 27 September 2016 / Accepted: 29 September 2016

http://dx.doi.org/10.1097/MD.0000000000005181

2. Materials and methods

We retrospectively reviewed patient records from the Seoul National University Children's Hospital pediatric surgery database for the period January 2010 through August 2015. Medical and surgical records of patients with abdominal tumors were thoroughly examined to determine the surgical intent, whether diagnostic or curative. A total of 205 operations were selected for study and involved a total of 173 pediatric patients. The patients ranged in age from 0 to 18 years.

The following patient data were obtained: sex, age, and body weight on the day of the operation; the diagnosis, location and size of the tumor, preoperative chemotherapy, operation performed, and pathology report; intraoperative transfusion, operative time, and hospital stay; and postoperative clinical course, recurrence, complications, and results of outpatient follow-up.

The diagnostic surgical exploration included a biopsy procedure to confirm the lesion and a cancer-staging procedure.

Statistical analyses to compare the 2 groups were done using Fisher exact test or the Mann–Whitney test and a chi-square test using SPSS software version 18.0 (SPSS Inc., Chicago, IL).

This study was approved by the institutional review board at Seoul National University Hospital (IRB file no. 1602-066-740).

3. Results

A total of 205 operations were carried out in 173 pediatric patients, 49 (23.9%) of whom underwent MIS and 156 (76.1%) of whom underwent open surgery. Sex distribution between the 2 groups was similar. On average, the MIS group was older than the open surgery group (6.09 ± 5.2 vs 4.57 ± 4.43 years), although this difference was not statistically significant. Significantly more patients with malignancy underwent open surgery (82% vs 51% for MIS, $P < 0.001$). The rate of intraoperative transfusions was significantly higher in the open surgery group (58.5% vs 34.2% for MIS, $P = 0.01$), as was the amount of blood transfused (22 vs 14 mL/kg with MIS, $P = 0.001$). The mean postoperative hospital stay was significantly shorter in the MIS group as compared with the open surgery group (4.49 ± 2.19 vs 6.91 ± 4.88 days, $P < 0.001$). There were no significant differences in operating times or in postoperative complications between the 2 groups (Table 1).

In 49 patients in the MIS group, neuroblastoma was the most frequent tumor (n = 14, 28.6%), and ovarian tumors (n = 11, 22.4%) were the second most common lesion (Table 2).

Patients characteristics and operative outcomes were also compared based on surgical intent, either diagnostic exploration (n = 32, 15.6%) or curative resection (n = 173, 84.4%) (Table 3).

MIS was performed in 11 (34.3%) of the 32 cases of diagnostic exploration. Mean ages were similar in the MIS and open surgery groups who underwent diagnostic exploration (6.32 ± 6.1 vs 6.91 ± 5.2 years, $P = 0.702$), and there was no significant difference in the rate of malignancies between the 2 groups (90.9% vs 95.2%, $P = 1.0$). Operative time, intraoperative transfusion, postoperative hospital stay, and complication rate were similar in the 2 groups.

In contrast, when the operation was intended to be curative, the mean age was significantly lower in the open surgery group than in the MIS group (4.21 ± 4.20 vs 6.02 ± 4.99 years, $P = 0.047$), and the rate of operations for malignancy differed significantly between the MIS group and the open surgery group (80% vs 39.4% for MIS, $P < 0.001$). Recurrence during follow-up was significantly less common in the MIS group (6.7% vs 35.1% for MIS, $P = 0.035$). In addition, the rate of intraoperative transfusions was significantly lower in the MIS group (34.2% vs 58.5% for MIS, $P = 0.01$), as was the median amount of transfusion (14 vs 22 mL/kg, $P = 0.001$). The MIS group had a significantly shorter mean postoperative hospital stay as compared with the open surgery group (4.66 ± 2.36 vs 7.21 ± 5.09 days for MIS, $P < 0.001$). Although the difference was not statistically significant, infection at the surgical site occurred in only 1 patient in the MIS group, whereas 13 postoperative complications occurred in the open surgery group, including fluid collection at the operative site (n = 5), surgical site infection (n = 2), ileus (n = 2), anastomotic obstruction (n = 1), chylous fistula (n = 1), renal artery stenosis (n = 1), and margin of specimen positive for malignancy (n = 1).

MIS was converted to open surgery in 8 of the 49 cases, 3 during the diagnostic exploration and 5 during the curative resection. The main reasons for conversion were major vessel invasion and severe adhesions (Table 4).

4. Discussion

Gans et al[11] first introduced the use of laparoscopic surgery in pediatric patients in 1973. However, at that time, technical shortcomings limited the use of MIS. Thanks to technical innovations, surgeons can now perform totally laparoscopic surgery, as adjusted for adult patients. In 1994, laparoscopic surgery based on present concepts was applied to the pediatric population,[12] and since then, numerous pediatric surgeons around the globe have included it in their practices.

Laparoscopy allows information about the abdominal anatomy, tumor size and location, and the presence of metastasis or recurrence to be obtained by evaluating the abdominal cavity. Before one can undertake MIS, however, certain principles of surgical oncology must be assured.[13] The MIS should guarantee results similar to those achieved with open surgery while minimizing technical risks, such as tumor rupture.[14] That is why skill and experience with the laparoscopic technique are essential for the surgeon performing MIS.

Although MIS has been accepted as a standard procedure in many types of pediatric surgery, its application is still limited to benign disease.[1–4] The usefulness of MIS in pediatric patients with abdominal tumors, especially malignancies, has not been clear until now. In 2010, a group of pediatric surgeons in Italy

Table 1

Characteristics and surgical outcomes according to MIS and traditional open surgery (n = 205).

Characteristic/outcome	MIS (n = 49)	Open (n = 156)	*P* value
Diagnostic exploration	11 (22.4%)	21 (13.5%)	0.174
Curative operation	38 (77.6%)	135 (86.5%)	
Male	24 (48.9%)	57 (36.5%)	0.134
Age, y	6.09 ± 5.2	4.57 ± 4.43	0.071
Malignancy	25 (51%)	128 (82%)	<0.001
Recurrence after curative operation	1/15	38/108	0.035
Operative time, min	139.8 ± 85.24	142.6 ± 101.64	0.861
Number of transfusions	15 (30.6%)	86 (55.1%)	0.003
Amount, mL/kg*	28 (6–80)	41 (6.7–560)	0.007
Hospital days	4.49 ± 2.19	6.91 ± 4.88	<0.001
Number of complications	1	13	0.195
Follow-up, mo	19 ± 13.54	28.79 ± 19.94	<0.001

MIS = minimally invasive surgery.
* Median values.

Table 2

Outcomes of MIS for abdominal tumors (n=49).

Diagnosis (number of patients)	Diagnostic exploration	Conversion	Curative resection	Conversion
Neuroblastoma (14)	4	3	10	
Ovarian tumor (11)			11	1
Benign adrenal tumor (4)			4	
Solid pseudopapillary tumor (3)			3	
Lymphoma (3)	2		1	
Lymphangioma (2)			2	1
Mature teratoma (2)			2	
Germ cell tumor (2)	2			
Rhabdomyosarcoma (2)	1		1	1
Pheochromocytoma (1)			1	1
Hemangioma (1)			1	1
Other (4)*	2		2	
Total (49)	11	3 (27.3%)	38	5 (13.2%)

* Diagnostic exploration: Renal amyloidosis (1), metastatic hepatic tumor (1). Curative resection: Extralobar pulmonary sequestration (1), appendiceal mucinous neoplasm (1).

suggested the use of MIS in pediatric oncology.[15] The advantage of MIS in solid tumors is that it can precisely obtain the target tissue, or even resect it, by means of a minimal incision. Other advantages of MIS include thorough dissection, assisted by magnification, and a fast recovery, allowing the earlier application of adjuvant therapies.[1,7] In a 2007 article reporting cases of pediatric abdominal masses, 165 incisional biopsies were performed, 98.8% of which were successful.[16] MIS can also be used for staging alongside many radiological imaging modalities. In a study of abdominal malignancies in adult patients, laparoscopic examination was shown to lower the frequency of unnecessary laparotomy by 67%.[17]

In our study, we included the biopsy and staging procedures in the diagnostic exploration category. Six cases (3 neuroblastomas, 2 germ cell tumors, and 1 lymphoma) out of 11 diagnostic MIS procedures were performed for tissue confirmation after laparotomy for the primary tumor in cases of suspected recurrence. Five cases were performed for staging or tissue confirmation before determining the treatment strategy. In every case, the surgical goal was accomplished. Spurbeck et al[1] reported that the success rate of MIS was higher than 93%, and this included new identification of mass, confirmation of metastasis or recurrence, and assessing resectability.

There are several reports on curative MIS, and neuroblastoma is the most common subject. In a recent report on neuroblastomas, MIS was performed in 21 cases, with a median operative time of 90 minutes and no conversion to open surgery or complications involving the port site or peritoneal metastasis[6]; however, the study enrolled only patients who did not have image-defined risk factors, and other studies have reported conversion rates of up to 5% to 16.7%.[18–20] The most common reason of conversion was intravascular extension of the tumor. Although laparoscopic resection is already being attempted in patients with advanced-stage disease, MIS in neuroblastoma is presently recommended only in patients with small, localized, and well encapsulated tumors.[21,22] In our study, among 50 cases of curative resection (10 with MIS and 40 with open surgery) of neuroblastoma, MIS and open surgery were performed in 6 and 5 cases, respectively, in patients with stage I or II neuroblastoma. However, in patients with stage III or IV neuroblastoma, which differed significantly from the 4 and 35 cases of MIS and open surgery, respectively ($P=0.004$).

Although data on laparoscopic resection of hamartoma[23,24] and small-sized hepatoblastoma[25] have already been reported, the use of MIS on children with liver masses will require further investigation, because the operative field is too limited, making it

Table 3

Characteristics and surgical outcomes according to diagnostic and curative operation.

	Diagnostic exploration			Curative resection		
Characteristic/outcome	MIS (n=11)	Open (n=21)	*P* value	MIS (n=38)	Open (n=135)	*P* value
Male	8	9	0.147	16	48	0.569
Age, y	6.32±6.1	6.91±5.2	0.702	6.02±4.99	4.21±4.20	0.047
Malignancy, %	10 (90.9%)	20 (95.2%)	1.0	15 (39.5%)	108 (80%)	<0.001
Recurrence	0	0	–	1 (6.7%)	38 (35.1%)	0.035
Operative time, min	141.82±52	129.38±77.33	0.267	139.21±93.24	144.67±105	0.772
Number of transfusions	2 (18.2%)	7 (33.3%)	0.441	13 (34.2%)	79 (58.5%)	0.01
Amount, mL/kg*	21 (16–26)	13 (3–19)	0.111	14 (3–40)	22 (3–230)	0.001
Hospital days	3.91±1.37	4.95±2.46	0.328	4.66±2.36	7.21±5.09	<0.001
Number of complications	0	0	–	1	13	0.309
Follow-up duration, mo	25.64±13.27	27.24±19.9	0.807	17.08±13.17	29.04±20.01	<0.001
Number of conversions	3 (27.2%)			5 (13.1%)		

MIS = minimally invasive surgery.
* Median values.

Table 4

Patient characteristics in conversions to open surgery.

Case	Sex	Age, y	Diagnosis	Operation	Reason of conversion
1	M	17	Extra-adrenal paraganglioma	Excision	Invasion of aorta
2	M	18	Metastatic neuroblastoma	Excision	Severe adhesion
3	M	1	Jejunal hemangioma	SBR&A*	Limited visibility
4	M	3	Mesenteric lymphangioma	Excision	Limited visibility
5	F	8	Recurrent neuroblastoma	Excision	Severe adhesion
6	M	6	Rhabdomyosarcoma	Excision	Invasion of aorta and iliac artery
7	M	12	Metastatic neuroblastoma	Excision	Invasion of aorta
8	F	14	Hemorrhagic ovarian cyst	Cystectomy	Severe adhesion

* SBR&A = small bowel resection and anastomosis.

hard to guarantee good visibility and making anatomical resection difficult, thus restricting the ability to control bleeding when compared with open surgery. Our results also revealed the tendency to choose open surgery for patients with a liver mass (1 with MIS vs 34 with open surgery, $P<0.001$). Based on the proportion and choice of curative resection in cases of malignancy, as well as the recurrence rate, the number of intraoperative transfusions and the amount of blood transfused, the choice of curative MIS over open surgery appeared to be confined to the simpler cases.

It is well known that MIS is associated with a shorter hospital stay, better cosmesis, less pain, earlier recovery, and less bowel adhesion.[26–28] However, visceral injury[29] and trocar site herniation[30] have been noted as disadvantages of MIS. With regard to safety, tumor spillage or trocar site recurrence should always be a concern. Chui and Lee[31] reported peritoneal metastasis after laparoscopic surgery in patients with Wilms tumor, and Metzelder and Ure[32] reported port-site metastasis after laparoscopic biopsy of a Burkitt lymphoma. In the operations intended for diagnostic exploration, patient characteristics and surgical outcomes were similar in the MIS and open surgery groups in our study. Among the operations intended for curative resection, the open surgery group was younger and had a higher rate of malignancy. However, the MIS group showed better results than the open surgery group in terms of recurrence rates, rates of intraoperative transfusion, amount of transfusion, and postoperative hospital stay. In our study, local recurrence was noted 10 months after MIS in a 4-year-old patient who had stage IV neuroblastoma and underwent reoperation. Otherwise, we found no recurrence or port-site metastasis in the MIS group. Postoperative complications occurred in 1 patient in the MIS group (2%) and in 13 patients in the open surgery group (8.3%), but this difference was not statistically significant. These data speak to the safety and feasibility of MIS in pediatric patients with abdominal tumors.

In 8 out of 49 patients (16.3%), MIS was converted to open surgery. Severe adhesions were the reason in 6 cases, and invasion of the aorta or iliac artery accounted for half the cases of conversion (n = 3). Previous studies of pediatric abdominal tumors have reported conversion rates of 5.2% to 24.6%, emphasizing the risk of bleeding due to major vessel encasement.[1,5,7,33,34] In these situations, a preoperative multidisciplinary approach involving the surgeon and the radiologist is required, especially in patients with a history of abdominal surgery.

In 2010, Cecchetto et al[15] proposed the use of MIS in pediatric oncology. Back then, however, the outcome data were too scarce for the procedure to be applied worldwide. The only prospective, randomized, controlled study for determining the role of MIS in pediatric cancer failed because of lack of accrual.[35] In their recent Cochrane review, van Dalen et al[10] pointed out that the published reports on solid abdominal and thoracic neoplasms are all case series, retrospective studies, or cohort studies, thus restricting the viability of MIS for pediatric solid tumor and indicating the need for a high-quality randomized, controlled trial.

In our early experience, especially during the first year of MIS for pediatric abdominal tumors, patients with tumors no larger than 10 cm, no invasion to adjacent organs, no major vessel abutting or encasement were carefully selected for MIS. Over time, with improving surgical experience and technique, we were able to perform MIS for the majority of abdominal tumors except for a few contraindications. We think that the absolute contraindications for MIS in pediatric abdominal tumors are huge solid tumors which occupy the whole intraabdominal cavity, major vessel encasement, and uncorrectable coagulopathy. Relative contraindications are as followed: compromised cardiopulmonary status, ventriculoperitoneal shunt, major vessel abutting, and tumor infiltration to the porta hepatis or hepatoduodenal ligament. We think that tumor size is not a significant problem in MIS. In our study, the average tumor size was 5.02 ± 4.17 cm in MIS with the maximum size of 22 cm in a 3-year-old boy with cystic lymphangioma. We also think that history of open abdominal surgery is not a contraindication since adhesion is not always a consequence of open surgeries.

Although our study was a retrospective one, we hoped to determine the potential of MIS in diagnosing and treating pediatric abdominal tumors based on our 5-year experience at a single center. However, our study had some limitations. Because we included all the abdominal tumors found in the chart review, disease heterogeneity was inevitable. The proportion of cases of open surgery was high, especially for more advanced stages of disease, such as with neuroblastoma. The fact that lesions at high risk for bleeding (e.g., liver masses) were usually treated with open surgery was another limitation. Therefore, a multicenter, prospective study with a long follow-up will be required to determine the role of MIS in pediatric abdominal tumors.

5. Conclusion

MIS is favorable compared to open surgery regarding the rate of recurrence, the incidence of intraoperative transfusions, the median amount of blood transfused, and the mean hospital stay in curative resection. Moreover, the complication rate difference between MIS and open surgery was insignificant. With regard to diagnostic exploration, the surgical outcomes were found to be similar for MIS and open surgery. Therefore, MIS was found to be both feasible and effective for the diagnosis and curative resection of pediatric abdominal tumors. However, there are still no adequate guidelines for the utilization of MIS in the surgical treatment of these lesions. Multicenter, prospective studies with a long follow-up for each individual abdominal tumor are needed to determine the role of MIS in these patients.

References

[1] Spurbeck WW, Davidoff AM, Lobe TE, et al. Minimally invasive surgery in pediatric cancer patients. Ann Surg Oncol 2004;11:340–3.
[2] Bax NM. Laparoscopic surgery in infants and children. Eur J Pediatr Surg 2005;15:319–24.
[3] Johnson A. Laparoscopic surgery. Lancet 1997;349:631–5.
[4] Georgeson KE, Owings E. Advances in minimally invasive surgery in children. Am J Surg 2000;180:362–4.
[5] Metzelder ML, Kuebler JF, Shimotakahara A, et al. Role of diagnostic and ablative minimally invasive surgery for pediatric malignancies. Cancer 2007;109:2343–8.
[6] Mattioli G, Avanzini S, Pini Prato A, et al. Laparoscopic resection of adrenal neuroblastoma without image-defined risk factors: a prospective study on 21 consecutive pediatric patients. Pediatr Surg Int 2014; 30:387–94.
[7] Acker SN, Bruny JL, Garrington TP, et al. Minimally invasive surgical techniques are safe in the diagnosis and treatment of pediatric malignancies. Surg Endosc 2015;29:1203–8.
[8] Warmann SW, Godzinski J, van Tinteren H, et al. Surgical Panel of the SRTSGMinimally invasive nephrectomy for Wilms tumors in children—data from SIOP 2001. J Pediatr Surg 2014;49:1544–8.
[9] Lima M, Ruggeri G, Domini M, et al. The role of endoscopic surgery in paediatric oncological diseases. Pediatr Med Chir 2002;24:41–4.
[10] van Dalen EC, de Lijster MS, Leijssen LG, et al. Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children. Cochrane Database Syst Rev 2015;1: CD008403.
[11] Gans SL, Berci G. Peritoneoscopy in infants and children. J Pediatr Surg 1973;8:399–405.
[12] Holcomb GW3rd. Indications for laparoscopy in children. Int Surg 1994;79:322–7.
[13] Malkan AD, Loh AH, Sandoval JA. Minimally invasive surgery in the management of abdominal tumors in children. J Pediatr Surg 2014; 49:1171–6.
[14] Javid PJ, Lendvay TS, Acierno S, et al. Laparoscopic nephroureterectomy for Wilms' tumor: oncologic considerations. J Pediatr Surg 2011;46: 978–82.
[15] Cecchetto G, Riccipetitoni G, Inserra A, et al. Italian Group of Pediatric Surgical OMinimally-invasive surgery in paediatric oncology: proposal of recommendations. Pediatr Med Chir 2010;32:197–201.
[16] Cribbs RK, Wulkan ML, Heiss KF, et al. Minimally invasive surgery and childhood cancer. Surg Oncol 2007;16:221–8.
[17] Ramshaw BJ, Esartia P, Mason EM, et al. Laparoscopy for diagnosis and staging of malignancy. Semin Surg Oncol 1999;16:279–83.
[18] Mirallie E, Leclair MD, de Lagausie P, et al. Laparoscopic adrenalectomy in children. Surg Endosc 2001;15:156–60.
[19] Skarsgard ED, Albanese CT. The safety and efficacy of laparoscopic adrenalectomy in children. Arch Surg 2005;140:905–8. discussion 909.
[20] Miller KA, Albanese C, Harrison M, et al. Experience with laparoscopic adrenalectomy in pediatric patients. J Pediatr Surg 2002;37:979–82. discussion 979–982.
[21] Leclair MD, de Lagausie P, Becmeur F, et al. Laparoscopic resection of abdominal neuroblastoma. Ann Surg Oncol 2008;15:117–24.
[22] Heloury Y, Muthucumaru M, Panabokke G, et al. Minimally invasive adrenalectomy in children. J Pediatr Surg 2012;47:415–21.
[23] Dutta S, Nehra D, Woo R, et al. Laparoscopic resection of a benign liver tumor in a child. J Pediatr Surg 2007;42:1141–5.
[24] Yoon YS, Han HS, Choi YS, et al. Total laparoscopic left lateral sectionectomy performed in a child with benign liver mass. J Pediatr Surg 2006;41:e25–8.
[25] Kim T, Kim DY, Cho MJ, et al. Use of laparoscopic surgical resection for pediatric malignant solid tumors: a case series. Surg Endosc 2011; 25:1484–8.
[26] Sandoval C, Strom K, Stringel G. Laparoscopy in the management of pediatric intraabdominal tumors. JSLS 2004;8:115–8.
[27] Barmparas G, Branco BC, Schnuriger B, et al. The incidence and risk factors of post-laparotomy adhesive small bowel obstruction. J Gastrointest Surg 2010;14:1619–28.
[28] Garrard CL, Clements RH, Nanney L, et al. Adhesion formation is reduced after laparoscopic surgery. Surg Endosc 1999;13:10–3.
[29] Adikibi BT, Mackinlay GA, Clark MC, et al. The risks of minimal access surgery in children: an aid to consent. J Pediatr Surg 2012;47:601–5.
[30] Castilho LN, Castillo OA, Denes FT, et al. Laparoscopic adrenal surgery in children. J Urol 2002;168:221–4.
[31] Chui CH, Lee AC. Peritoneal metastases after laparoscopic nephron-sparing surgery for localized Wilms tumor. J Pediatr Surg 2011;46: e19–21.
[32] Metzelder M, Ure B. Port-site metastasis after laparoscopic biopsy of a posttransplant Burkitt lymphoma in a child. Eur J Pediatr Surg 2009; 19:126–7.
[33] Iwanaka T, Arai M, Kawashima H, et al. Endosurgical procedures for pediatric solid tumors. Pediatr Surg Int 2004;20:39–42.
[34] Saenz NC, Conlon KC, Aronson DC, et al. The application of minimal access procedures in infants, children, and young adults with pediatric malignancies. J Laparoendosc Adv Surg Tech A 1997;7:289–94.
[35] Ehrlich PF, Newman KD, Haase GM, et al. Lessons learned from a failed multi-institutional randomized controlled study. J Pediatr Surg 2002; 37:431–6.