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Original Article

Efficacy and complications of laparoscopic appendectomy for pediatric appendicitis

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Abstract: Objective: To investigate the clinical efficacy and safety of laparoscopic appendectomy in the management of appendicitis in child patients. Methods: Complete clinical data from 112 children with appendicitis were collected and analyzed retrospectively. The time for data collection was from December 2015 to December 2016. The children were divided into the open appendectomy group (children undergoing conventional open appendectomy, n=55) and the laparoscopic appendectomy group (children undergoing laparoscopic appendectomy, n=57) in terms of the surgical methods. Surgical procedures, postoperative recovery and laboratory parameters, as well as complications were compared between the two study groups. Results: The differences in course of disease, levels of neutrophils and subtypes of appendicitis were insignificant between the two groups. As compared to children with open appendectomy, children undergoing laparoscopic appendectomy had shorter operation time, less blood loss and shorter hospitalization time (P<0.05). Postoperative exhaust time and feeding time for the children in the laparoscopic appendectomy group were significantly shorter than those in the open appendectomy group (P<0.05). The children undergoing laparoscopic appendectomy had lower body temperature and lower levels of postoperative neutrophils as compared with those with open appendectomy (P<0.05). The rate of complications was also lower in children with laparoscopic appendectomy than in those with open appendectomy (3.51% vs. 12.73%; P<0.05). Conclusion: As an alternative for treatment of pediatric appendicitis, laparoscopic appendectomy is effective, safe and minimally invasive, with better postoperative recovery, improved laboratory parameters and reduced complications.

Keywords: Pediatric appendicitis, laparoscopic appendectomy, open appendectomy, contraindications

Introduction

Appendicitis is an extremely common acute abdomen disease with a high mortality among the patient population [1]. Some scholars have pointed out that the incidence of appendicitis can reach 6% up to 10% [2]. As far as age distribution of the affected population is concerned, adults and children are most possibly affected. Conservative treatment and surgery are commonly used in the treatment of children with different subtypes of appendicitis at diverse ages [3]. Conventional open appendectomy and laparoscopic appendectomy are alternative protocols for appendicitis in children [4]. Once the children are diagnosed as having pediatric appendicitis, they should be treated as soon as possible as most pediatric appendicitis is acute. In the process of surgical treatment, children have a low tolerance due to their low body mass index (BMI) and immature organs. Therefore, during a conventional open appendectomy, big surgical incisions and larger blood loss may cause greater damages to the children while laparoscopic appendectomy is safer and more minimally invasive. According to previous literature, the children undergoing laparoscopic appendectomy have better outcomes in hospitalization time, postoperative pain, recovery of intestinal function, postoperative complications, and re-admission rates than those receiving open appendectomy with small incisions [5-7]. Some studies, however, have demonstrated that there are insignificant differences in the above aspects between the two surgery techniques, and laparoscopic appen-

Table 1. Analyses of clinical data of children in both groups

Group	Laparoscopic appendectomy group	Open appendectomy group	t	P
Case (n)	57	55		
Gender (n)			4.1221	0.0615
Male	30	30		
Female	27	25		
Mean age ($\bar{x}$±s, year)	6.12±2.33	7.02±1.38	2.4758	0.0564
Time from onset to treatment ($\bar{x}$±s h)	26.15±2.23	25.33±1.08	0.573	0.597
Subtypes of appendicitis			1.5647	0.0702
Simplex	20	19		
Purulent	22	21		
Gangrenous	15	15		
Mean neutrophils (%)	0.85±0.12	0.84±0.15	0.3902	0.0607

dectomy may bring higher risks, including intraperitoneal abscess and postoperative ankylenteron [8]. Currently, researchers' viewpoints vary in the utilization of laparoscopic appendectomy in the management of pediatric appendicitis. Jen et al. conducted a study of 95,806 children and came to the conclusion that laparoscopic appendectomy would increase the risk of intraperitoneal abscess and did not have better therapeutic effect than open appendectomy [9]. By contrast, Masoomi et al. argued in a retrospective study with 212,958 children, as for the efficacy of laparoscopic appendectomy in pediatric perforated appendicitis, the children with laparoscopic appendectomy were superior to those with small-incision open appendectomy in hospitalization time and postoperative recovery. However, there were no such differences when laparoscopic appendectomy was applied for pediatric non-perforated appendicitis [10]. In the present study, 112 children with pediatric appendicitis were enrolled, with the aim to investigate the clinical efficacy and safety of laparoscopic appendectomy in pediatric appendicitis.

Materials and methods

Clinical data

Complete clinical data from children were collected for a retrospective analysis. The data were collected from December 2015 to December 2016. Sixty children were male and 52 were female, aged 4-9 years (mean, 6.17±2.37 years). We included the children, who met the diagnostic criteria for appendicitis, had ineffective conservative treatment and showed operative indications [10]. But we excluded the children who had significant systemic infection, plus diffuse peritonitis and severe cardiorenal disease. The eligible children were assigned to receive either conventional open appendectomy group (the open appendectomy group, n= 55) or laparoscopic appendectomy group (the laparoscopic appendectomy group, n=57) in terms of surgical methods.

Surgical methods

The children in the open appendectomy group were given open appendectomy whereas those in the laparoscopic appendectomy group were given laparoscopic appendectomy. The specific procedures are shown as follows: A curved incision (5 mm in length) was made in the navel of the patient under routine anesthesia to establish artificial pneumoperitoneum. With the patient's abdominal distention, a trocar was inserted into the navel of the patient, through which a laparoscope was placed into the abdominal cavity. The patient's abdominal cavity was observed under the laparoscopic lens and then the trocar was inserted at McBurney point as the operating hole under the direct vision of the laparoscope. The laparoscopic forceps were placed into the abdominal cavity. The appendix was found and pulled into the cannula of the operating whole. After that, the trocar was removed and the appendix was pulled out of the abdominal cavity from the operation hole after pneumoperitoneum exhaust. The appendix was removed, followed by putting the caecum and residual appendiceal stumps back into the abdominal cavity, check of the wound bleeding, removal of the trocar and routine clo-

Table 2. Comparison of surgery-related factors of children in both groups ($\bar{x}\pm s$)

Group	Case (n)	Operation time (min)	Intraoperative bleeding (ml)	Hospitalization (d)
Laparoscopic appendectomy group	57	57.12±3.25	32.15±5.33	5.12±1.03
Open appendectomy group	55	65.33±2.13	45.35±5.67	9.85±1.65
t		3.66	2.938	18.2670
P		0.0220	0.0420	0.0246

Table 3. Comparison of postoperative factors of children in both groups ($\bar{x}\pm s$)

Group	Case (n)	Postoperative exhaust (h)	Postoperative Feeding (d)
Laparoscopic appendectomy group	57	15.21±3.12	1.65±0.44
Open appendectomy group	55	40.33±5.12	3.24±0.52
t		31.4780	17.4910
P		0.0103	0.0327

Table 4. Comparison of clinical laboratory indexes of children in both groups

Group	Case (n)	Body temperature (°C)	Postoperative neutrophils (%)
Laparoscopic appendectomy group	57	37.15±0.51	0.65±0.04
Open appendectomy group	55	38.15±0.41	0.79±0.13
t		11.4110	7.7599
P		0.0346	0.0457

sure of the incision. After the surgery was completed, the children in both groups were treated with conventional hemostasis, anti-inflammation.

Outcome measures

Among the children in the two groups, the surgery-related factors (including operation time, intraoperative bleeding and hospitalization time), postoperative recovery status (postoperative exhaust time and feeding time), laboratory indexes (body temperature on the second day after surgery and postoperative neutrophils) and complications factors (including incisional infection, abdominal abscess and intestinal obstruction) were observed and compared.

Statistical analyses

The complete data of the findings of the study were collected and processed on the computer with the use of the SPSS software (version 17.0). The measurement data including the operation time, intraoperative bleeding and hospitalization time of the children were presented as mean ± standard deviation and the grouping design was performed using a student' t-test. On the other hand, the count data which consisted of the complications rate were processed with the use of a chi-square test. An alpha level of 0.05 was utilized for judgment of the significance level of the differences.

Results

Statistics and comparison of basic data of both groups

The children' course of disease, levels of neutrophils and subtypes of appendicitis were compared between the two groups and no significant differences were found (all P>0.05). The specific results are shown in **Table 1**.

Comparison of surgery-related factors of children in both groups

The operation time and intraoperative bleeding and hospitalization time of the children were recorded and analyzed, and significant differences were found between the two groups in the three factors. Among them, the operation time was considerably shorter or less among the children with laparoscopic appendectomy than those with open appendectomy (all P<0.05, **Table 2**).

Comparison of postoperative factors of children in both groups

The time for postoperative exhaust and for feeding were strikingly shorter in the children in with laparoscopic appendectomy than those with open appendectomy (all P<0.05, **Table 3**).

Table 5. Safety testing and analysis of children in both groups

Group	Case (n)	Incision infection (n)	Abdominal abscess (n)	Intestinal obstruction (n)	Complications rate (%)
Laparoscopic appendectomy group	57	1	1	0	3.51
Open appendectomy group	55	4	3	2	12.73
t		0.914	0.298	0.546	3.872
P		0.339	0.585	0.460	0.049

Comparison of clinical laboratory indexes of children in both groups

The body temperature on the second day after surgery and the level of postoperative neutrophils in the laparoscopic appendectomy group significantly lowered as compared to those in the open appendectomy group (all P<0.05, **Table 4**).

Safety testing and analysis of children in both groups

As demonstrated by safety testing, the rate of complications of children in the laparoscopic appendectomy group was 3.51%, which was significantly lower than 12.73% of children in the open appendectomy group (all P<0.05, **Table 5**).

Discussion

Pediatric appendicitis is one of the most common acute abdominal diseases in children, but it is often misdiagnosed. As a result, the patient missed the best operation time as it develops into periappendiceal abscess [11]. Therefore, once the disease was confirmed, the patient should undergo an immediate emergency surgery. The frequent techniques for clinical appendicitis resection include the conventional open appendectomy and the laparoscopic appendectomy [6].

Open appendectomy is already a very mature technology, but its postoperative complications are not so optimistic. In this context, the laparoscopic technology has made a rapid development that it has extensively used in clinical practice owing to its advantages of small injury, fewer complications and rapid postoperative recovery [12, 13]. With the laparoscopic appendectomy, it is easy to find the appendix in the abdominal cavity under the wider vision of the visual light source, so the required operation time is shortened. In contrast, with the open appendectomy, finding the appendix in the abdominal cavity is the focus and difficulty during the surgery, especially when the appendix is in the posterior of the cecum or severe adhesive appendix occurs [14, 15]. In the present study, we found that the operation time for the children in the laparoscopic appendectomy group was significantly shorter than that in the open appendectomy group. This is similar to the finding in the previous literature that the time for the conventional open appendectomy in the children was longer than that for the laparoscopic appendectomy in children [14]. The possible reasons include: the purse-string technique is utilized to suture the residual appendiceal stumps in a conventional open appendectomy whereas an electrocoagulation is applied to suture the residual appendiceal stumps in the laparoscopic appendectomy which can substantially shorten the operation time; it takes much more time to find the site of the appendix with a conventional open appendectomy, but it is much easier to find the appendix with a laparoscopic appendectomy as it can get a wider visible range of exploration [16].

In the present study, less intraoperative bleeding was observed among the children with laparoscopic appendectomy when compared with those with open appendectomy. This may be attributed to the causes that the biological folders or the titanium clips were used to deal with the mesentery after laparoscopic appendectomy, which contributed to less bleeding; whereas the hemostatic forceps were utilized for hemostasis after conventional open appendectomy, which led to inadequate hemostasis, hence more traumas to the patient. Therefore, intraoperative bleeding was less in children with laparoscopic appendectomy than in those with conventional open appendectomy. Besides, the time for intestinal function recovery was also significantly shorter in children with

laparoscopic appendectomy. That is, the children with laparoscopic appendectomy needed less time for postoperative exhaust and feeding. This may be associated with the fact that the laparoscopic appendectomy attributed to less intestinal damage and lighter postoperative pain. Moreover, after laparoscopic appendectomy, the drainage tube was placed in lower position which brought fast drainage, earlier ambulation and faster recovery of gastrointestinal functions to the children [17].

In addition to quicker recovery of gastrointestinal function, the children with laparoscopic appendectomy also had fewer events of systemic inflammation than those with conventional open appendectomy. In the present study, we found markedly lower body temperature and lower levels of postoperative neutrophils among the children with laparoscopic appendectomy on the second day after surgery. This may be attributed to less systemic injury and mild inflammation in children after laparoscopic appendectomy [18].

Minutolo and Prendergast reported the rates of complications after conventional open appendectomy ranged from 10% to 20% [19, 20]. In the present study, as shown by safety testing, the rate of complications among the children with laparoscopic appendectomy was 3.51%, significantly lower than 12.73% of the children with open appendectomy ($P<0.05$). This suggests that the laparoscopic appendectomy is effective in the reduction of surgical complications. However, in the performance of laparoscopic appendectomy, special attention should be paid to strict control of the associated surgical contraindications. For the children complicated with obvious systemic infection, diffuse peritonitis, and severe cardiorenal disease, the implementation of laparoscopic appendectomy is not advisable.

In summary, laparoscopic appendectomy in pediatric appendicitis was characterized by effectiveness, safety and minimal invasion, which contributes to better postoperative recovery, laboratory indexes and fewer complications in the children.

Disclosure of conflict of interest

None.

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