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Application of transumbilical single-incision laparoscopy in the treatment of complicated appendicitis in overweight/obese adolescents

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Abstract

Objective To investigate the clinical efficacy of transumbilical single-incision laparoscopic surgery in the treatment of complicated appendicitis in overweight/obese adolescents.

Methods A retrospective analysis was conducted on the clinical data of 226 adolescent patients with complicated appendicitis who were admitted to our hospital from January 2014 to June 2022. Among them, 102 cases underwent transumbilical single-incision laparoscopic appendectomy as the observation group, and another 124 cases underwent conventional three-port laparoscopic appendectomy as the control group. The surgical time, intraoperative blood loss, duration of incisional pain, postoperative flatus time, length of hospital stay, surgical site infection (SSI), satisfaction with cosmetic result, and occurrence of postoperative complications were compared between the two groups.

Results Both groups completed the surgery smoothly, and there were no statistically significant differences in gender, age, BMI, duration of illness, white blood cell count, and preoperative CRP value between the two groups ($P > 0.05$). There were no statistically significant differences in surgical time and intraoperative blood loss between the two groups ($P > 0.05$). However, the observation group had shorter hospital stays, shorter duration of incisional pain, shorter postoperative time to flatus, and lower overall postoperative complication rates compared to the control group, with statistically significant differences ($P < 0.05$). The observation group had higher satisfaction with cosmetic result compared to the control group, with statistically significant differences ($P < 0.05$). Both groups were followed up for one year postoperatively, and there were no occurrences of residual appendicitis or severe adhesive intestinal obstruction.

Conclusion When proficiently mastered, the application of transumbilical single-incision laparoscopy in the treatment of complicated appendicitis in overweight/obese adolescents offers advantages such as minimal trauma, rapid recovery, fewer complications, and improved aesthetic outcomes.

Keywords Single-incision laparoscopy, Adolescents, Complicated appendicitis, Overweight, Obesity

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Introduction

Acute appendicitis is one of the common causes of acute abdominal pain in adolescents [1, 2]. Due to its unique anatomical features, including a long, narrow, and tortuous appendiceal lumen, it is prone to fecalith impaction, obstruction, and difficult evacuation. Additionally, the thin appendiceal wall and abundant lymphoid follicles make it susceptible to inflammation, perforation, or necrosis, leading to severe conditions such as diffuse peritonitis. Especially in overweight or obese patients, the symptoms of tenderness and peritonitis may not be typical, leading to potential delays in diagnosis and treatment [3]. In recent years, laparoscopic appendectomy has largely replaced traditional open surgery [4–6], and the surgical approach has shifted from multi-port and multi-site to single-port or single-site [7–9], offering advantages in terms of cosmetic outcomes and patient experience. Currently, transumbilical single-incision laparoscopy has been widely used in the treatment of acute appendicitis in children. However, there is limited literature on its application in complicated appendicitis in overweight or obese adolescents. This study aims to compare the efficacy of transumbilical single-incision laparoscopy and conventional three-port laparoscopy in the treatment of complicated appendicitis in overweight/obese adolescents. The findings are reported as follows.

Materials and methods

General information

Analysis of clinical data of 226 overweight and obese adolescents with complicated appendicitis treated at our hospital from January 2014 to June 2022. All patients were operated on by the same medical team, and before the surgery, the family members were fully informed of the advantages and disadvantages of the two surgical options, and the surgical method was chosen based on the family's wishes. Among them, 102 cases underwent transumbilical single-incision laparoscopic appendectomy as the Observation Group (OG), while 124 cases underwent conventional three-port laparoscopic appendectomy as the Control Group (CG). In the Observation Group, there were 60 males and 42 females, with 78 overweight and 24 obese cases; in the Control Group, there were 69 males and 55 females, with 92 overweight and 32 obese cases. Data collected for both groups include: General information such as gender, age, BMI; Time from initial symptoms to surgery, preoperative symptoms (abdominal pain, diarrhea, nausea, vomiting, fever), preoperative white blood cell count, neutrophil percentage, preoperative CRP value, surgical duration, intraoperative blood loss, time to postoperative flatus or defecation, postoperative pain VAS score, postoperative hospital stay, short-term postoperative complications (bleeding, intestinal fistula, wound infection, residual intra-abdominal abscess, acute paralytic ileus); Long-term postoperative complications (recurrent abdominal pain, residual appendicitis, and adhesive small bowel obstruction), and postoperative wound satisfaction score for follow-up data (Table 1).

Table 1 Baseline patient characteristics

Group (*n*)	OG(*n* = 102)	CG (*n* = 124)	X2/Z	*P*
Male, sex	60 (58.8%)	69 (55.6%)	0.231	0.631
Age, year	12 (11, 13)	12(11,14)	-1.621	0.105
BMI(kg/m2)	23.4 (22.0, 24.6)	23.4(22.5, 24.75)	-0.720	0.472
Time from first symptom to surgery (h)	32(25, 42.75)	33(25, 45)	-1.103	0.270
WBC count of preoperative(×10^9/L)	16.2(14.5, 17.5)	16.5(14.6, 17.8)	-0.828	0.408
CRP value of preoperative (mg/L)	46(26, 63)	46(26, 63)	-0.054	0.957

OG, Observation Group ; CG, Control Group; BMI, Body Mass Index; WBC, Body Mass Index; CRP, C-reactive protein

Inclusion criteria: Age between 8 and 14 years old; Clinical diagnosis of acute appendicitis, with ultrasound or CT showing appendiceal thickening with peri-appendiceal inflammation; The Body Mass Index (BMI) is calculated by dividing weight in kilograms by the square of height in meters for individuals of all age groups, and all results meet the criteria for overweight or obesity, specifically referring to the "Screening for Overweight and Obesity in School-Aged Children and Adolescents" published in 2018 by the People's Republic of China's health industry standards; Intraoperative discovery of appendiceal perforation, necrosis, or pericecal abscess, accompanying localized peritonitis or generalized peritonitis.

Exclusion criteria: Simple appendicitis; Acute exacerbation of chronic appendicitis; Preoperative concomitant other infectious diseases or history of surgery or trauma within 3 months; Intraoperative discovery of other concurrent diseases; Conversion to open surgery.

All surgeries were done by the same team. The study was approved by the Startup Fund for scientific research, Fujian Medical University (Approval No: 2022QH1298) and the Fujian Natural Science Foundation (Approval No:2022J011010).

Surgical techniques

The observation group underwent single-incision laparoscopic appendectomy through the umbilicus: After general anesthesia in pediatric patients, standard disinfection and draping were performed. An arc-shaped incision was made at the left side skin fold of the umbilical ring, the skin and subcutaneous tissue were cut open, and the abdominal cavity was accessed layer by layer from the medial side of the rectus abdominis muscle. A single-port base and channel were installed (Fig. 1A),

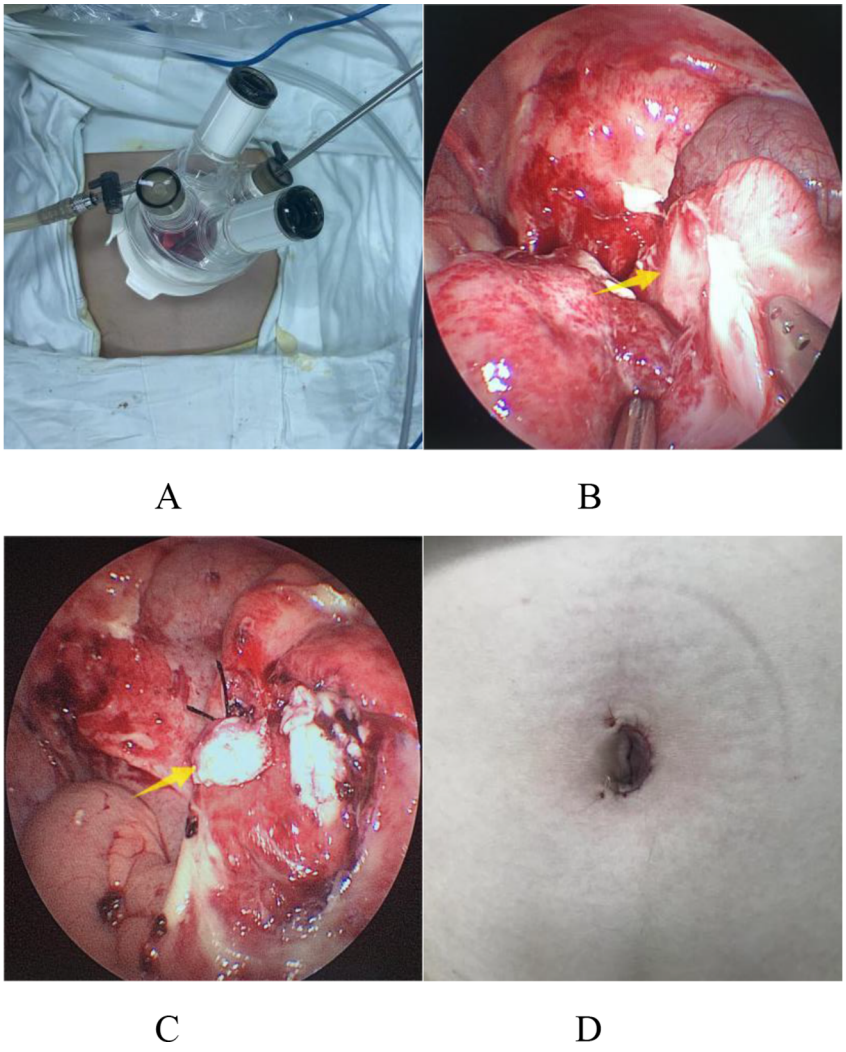

Fig. 1 Appendectomy under single-incision laparoscopy through the umbilicus **A**. Installation of single-port laparoscopic device; **B**. Intraoperative view showing appendiceal perforation, necrosis, and pericecal inflammation; **C**. Ligature of the appendiceal base with absorbable sutures; **D**. Postoperative appearance of the umbilical incision

pneumoperitoneum was established, and the patient was positioned with the head lowered and the feet elevated, tilted approximately 15–30 degrees to the left. Intraoperatively, the abdominal organs, intestinal adhesions and dilation, pelvic fluid accumulation, and appendix were explored along the mesocolon. Confirmation was made for appendiceal perforation, necrosis, or pericecal abscess (Fig. 1B). Pus was aspirated under single-port multichannel laparoscopy, and the appendix was gradually dissected free from surrounding adhesions, exposed, and its mesenteric vessels were ligated with absorbable sutures using an ultrasonic scalpel. The appendix was then dissected at its base and, if tightly adhered at the distal end, it was retrogradely excised from the base. If there was perforation at the base, the appendix was excised, and the appendiceal stump was reinforced with an 8-shaped suture at the site of normal blood supply in the ileocecal region. The appendiceal tissue was retrieved through the single-port device channel(Fig. 1C). After re-establishing the pneumoperitoneum, the base of the appendix and the condition of abdominal effusion were inspected, and any effusion was thoroughly suctioned out. After ensuring there was no active bleeding, the laparoscopic instruments and the single-port device were removed, and the peritoneum and incision were closed(Fig. 1D). The control group underwent conventional three-port laparoscopic surgery, with a 5 mm trocar inserted at the right lateral edge of the rectus abdominis muscle at the level of the umbilicus and a 10 mm trocar at the left McBurney's point. Intraoperative exploration and appendectomy were performed as in the observation group. Details of intraoperative and postoperative incisions in the observation group are shown in Fig. 1.

Table 2 Comparison of Surgical conditions between two groups

Group (*n*)	OG (102)	CG (124)	t	*P*
Operative Time (min)	68(59,70)	64.5(58,74)	-0.918	0.359
Intraoperative blood loss (ml)	10(8,11)	10(9,12)	-1.364	0.173
Duration of incision pain (d)	2(2,3)	3(2,3)	-2.876	0.004
Postoperative exhaust time (h)	12(10,14)	16(14.25,18)	-7.863	0.000
Length of stay (d)	6(6,7)	7(6,8)	-3.203	0.001

OG, Observation Group ; CG, Control Group

Observation indicators

Compare the two groups in terms of operation time, intraoperative blood loss, duration of postoperative incisional pain, time to first flatus after surgery, length of postoperative hospital stay, incisional infection rate, satisfaction with incisional appearance, and postoperative complications including incisional bleeding, incisional infection, intra-abdominal abscess, enterocutaneous fistula, and adhesive small bowel obstruction. Follow-up observations were conducted for one year postoperatively to assess the occurrence of enterocutaneous fistula, residual appendicitis, and severe intestinal obstruction.

Postoperative incision satisfaction was assessed using a Likert scale [10], including very satisfied, satisfied, neutral, dissatisfied, and very dissatisfied. The satisfaction rate was calculated as (very satisfied + satisfied) / total number of cases × 100%.

Statistical analysis

The analysis was conducted using SPSS 22.0 statistical software. For continuous data, the Shapiro-Wilk test was employed to assess normality. If the Shapiro-Wilk test yielded a p-value > 0.05, the data were considered to follow a normal distribution; otherwise, the data were deemed non-normally distributed. For normally distributed data, results were expressed as mean ± standard deviation (x ± s), and between-group comparisons were performed using independent sample t-tests. For non-normally distributed data, results were expressed as median (Q1, Q3), and between-group comparisons were conducted using the Mann-Whitney U test. Categorical data were presented as percentages (%), and between-group comparisons were carried out using the chi-square test. A p-value < 0.05 was considered statistically significant.

Results

Both the observation group and the control group successfully completed the surgeries. There were no statistically significant differences between the two groups in terms of operation time and intraoperative blood loss ($P > 0.05$). However, comparisons of hospital stay duration, duration of incisional pain, and time to first flatus after surgery revealed that the observation group had lower values than the control group, with statistically significant differences ($P < 0.05$) (Table 2).

Table 3 Comparison of postoperative complications between the two groups [n(%)]

Group (*n*)	OG(102)	CG(124)	χ^2	*P*
Incisional oozing	2 (1.96)	6 (4.84)		
SSI	3 (2.94)	8 (6.45)		
Abdominal abscess	4 (3.92)	7 (5.64)		
Intestinal fistula	0 (0.00)	0 (0.00)		
Paralytic ileus	3 (2.94)	6 (4.84)		
Total Occurrence	12 (11.76)	27 (21.77)	3.927	0.048

OG, Observation Group ; CG, Control Group; SSI, Surgical site infection

Table 4 Comparison of postoperative cosmetic result satisfaction between the two groups [n(%)]

Group (*n*)	OG(102)	CG(124)	χ2	*P*
Very satisfied	79	76		
Satisfied	17	29		
General	6	13		
Not satisfied	0	6		
Very dissatisfied	0	0		
Total satisfaction	96 (94.12)	105 (84.7)	5.069	0.024

OG, Observation Group ; CG, Control Group

Comparing the incidence of postoperative complications between the two groups, including incisional bleeding, wound infection, intra-abdominal abscess, enterocutaneous fistula, and paralytic ileus, the overall incidence of postoperative complications was lower in the observation group than in the control group, with statistically significant differences ($P < 0.05$) (Table 3). Both groups were followed up for one year postoperatively, with no occurrences of recurrent abdominal pain, residual appendicitis, or severe adhesive ileus.

Comparison of postoperative cosmetic result satisfaction between the two groups showed that the observation group was higher than the control group, with statistically significant differences ($P < 0.05$) (Table 4).

Discussion

Acute appendicitis is one of the most common acute abdominal emergencies in general surgery, which can occur at any age, especially in adolescents. Often, signs of peritonitis are already present at the time of consultation. Conservative treatment at this stage is lengthy with moderate efficacy, and there is a high risk of perforation leading to worsening of the condition. Therefore, surgical treatment should be prioritized [11]. With the continuous development and innovation of laparoscopic minimally invasive techniques, the treatment of appendicitis has transitioned from open surgery to laparoscopic surgery. Initially, from three-port laparoscopic surgery to single-incision or single-port laparoscopic surgery, minimizing surgical trauma, optimizing aesthetic outcomes,

speeding up recovery, reducing complications, and improving the surgical experience [12].

In clinical practice, for complex appendicitis in overweight or obese patients, most often the three-port laparoscopic surgical approach is chosen [13–15]. This decision primarily considers the thickening of the abdominal wall fat and concerns regarding incisional infections. However, based on the author's experience, the application of single-port laparoscopy in these patients does not increase the risk of incisional infections [16–18]. Incisional infections generally stem from contamination of the abdominal wall channel during appendiceal specimen retrieval. The single-port device can isolate contact between the abdominal wall and the appendix and provide sufficient space for specimen retrieval. Retrieving complex appendices with a diameter exceeding 10 mm during three-port laparoscopic surgery can be particularly challenging and may lead to appendix rupture, contaminating the abdominal wall or cavity with pus, thereby increasing the risk of incisional infections or intra-abdominal abscesses. Additionally, in overweight or obese patients with thickened abdominal wall fat, inserting the trocar or puncture sheath during three-port laparoscopic surgery can be relatively difficult. In such cases, single-port laparoscopic surgery allows for direct visualization and stepwise entry into the abdominal cavity, reducing the risk of abdominal cavity injury associated with punctures.

For overweight or obese adolescents with complicated appendicitis, undergoing single-incision laparoscopic appendectomy via the umbilicus, the author has summarized their surgical experiences as follows: First, selection of umbilical incision: Choosing a left-sided circumumbilical incision with a circumference of approximately half of the umbilical ring is recommended. Due to the deeper umbilical fossa in obese children, the incision should be placed closer to the inner side or along skin creases. Postoperatively, the incision should be closed with intracutaneous sutures for better concealment and aesthetics. Utilizing the natural anatomical advantage of the umbilicus, the incision allows for a layered entry into the abdominal cavity from the medial aspect of the rectus abdominis muscle, minimizing muscle irritation and damage, thus reducing postoperative pain. Compared to the multi-port approach, the single umbilical incision results in a smaller perceived area of pain for the patient, contributing to a better surgical experience. Second, chopstick effect in single-port laparoscopy: The close proximity of the camera and instrument shafts passing through the same channel creates a chopstick effect, necessitating skilled coordination between the surgeon and assistant [19]. The assistant's scope should lag behind the surgeon's operative forceps, positioned centrally between the two operative forceps. Gentle and steady advancement of the operative maneuvers is recommended to avoid overreaching. Third, handling of the appendiceal mesentery and base during surgery: Given the varied morphology of the appendix in complicated appendicitis, careful identification and handling of the appendiceal mesentery, especially in cases of congested and severely adherent tissue, are crucial to prevent inadvertent injury to adjacent structures such as the ureter and bowel. In cases of appendiceal base perforation, options include base closure or purse-string closure; for non-perforated bases, ligature with absorbable sutures is preferred to avoid premature detachment of the appendix and subsequent fistula formation. The appendix was disassembled with an ultrasonic knife and removed directly from a single orifice channel without the need for a bag. Fourth, management of intra-abdominal pus: A three-step approach is employed for handling intra-abdominal pus during surgery. Firstly, after induction of anesthesia, the patient is positioned in a head-up, feet-down tilt to facilitate drainage, and intra-abdominal pus, particularly from the pelvic region, is aspirated upon entry of the laparoscope. Secondly, a left lateral tilt with head-down, feet-up positioning is adopted for appendectomy, with prompt suction of any surrounding exudate. Finally, following appendectomy, thorough inspection and aspiration of intra-abdominal spaces, including perihepatic recesses and the pelvic floor, are conducted to ensure complete drainage. Both groups of cases did not have abdominal drainage tubes placed, except for those who could not have their appendix removed during surgery and underwent simple abdominal drainage.The placement of intra-abdominal drainage tubes is not advocated, as observed in our study cohort, with one case in the observation group and three cases in the control group developing postoperative intra-abdominal abscesses, likely attributed to the severity of preoperative intra-abdominal inflammation. Among the control group, two cases with significant pelvic fluid underwent ultrasound-guided percutaneous drainage, with drainage tubes removed five days postoperatively, while the remaining two cases of intra-abdominal abscesses resolved following antimicrobial therapy with subsequent absorption of pus.

In this study, the observation group showed shorter hospital stays, duration of incision pain, and postoperative gas discharge time compared to the control group. The analysis attributes this to the less pronounced pain at the umbilical incision site in single-port laparoscopy, early mobilization of pediatric patients, and faster intestinal recovery, resulting in shorter hospital stays. As for postoperative SSI, single-port laparoscopy allows for larger specimen retrieval through a single port, whereas in three-port laparoscopy, retrieving significantly swollen appendix specimens can lead to secondary rupture, contamination of the abdominal wall channel by pus, and subsequent

infection. On the other hand, direct spread of intraperitoneal pus may contaminate the abdominal wall channel and cause incisional infection. For such patients, specimen retrieval requires the use of retrieval bag inserted into the channel before retrieval. If the specimen is excessively swollen, the incision may be appropriately extended to avoid repeated squeezing of the specimen, which could lead to pus extravasation [20].Of course, the cost of single-incision surgery will be slightly higher than that of three-port surgery, but it is still within the family's affordability.

In conclusion, for adolescents with complicated appendicitis who are overweight or obese, single-incision laparoscopic surgery can be utilized for treatment, offering advantages such as minimal trauma, fast recovery, fewer complications, and aesthetic incisions, providing patients with a better surgical experience. However, limitations of this study include a small number of cases, short follow-up duration, and being a single-center study. Future efforts should focus on expanding the sample size, prolonging the follow-up period, and participating in multicenter studies to further validate the findings.

Author contributions

Zhixiang Xiao and Lijing Wu wrote the main manuscript text, Jun Li and Shaohua He and Jingyi Chen prepared Fig. 1, Lizhi Li and Di Xu prepared Tables 1, 2, 3 and 4. Yingquan Kang is the main surgeon of these surgeries. All authors reviewed the manuscript.

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The retrospective medical review was approved by the institutional review board (IRB) of the Fujian Provincial Hospital.And the study was performed in accordance with the principles stated in the Declaration of Helsinki. All patients were managed with standard of care; and the parents or guardians of the patients were thoroughly informed about the procedure, its associated risks, and complications before the surgery. The study obtained informed consent from parents or legal guardians of all participants under the age of 16.

Consent for publication

All data in this study do not involve patient sensitive information, so this section is not applicable.

Competing interests

The authors declare no competing interests.

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