World Journal of Gastroenterology

Submit a Manuscript: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.3748/wjg.v20.i39.14338

World J Gastroenterol 2014 October 21; 20(39): 14338-14347
ISSN 1007-9327 (print) ISSN 2219-2840 (online)

TOPIC HIGHLIGHT

WJG 20th Anniversary Special Issues (15): Laparoscopic resection of gastrointestinal

Laparoscopic treatment of perforated appendicitis

Heng-Fu Lin, Hong-Shiee Lai, I-Rue Lai

Heng-Fu Lin, Department of Surgery, Far-Eastern Memorial Hospital, Taipei 220, Taiwan
Heng-Fu Lin, Department of Emergency Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei 100, Taiwan
Hong-Shiee Lai, I-Rue Lai, Department of Surgery, National Taiwan University Hospital, Taipei 100, Taiwan
I-Rue Lai, Department of Anatomy and Cell Biology, Medical College, National Taiwan University, Taipei 100, Taiwan
Author contributions: All the authors contributed to this manuscript.
Correspondence to: I-Rue Lai, MD, PhD, Department of Surgery, National Taiwan University Hospital, No 7, Chung-Shan South Rd, Taipei 100, Taiwan. iruelai@gmail.com
Telephone: +886-2-23123456 Fax: +886-2-23915292
Received: November 15, 2013 Revised: December 18, 2013
Accepted: May 29, 2014
Published online: October 21, 2014

Key words: Perforation; Laparoscopic appendectomy; Intra-abdominal abscess; Cost

Core tip: Appendicitis is the most common abdominal emergency, and the perforated appendicitis often leads to serious infectious complication. There are concerns of using laparoscopic appendectomy to perforated appendicitis This article reviewed the recent progress and concerns in using laparoscopic appendectomy for treating perforated appendicitis.

Lin HF, Lai HS, Lai IR. Laparoscopic treatment of perforated appendicitis. *World J Gastroenterol* 2014; 20(39): 14338-14347 Available from: URL: http://www.wjgnet.com/1007-9327/full/v20/i39/14338.htm DOI: http://dx.doi.org/10.3748/wjg.v20.i39.14338

Abstract

The use of laparoscopy has been established in improving perioperative and postoperative outcomes for patients with simple appendicitis. Laparoscopic appendectomy is associated with less wound pain, less wound infection, a shorter hospital stay, and faster overall recovery when compared to the open appendectomy for uncomplicated cases. In the past two decades, the use of laparoscopy for the treatment of perforated appendicitis to take the advantages of minimally invasiveness has increased. This article reviewed the prevalence, approaches, safety disclaimers, perioperative and postoperative outcomes of the laparoscopic appendectomy in the treatment of patients with perforated appendicitis. Special issues including the conversion, interval appendectomy, laparoscopic approach for elderly or obese patient are also discussed to define the role of laparoscopic treatment for patients with perforated appendicitis.

INTRODUCTION

Laparoscopic appendectomy (LA) is a safe and effective procedure for the treatment of simple appendicitis. Laparoscopic approach is superior to open appendectomy (OA) in terms of postoperative wound infections, analgesia requirement, hospital length of stay (LOS), return to work, and overall recovery[1,2]. With the accumulated experience in simple appendicitis, LA has been attempted more frequently for treating perforated appendicitis. In our retrospective, comparative study, 91 of 99 patients with perforated appendicitis were treated successfully by LA, and the wound infection rate (15.2%) was lower than that of the OA group (30.7%)[3]. Similar favorable outcomes in terms of LOS, antibiotic usage, return of oral intake, and rate of wound infection of LA than OA for patients with perforated appendicitis were shown, too[4-6]. However, the higher incidence of intra-abdominal abscess (IAA) formation following the uses of laparoscopy for perforated appendicitis were reported[7-9], which remained a major concern in using LA

for perforated appendicitis[10-12]. Compared to OA, the beneficial role of LA for perforated appendicitis is still controversial. This literature review summarized the past and the current status on the effectiveness and outcomes of LA in compared to OA for perforated appendicitis. We search the website for original articles whose keywords included laparoscopic, appendicitis, and perforation. Case reports or case series which lack in a control group for comparison were excluded from this review.

TREND AND TECHNIQUE OF LA TO TREAT PERFORATED APPENDICITIS

Use of laparoscopy for perforated appendicitis: Increased

With the advance of laparoscopic instruments and accumulated experience in using LA for uncomplicated appendicitis, LA has been more frequently used for perforated appendicitis. Nationwide studies in United States demonstrated that utilization rate of LA for perforated appendicitis increased from 45.0% in 2006 to 50.5% in 2008 for adults[6], and from 9.9% in 1999 to 46.6% in 2007 for children[13] Another nationwide population-based study in Taiwan also illustrated that the increased use of LA for both simple and perforated appendicitis from 2001 to 2008[14]. Besides, reports showed that the use of LA on females increased, although the majority of patients were males[6,15,16].

Who uses LA to treat perforated appendicitis: Surgeons' characteristics

In the establishment of a new technique for treating an old disease, the surgeons' training and decisions are always important. In Taiwan, LA was more popularly used to treat uncomplicated and complicated appendicitis by surgeons younger than 50 years, by surgeons who practice in urban rather than rural areas, and by surgeons in teaching rather than district hospitals[15]. The same happened in United States where surgeons recertifying after 10 years performed more laparoscopic procedures, when compared with those recertifying after 20 or 30 years[17]. The training of using laparoscopic surgery in their residency might account for these characteristics.

Is single-port better than multiport technique?

The most common approach of LA is by a multiport laparoscopic technique, whether the appendix perforated or not. Further efforts to minimize the invasiveness of the procedure led the idea of performing a single-port LA. With the recent development of multichannel, single-port articulating and curved instruments, successful single-port LA have been reported in adult[18] and pediatric patients[19,20]. Kim *et al*[18] had performed a successful single-port procedure for 2 perforated appendicitis in 43 adult patients. Although the rate of conversion to multi-port was high (25% need additional trocars) and technically demanding, Muensterer *et al*[19] still considered single-port approach is achievable for children with perforated appendicitis. However, most of the perforated appendicitis cases were not diagnosed preoperatively in these series. The feasibility of using single port LA for perforated appendicitis remains undetermined. At present, multiport approach technique is still the choice of approach for patients with perforated appendicitis.

Methods of the appendiceal stump closure

The insecure management of the appendiceal stump is one of the most important causes that lead to the formation of IAA when treating appendicitis. Different techniques including endoclips, endoloops, or staplers have been used for secure ligations of appendiceal stumps while performing LA[21]. Staplers have the advantage of relatively easy handling and a possible reduction in the incidence of leakage in advanced appendicitis owing to closure with a double row of staples[22]. Kazemier *et al*[23] reported that using a stapler for an appendiceal stump is safer than an endoloop: because there is an evident reduction in operation time, wound infection, and postoperative ileus. Similarly, Beldi *et al*[24] reached the conclusion in a study of 6489 patients that stapler usage is safer than endoloops in terms of IAA formation and readmission. On the other hand, using endoloops is advantageous in reducing medical costs because they are 6 to 12 times cheaper than stapling devices. Concerns of using an endoloop in perforated appendicitis included first, it takes good surgical technique to settle a knot and adjust the strain in laparoscopic procedure; Second, the risks of stump leakage by using endoloops may be higher, because the fragile, necrotic appendiceal tissue might not sustain the ligature. Sahm *et al*[25] showed that the rate of IAA after using endoloops or staplers for perforated appendicitis is not significantly different with the use of staplers in the majority of patients (3.5% *vs* 4.2%, $P = 0.870$), and staplers were indicated in only a few patients. The decision of using an endoloop or a stapler for appendiceal stump closure in perforated appendicitis needs more studies.

Efficacy of peritoneal lavage

The practice of peritoneal lavage for the management of perforated appendicitis was common, only 7% the respondents in the survey of North American pediatric surgeons in 2004 reported using no irrigation[26]. However, the efficacy of lavage remains a controversy. The pros suggest that thorough lavage under laparoscopic guide before closing the wound decrease residual fluid accumulation in patients with perforated appendicitis[3]. Ohno *et al*[27] has shown a large amount of lavage fluid is necessary to minimize residual contamination in perforated appendicitis. The European guideline also recommended thorough peritoneal lavage (6-8 L) and aspiration can minimize the IAA rate in complicated appendicitis[28]. In contrast, the cons proposed that lavage itself might help spreading the infectious materials. One comparative study documented a higher abscess rate when irrigation was used during appendectomy for perforated appendicitis including LA[29]. A prospective randomized study for children also showed that there is no advantage to

Table 1 Summary of the population-based studies on the mortality and morbidities for patients with perforated appendicitis in United States

Study	Patient numbers	Mortality	Overall morbidities	30-d readmission	Wound infection	IAA	Bowel obstruction
Tuggle *et al*[12]	LA: 2060 OA: 730	LA: 0.54% OA: 1.11% (P = 0.11)	-	-	LA: 2.56%[b] OA: 8.05%	LA: 6.74%[b] OA: 3.69%	-
Tiwari *et al*[16]	LA: 5212 OA: 5323	LA : 0.13%[b] OA: 1.03%	LA: 17.43%[b] OA: 26.68%	LA: 5.04% OA: 5.93% (P = 0.05)	-	-	-
Masoomi *et al*[6]	LA: 69840 OA: 68344	LA: 0.06%[b] OA: 0.31%	LA: 18.75%[b] OA: 26.76%	-	LA: 0.58%[b] OA: 2.09%	LA: 1.65%[b] OA: 3.57%	LA: 1.24%[b] OA: 2.84%
Oyetunji *et al*[13]	Total 72787 LA: 29.2% OA: 70.8%	-	-	-	-	LA: 4.9% OA: 3.8%	-
Jen *et al*[45]	LA: 9246 OA: 21347	-	-	LA: 6.3% OA: 6.9% (P = 0.16)	LA: 5.5% OA: 6.4% (P = 0.02)	-	LA: 2.0% OA: 2.6% (P = 0.02)

[b]P < 0.01 *vs* perforated appendicitis (OA) group. LA: Laparoscopic appendectomy; IAA: Intra-abdominal abscess.

irrigation of the peritoneal cavity over suction alone during LA for perforated appendicitis, for the rate of IAA was similar (18.3% *vs* 19.1%, P = 1.0) but the operation time was longer[30]. The necessity of peritoneal irrigation in LA for perforated appendicitis remains debatable.

Routine abdominal drainage

To reduce fluid collections and thus reduce postoperative intra-abdominal infectious complications, drains have been routinely used in various abdominal surgeries. There are two different intentions to drain the abdominal cavity in the setting of emergency surgery, therapeutic and prophylactic[31]. Placement of a drain tube after LA for perforated appendicitis consisted of both to evacuate the residual abscess and prevent recurrent IAA. The positioning of a drain for the aspiration of the residual fluid after peritoneal lavage in the first 24 h postoperatively might lower the incidence of IAA in case of insufficient lavage. Routine prophylactic drainage of the abdominal cavity after LA has been a common practice in order to prevent abscess formation in case of perforation with pre-existing abscess[32], but this concept has been challenged. Sleem *et al*[5] has found placement of a pelvic drain did not reduce the rate of IAA at the time of LA or OA. Allemann *et al*[33] showed that patients without drain had significantly less overall complications (7.7% *vs* 18.5%, P = 0.01) and a shorter hospital LOS (4.2 *vs* 7.3 d , P < 0.0001) in their case match study. Similarly, Pessaux *et al*[32] also reported increased wound infection rates after drainage of the abdominal cavity during laparoscopic interventions. It seems that routine drainage of the abdominal cavity for complicated appendicitis might not be not routine, because the intentions to reduce intra-abdominal infections were questioned[32,33].

SAFETY OF USING LA TO TREAT PERFORATED APPENDICITIS

Conversion of laparoscopy to an open procedure for perforated appendicitis

Laparoscopic treatment of perforated appendicitis is technically more demanding and has been associated with a higher conversion rate than treating uncomplicated appendicitis[34-36]. The conversion rates from LA to OA from 0% to 47% have been reported[3-4,11,36-39] and correlated with the surgeon's experience[36]. The conversion rate did have an impact on the outcomes analysis between LA and OA for perforated appendicitis. A higher conversion rate would place more patients undergoing converting appendectomy into the LA group because the use of "intention to treat" analysis. In this case, the advantages of LA than would be underestimated[21]. Piskun *et al*[39] found a 19.2% conversion rate of patients undergoing LA for perforated appendicitis and concluded that conversion is associated with longer operation time and increased rates of morbidities. Vahdad *et al*[40] demonstrated that pediatric patients who required a conversion procedure take a longer operation time and carry higher risks of re-admissions, re-operations, and occurrence of wound infections compared to either LA or OA. These results might be simply explained by the presence of more severe inflammation in the conversion groups or an impact of a longer operation time. It deserves further studies to assess the actual role of the conversion procedure on the outcomes of patients with perforated appendicitis.

Surgical mortality

The results of population-based studies from United States regarding postoperative mortality and morbidities were listed in Table 1. As shown in Table 1, Masoomi *et al*[6] reported that the in-hospital mortality rate was significantly lower for LA than OA for perforated appendicitis, so as Tiwari *et al*[16]. The study by Tuggle *et al*[12] illustrated a not significantly lower mortality rate of LA compared to OA (0.54% *vs* 1.11%, P = 0.11) The small mortality and the small differences in percentage between the two procedures can be attributed to the fact that appendicitis is not commonly a fatal disease for adult patients.

Overall morbidities

Early studies on LA often reported higher complication

rates for LA than OA[41,42], but recent studies have noticeably found LA to have lower complication rates than OA[21]. The rates of overall postoperative morbidities for perforated appendicitis with LA has been shown to be consistently lower than OA, varied from 12.8% to 39.5% for LA and 26% to 37% for OA[3,11,36]. As shown in Table 1, Tiwari *et al*[16] showed a 9.2% reduction of the overall complication rates by LA than OA (17.43% *vs* 26.68%, $P < 0.001$). Similarly, Masoomi *et al*[6] also illustrated that the overall frequency of postoperative complications was significantly lower for LA than OA for perforated appendicitis.

30-d readmission rate

Since Bonanni *et al*[8] reported 5 of 11 patients who underwent LA for perforated appendicitis required readmission, the 30-d readmission rate after discharge remained a concern in LA for perforated appendicitis. For children, Vahdad *et al*[40] have shown that LA resulted in fewer readmissions (1.3% *vs* 12.3%, $P = 0.006$) compared to OA. As shown in Table 1, Tiwari *et al*[16] also reported a relatively less 30-d readmission rate in LA compared to OA (5.04% *vs* 5.93%, $P = 0.050$). Wang *et al*[15] showed that patients undergoing LA had significantly lower odds of 30-d readmission than patients undergoing OA for perforated appendicitis. Consistent with the results in reducing the postoperative complications, most recent studies concluded a lower 30-d readmission rate for perforated appendicitis in LA than OA[15,16,40].

INFECTIOUS COMPLICATIONS

Wound infection rate

Most of the studies reported that LA reduced the postoperative wound infection rate than OA in adults[2-6,11,12,36,38] and children[10,40,43-45] with perforated appendicitis. The wound infection rates in the reported series were 0% to 15% for LA, compared to 2% to 48% for OA[21]. The contamination of the perforated appendix or infected discharge of the incision wounds may explain the higher wound infection rate in treating complicated appendicitis than in simple appendicitis. In practice, the removed appendix is placed in an endoscopic bag before retrieved out of abdomen, and the accumulated fluid is aspirated before closing the wound in laparoscopic appendectomy procedure. These maneuvers prevent the abdominal wall from being in contact with the infected source, and thus reduce the rate of wound infection[4].

Intra-abdominal abscess rate

A major concern in earlier studies about using LA for perforated appendicitis was the increased occurrence of IAA. The occurrence of IAA leads to prolonged antibiotic usage, increased rate of readmission, and increased medical costs. Frazee *et al*[7] reported 26% IAA in 34 cases of gangrenous perforated appendicitis treated by LA. As experience in using LA for perforated appendicitis accumulated, the occurrence of postoperative IAA has improved. Some studies have shown the rates of postoperative IAA is similar[3-5,10-11,36-38,40,43] or even lower[6,46] in LA compared to OA. Masoomi *et al*[6] also reported a superior outcome of reducing the rate of IAA in LA than OA (1.65% *vs* 3.57%, $P < 0.01$) on a large administrative basis. However, the incidences of IAA following LA for perforated appendicitis were still high in some recent reports[12,45,47]. The risk factors associated with IAA formation after LA include the methods of the appendiceal stump closure, efficacy of peritoneal irrigation, and the role of routine abdominal drainage which have been discussed in the previous sections.

NON-INFECTIOUS COMPLICATION (SMALL BOWEL OBSTRUCTION)

Small bowel obstructions (SBO) can occur following any abdominal surgery secondary to adhesion formation. SBO following appendectomy has been thought to be uncommon with the rate to be approximately 1%[48]. Leung *et al*[49] reported a 2.8% rate of SBO following 1777 appendectomy in over an average 4.1-year follow-up period. The authors found that the risk factors of developing SBO included perforated appendicitis, but did not find significant difference in SBO rates following LA compared with OA. However, as shown in Table 2, Masoomi *et al*[6] found that application of LA for perforated appendicitis was associated with a lower rate of SBO than OA (1.24% *vs* 2.84%, $P < 0.01$). A pediatric study by Tsao *et al*[50] demonstrated that 7 (6 perforated) patients required adhesiolysis for SBO after OA, in contrast to 1 patient after LA ($P = 0.01$). The authors argued that LA may be associated with less adhesion formation for patients with perforated appendicitis, and hence a lower rate of SBO. As shown in Table 1, Jen *et al*[45] also demonstrated a lower rate of postoperative SBO in LA than OA.

EFFICIENCY AND COST IN USING LA TO TREAT PERFORATED APPENDICITIS

Impact of surgical procedures on duration of operation

Most studies for adults suggested that LA has a similar[2,36,37] or longer[3,11,39] operation time than OA, while few reported a shorter operation time[4,38]. The disparity in the results of these reports may be attributed to the surgeons' experience in LA and the effect of a learning curve[21].

Although the majority of reports illustrated a longer operation time for LA[44,51,52], some studies concluded that there is no difference in operation time between LA and OA for children with complicated appendicitis[40,53]. Increased experience of the pediatric surgeons in LA for perforated appendicitis could explain the lack of a significant difference in operation time[53]. The issue of operation time between LA and OA for perforated appendicitis is in debate, both for the adult and pediatric

Table 2 Population-based studies of patients with perforated appendicitis in United States: Profiles of study, length of stay, and medical costs

Study	Patient population	Data source	Study period	Patient numbers	Length of hospital stay, d	Medical costs, USD
Tuggle *et al*[12]	Adults	NSQIPD	2005-2007	LA: 2060, OA: 730	LA: 3.97[b] OA: 5.13	-
Tiwari *et al*[16]	Adults	UHCD	2006-2008	LA: 5212 OA: 5323	LA: 4.34[b] OA: 7.31	LA: 12125[b] OA: 17594
Masoomi *et al*[6]	Adults	NISD	2006-2008	LA: 69840 OA: 68344	LA: 4.0[b] OA: 6.0	LA: 32487[b] OA: 38503
Oyetunji *et al*[13]	Children < 18 yr	HCUP	1998-2007	Total: 72787 LA: 29.2% OA: 70.8%	LA: 5.06[b] OA: 5.60	LA: 27951[b] OA: 24965
Jen *et al*[45]	Children < 18 yr	CAPDD	1999-2006	LA: 9246 OA: 21347	LA: 5.2[b] OA: 5.5	-

[b]$P < 0.01$ *vs* perforated appendicitis (OA) group. NISD: Nationwide Inpatient Sample Database; UHCD: University Health System Consortium Database; HCUP: Healthcare Cost and Utilization Project; CAPDD: California Patient Discharge Database; NSQIPD: (American College of Surgeon's) National Surgical Quality Improvement Project Database; LA: Laparoscopic appendectomy; IAA: Intra-abdominal abscess.

patients.

DOES A PATIENT UNDERGOING LAPAROSCOPIC TREATMENT OF PERFORATED APPENDICITIS HAVE A FASTER RECOVERY?

Postoperative analgesia

Some studies showed the value of LA in reducing the postoperative analgesics use, and concluded that LA cause less pain than OA for adult patients with perforated appendicitis[3,4,11]. In contrast, most of the reports for children operated on by LA showed no difference[54,55]. It is difficult to form a conclusion because lack in a pain scoring system in most of these reports.

Restart of oral intake

While some studies have shown that there was no significant difference in the time of restart of oral intake between LA and OA for children with perforated appendicitis[10,55], Lin *et al*[3] illustrated that return of oral intake was 1.8 d earlier in LA than OA in adult patients. Fukami *et al*[4] and the other series[11,36] also demonstrated the same trend. However, lack in a precise definition of restart of oral intake (liquid or solid food) in these studies precluded a further analysis.

Length of hospital stay

Similar to the results of uncomplicated appendicitis treatment[56], LA was reported to reduce the hospital LOS either in adults[3-4,11,38,57] or in children[10,58,59] with perforated appendicitis. Because most of these case series were performed by surgeons experience in laparoscopy, it is prudent to assess LOS by analyzing studies on a large administrative basis. Yeh *et al*[14] concluded LA was associated with comparable costs and reduced LOS for patients with complicated appendicitis when compared with OA. Another population-based study in Taiwan also showed that patients undergoing LA for perforated appendicitis had significantly lower odds of 30-d readmission and a shorter LOS than patients undergoing OA[15]. As shown in Table 2, several nationwide population-based studies from United States including adult[6,12,16] and pediatric[13] patients assessed the impact of laparoscopic treatment on LOS for perforated appendicitis. Masoomi *et al*[6] has analyzed a total of 573244 adults undergoing urgency appendectomy from the Nationwide Inpatient Sample Data. They concluded that the difference in LOS was much more pronounced than non-perforated (0.7 d) where LA was shorter than OA by 2 d (4.0 d *vs* 6.0 d, $P < 0.01$) for perforated appendicitis. All these studies concluded that LA was associated with a shorter hospital LOS compared to OA for perforated appendicitis[6,12,13,16].

Medical cost

When examining the medical costs, some early studies found that the total hospital charges of LA were higher than OA[60,61]. Factors contributing to the higher operative costs of LA consisted of disposable laparoscopic instruments, high energy devices, and equipments for securing the appendiceal stumps. Both the in hospital costs and outpatient costs have to be considered in economical evaluation. In Germany, the health technology assessment reports concluded that the total in-patient costs of both procedures are approximately the same. They found that LA is associated with additional operation costs of approximately 150 to 200 Euro in comparison with OA, and there are cost savings of approximately 200 Euro due to shortening the hospital LOS. The total costs of both procedures lie in the same range because similar direct and indirect costs (costs of the productivity loss). The incremental cost-effectiveness ratio of LA and OA was thus driven to zero[62].

In other countries, studies for adults[14] and children[13] have demonstrated that LA was associated with comparable costs and reduced LOS for complicated appendicitis. Moreover, as shown in Table 2, Tiwari *et al*[16] and Masoomi *et al*[6] concluded that reduced medical costs for perforated appendicitis in LA than OA in their popula-

Table 3 Summary of 2 population-bases studies for elderly patients with perforated appendicitis

Study	Harrell *et al*[76]	Masoomi *et al*[6]
Study period	1997-2003	2006-2008
Data source	NCHAPD	NISD
Patient numbers	LA: 203, OA: 1289	LA: 13765, OA: 18915
Length of hospital stay, d	LA: 6.8, OA: 9.0[b]	LA: 5.8, OA: 8.7[b]
Routine discharge	LA: 86.6%, OA: 70.9%[b]	-
Mortality	LA: 1.0%, OA: 2.98% (P = 0.10)	LA: 1.4%, OA: 2.63%[b]
Overall complication rate	LA: 23.65%, OA: 23.74% (P = 0.97)	LA: 36.27%, OA: 46.92%[b]
Surgical charge, USD	LA: 22334, OA: 23855 (P = 0.93)	LA: 47339, OA: 57963[b]

[b]$P < 0.01$ *vs* perforated appendicitis (OA) group. NISD: Nationwide Inpatient Sample Database; NCHAPD: North Carolina Hospital Association Patient Data; LA: Laparoscopic appendectomy.

tion-based studies. Despite the actual impact of LA on the medical costs vary in different regions, there is a definite economic benefit from a patient-centered social perspective with a shorter hospitalization and quicker return to daily activities[63].

SPECIAL CONSIDERATIONS

Laparoscopic interval appendectomy for perforated appendicitis with phlegmon

Appendiceal abscess or phlegmon is found in about 3.8% of patients with appendicitis[64]. The management of patients with perforated appendicitis with a sizeable inflammatory phlegmon is usually conservative. Immediate appendecotmy is technically demanding with distorted anatomy, adhesive loops of bowel, and difficult to close the appendiceal stump because of the inflamed tissues[65]. Not infrequently, early laparoscopic treatment will become open conversion, ileocecal resection, or right hemicolectomy due to technical problems or distorted anatomy[66]. An alternative treatment for these patients is nonsurgical, including intravenous antibiotics and selective percutaneous drainage. Interval appendectomy has been advocated to prevent the recurrence of appendicitis and reported feasible (mostly LA) by some surgeons[67,68]. The advantage of the interval appendectomy is to perform the operation at a time when peritoneal contamination has resolved, potentially resulting in fewer intraoperative and/or postoperative complications[64]. However, the superiority of early LA over interval LA has been shown in some recent reports[69,70]. One pilot randomized trial found no major differences in outcomes when comparing early LA with interval LA in patients with well-formed IAA[69]. In a randomized study for children with appendiceal phlegmon, Blakely *et al*[70] concluded that early LA significantly reduced the time away from normal activities and the rates of overall adverse events than interval LA, with a comparable conversion rate to OA. Lastly, a study by Schurman *et al*[71] illustrated that families managed with interval LA are likely to suffer more negative impact on the quality of life than those managed with immediate LA. Based on these results, the issue of whether interval LA is superior to early LA for an appendiceal phlegmon remains a topic of debate.

GERIATRIC PATIENTS

As the size of the elderly population has been increasing, an increase in the occurrence of appendicitis in the elderly can be expected. A higher perforation rate in the geriatric population than younger age groups presented a challenge to surgeons[72]. The rate of perforation appendicitis has been reported as high as 50% in the elderly patients with appendicitis[73] . The high perforation rate in the elderly may attribute to the delay in diagnosing appendicitis, atypical presentations and underlying comorbidities in elderly patients[73]. Paranjape *et al*[74] has reported that the classical presentation of appendicitis was seen in only 10% of the elderly patients. Diagnostic discrepancies greatly influence the perforation rate of appendicitis in the geriatric population. In a retrospective analysis of 113 elderly patients, Storm-Dickerson *et al*[72] showed a decreased perforation rate over 10 years from 72% to 51% by utilizing computed tomography (CT) scanning on seriously ill patients for early diagnosis. Besides, Italian consensus guidelines on LA also recommended the routine use of preoperative CT for elderly patients to exclude other pathology[75].

The utility rate of LA for perforated appendicitis in elderly patients (age ⩾ 65 years) has been increasing, but still lower than those in younger age groups[73,76]. The use of pneumoperitoneum which might compromise the cardiopulmonary co-morbidities of the elderly, and the longer operation time might be the main concerns that surgeons favored open rather than laparoscopic appendectomy in this patient population. There were a few studies reporting the outcomes of LA to OA in the elderly population[2,14,74,76]. Paranjape *et al*[74] recommended using preoperative CT to increase the diagnosis rate, and they successfully performed LA for 18 of 29 elderly patients with perforated appendicitis. They concluded that laparoscopic cases had a shorter LOS and fewer complications than open cases with comparable operation time[2,14,74,76]. In 2006, Harrell *et al*[76] reported that the elderly patients treated by LA for their perforated appendicitis had a shorter LOS, a higher rate of discharge to home and equivalent cost when compared with OA. In another population- based study, Masoomi *et al*[73] reported the increased use of LA, the lower overall mortality and complication rates, shorter LOS, and less hospital costs than OA for treating perforated appendicitis in the selected patients elder than 65 year-old. Table 3 summarizes the results of 2 large studies comparing the outcomes between LA and OA for the management of elderly patients with perforated appendicitis. The utility of LA in elderly patients with perforated appendicitis

Table 4 Summary of 2 population-bases studies for obese patients with perforated appendicitis

Study	Varela *et al*[80]	Masoomi *et al*[6]
Study period	2002-2007	2006-2008
Data source	UHCD	NISD
Patient numbers	LA: 238, OA: 441	LA: 6769, OA: 7110
Definition of obesity	BMI ≥ 40 kg/m^2	BMI ≥ 30 kg/m^2
Length of hospital stay, d	LA: 5, OA: 7[b]	LA: 4.4, OA: 6.5b
Mortality	LA: 0%, OA: 0%	LA: 0%, OA: 0.50%[b]
Overall complication rate	LA: 18%, OA: 27%[b]	LA: 22.34%, OA: 34.65%[b]
Mean costs, USD	LA: 12300, OA: 16600[b]	LA: 36483, OA: 43901[b]

[b]$P < 0.01$ *vs* perforated appendicitis (OA) group. NISD: Nationwide Inpatient Sample Database; UHCD: University Health System Consortium Database; LA: Laparoscopic appendectomy; BMI: Body mass index.

deserves further studies.

OBESE PATIENTS

Obesity is now an epidemic problem worldwide. Surgeons were once reluctant to perform laparoscopic procedures on obese patients for difficulties including the access of abdominal entry, inflation-related ventilation problem, poor visualization for the intra- abdominal fat, longer operation time[77] and also the higher pre-operative sepsis rate[78].

With the advancement of laparoscopic skills, surgeon gradually favored using LA rather than OA on obese patients with appendicitis. Corneille *et al*[79] reported their successful LA in 73 of 85 patients with BMI more than 30, though 4 of the 12 converted LA had perforated appendicitis[79,80]. Varela *et al*[80] reported the cumulated experience of LA in 906 morbid obesity patients with appendicitis, and found that LA was associated with less overall complication, shorter hospital stay and equivalent or lower hospital charges when compared to OA. However, limited data was available for the use of LA in obese patients with perforated appendicitis. Table 4 showed the results of 2 population-based studies of using LA for obese patients with perforated appendicitis. Compared to OA, the overall complication rate and costs were lower in the LA group[80]. Another subgroup analysis using the database of American College of Surgeons National Surgical Quality Improvement Program also showed that the overall morbidity was lower in obese patients receiving LA[78]. Although the superiority of LA seems obvious in these studies, the selection bias existed. A randomized trial would be more informative to define the role of LA on obese patients with perforated appendicitis.

CONCLUSION

With the accumulated experience in simple appendicitis, LA has been more frequently used for perforated appendicitis in adults and children by surgeons experienced in laparoscopy. Although the operation time of LA may be longer, most studies have concluded that LA is superior to OA in terms of a faster recovery and less morbidities. LA is associated with a shorter hospital LOS, a lower mortality rate, a lower overall complication rates, a lower 30-d readmission rate, a lower SBO rate, a lower wound infection rate, and comparable costs in compared to OA for patients with perforated appendicitis. IAA remains a major concern in LA for perforated appendicitis, and the roles of irrigation and routine drainage to reduce risks of IAA remain debatable. Conversion procedure from LA to OA may be associated with higher rates of morbidities. For perforated appendicitis with phlegmon, the interval LA does not provide definite advantages over early LA. Laparoscopic treatment may be beneficial for some subsets of population, such as elderly and obese patients. It deserves more randomized and population-based studies to definite the actual roles of LA in the management of perforated appendicitis.

REFERENCES

1 **Frazee RC**, Roberts JW, Symmonds RE, Snyder SK, Hendricks JC, Smith RW, Custer MD, Harrison JB. A prospective randomized trial comparing open versus laparoscopic appendectomy. *Ann Surg* 1994; **219**: 725-728; discussion 728-731 [PMID: 8203983]

2 **Guller U**, Hervey S, Purves H, Muhlbaier LH, Peterson ED, Eubanks S, Pietrobon R. Laparoscopic versus open appendectomy: outcomes comparison based on a large administrative database. *Ann Surg* 2004; **239**: 43-52 [PMID: 14685099 DOI: 10.1097/01.sla.0000103071.35986.c1]

3 **Lin HF**, Wu JM, Tseng LM, Chen KH, Huang SH, Lai IR. Laparoscopic versus open appendectomy for perforated appendicitis. *J Gastrointest Surg* 2006; **10**: 906-910 [PMID: 16769550 DOI: 10.1016/j.gassur.2005.12.012]

4 **Fukami Y**, Hasegawa H, Sakamoto E, Komatsu S, Hiromatsu T. Value of laparoscopic appendectomy in perforated appendicitis. *World J Surg* 2007; **31**: 93-97 [PMID: 17180555 DOI: 10.1007/s00268-006-0065-x]

5 **Sleem R**, Fisher S, Gestring M, Cheng J, Sangosanya A, Stassen N, Bankey P. Perforated appendicitis: is early laparoscopic appendectomy appropriate? *Surgery* 2009; **146**: 731-737; discussion 737-738 [PMID: 19789033 DOI: 10.1016/j.surg.2009.06.053]

6 **Masoomi H**, Mills S, Dolich MO, Ketana N, Carmichael JC, Nguyen NT, Stamos MJ. Comparison of outcomes of laparoscopic versus open appendectomy in adults: data from the Nationwide Inpatient Sample (NIS), 2006-2008. *J Gastrointest Surg* 2011; **15**: 2226-2231 [PMID: 21725700 DOI: 10.1007/s11605-011-1613-8]

7 **Frazee RC**, Bohannon WT. Laparoscopic appendectomy for complicated appendicitis. *Arch Surg* 1996; **131**: 509-511; discussion 511-513 [PMID: 8624197]

8 **Bonanni F**, Reed J, Hartzell G, Trostle D, Boorse R, Gittleman M, Cole A. Laparoscopic versus conventional appendectomy. *J Am Coll Surg* 1994; **179**: 273-278 [PMID: 8069421]

9 **Krisher SL**, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal abscess after laparoscopic appendectomy for perforated appendicitis. *Arch Surg* 2001; **136**: 438-441 [PMID: 11296116]

10 **Yagmurlu A**, Vernon A, Barnhart DC, Georgeson KE, Harmon CM. Laparoscopic appendectomy for perforated appendicitis: a comparison with open appendectomy. *Surg Endosc* 2006; **20**: 1051-1054 [PMID: 16736313 DOI: 10.1007/

s00464-005-0342-z]
11 **Katsuno G**, Nagakari K, Yoshikawa S, Sugiyama K, Fukunaga M. Laparoscopic appendectomy for complicated appendicitis: a comparison with open appendectomy. *World J Surg* 2009; **33**: 208-214 [PMID: 19067040 DOI: 10.1007/s00268-008-9843-y]
12 **Tuggle KR**, Ortega G, Bolorunduro OB, Oyetunji TA, Alexander R, Turner PL, Chang DC, Cornwell EE, Fullum TM. Laparoscopic versus open appendectomy in complicated appendicitis: a review of the NSQIP database. *J Surg Res* 2010; **163**: 225-228 [PMID: 20599209 DOI: 10.1016/j.jss.2010.03.071]
13 **Oyetunji TA**, Nwomeh BC, Ong'uti SK, Gonzalez DO, Cornwell EE, Fullum TM. Laparoscopic appendectomy in children with complicated appendicitis: ethnic disparity amid changing trend. *J Surg Res* 2011; **170**: e99-103 [PMID: 21704334 DOI: 10.1016/j.jss.2011.05.001]
14 **Yeh CC**, Wu SC, Liao CC, Su LT, Hsieh CH, Li TC. Laparoscopic appendectomy for acute appendicitis is more favorable for patients with comorbidities, the elderly, and those with complicated appendicitis: a nationwide population-based study. *Surg Endosc* 2011; **25**: 2932-2942 [PMID: 21424194 DOI: 10.1007/s00464-011-1645-x]
15 **Wang CC**, Tu CC, Wang PC, Lin HC, Wei PL. Outcome comparison between laparoscopic and open appendectomy: evidence from a nationwide population-based study. *PLoS One* 2013; **8**: e68662 [PMID: 23874710 DOI: 10.1371/journal.pone.0068662]
16 **Tiwari MM**, Reynoso JF, Tsang AW, Oleynikov D. Comparison of outcomes of laparoscopic and open appendectomy in management of uncomplicated and complicated appendicitis. *Ann Surg* 2011; **254**: 927-932 [PMID: 21804381 DOI: 10.1097/SLA.0b013e31822aa8ea]
17 **Gagné JP**, Billard M, Gagnon R, Laurion M, Jacques A. Province-wide population survey of acute appendicitis in Canada. New twists to an old disease. *Surg Endosc* 2007; **21**: 1383-1387 [PMID: 17653814 DOI: 10.1007/s00464-007-9227-7]
18 **Kim HJ**, Lee JI, Lee YS, Lee IK, Park JH, Lee SK, Kang WK, Cho HM, You YK, Oh ST. Single-port transumbilical laparoscopic appendectomy: 43 consecutive cases. *Surg Endosc* 2010; **24**: 2765-2769 [PMID: 20396909 DOI: 10.1007/s00464-010-1043-9]
19 **Muensterer OJ**, Puga Nougues C, Adibe OO, Amin SR, Georgeson KE, Harmon CM. Appendectomy using single-incision pediatric endosurgery for acute and perforated appendicitis. *Surg Endosc* 2010; **24**: 3201-3204 [PMID: 20490556 DOI: 10.1007/s00464-010-1115-x]
20 **Dutta S**. Early experience with single incision laparoscopic surgery: eliminating the scar from abdominal operations. *J Pediatr Surg* 2009; **44**: 1741-1745 [PMID: 19735818 DOI: 10.1016/j.jpedsurg.2008.12.024]
21 **Markides G**, Subar D, Riyad K. Laparoscopic versus open appendectomy in adults with complicated appendicitis: systematic review and meta-analysis. *World J Surg* 2010; **34**: 2026-2040 [PMID: 20549210 DOI: 10.1007/s00268-010-0669-z]
22 **Poole GV**. Management of the difficult appendiceal stump: how I do it. *Am Surg* 1993; **59**: 624-625 [PMID: 8368672]
23 **Kazemier G**, in't Hof KH, Saad S, Bonjer HJ, Sauerland S. Securing the appendiceal stump in laparoscopic appendectomy: evidence for routine stapling? *Surg Endosc* 2006; **20**: 1473-1476 [PMID: 16823654 DOI: 10.1007/s00464-005-0525-7]
24 **Beldi G**, Vorburger SA, Bruegger LE, Kocher T, Inderbitzin D, Candinas D. Analysis of stapling versus endoloops in appendiceal stump closure. *Br J Surg* 2006; **93**: 1390-1393 [PMID: 16862615 DOI: 10.1002/bjs.5474]
25 **Sahm M**, Kube R, Schmidt S, Ritter C, Pross M, Lippert H. Current analysis of endoloops in appendiceal stump closure. *Surg Endosc* 2011; **25**: 124-129 [PMID: 20552371 DOI: 10.1007/s00464-010-1144-5]
26 **Muehlstedt SG**, Pham TQ, Schmeling DJ. The management of pediatric appendicitis: a survey of North American Pediatric Surgeons. *J Pediatr Surg* 2004; **39**: 875-879; discussion 875-879 [PMID: 15185217]
27 **Ohno Y**, Furui J, Kanematsu T. Treatment strategy when using intraoperative peritoneal lavage for perforated appendicitis in children: a preliminary report. *Pediatr Surg Int* 2004; **20**: 534-537 [PMID: 15205901 DOI: 10.1007/s00383-004-1210-y]
28 **Agresta F**, Ansaloni L, Baiocchi GL, Bergamini C, Campanile FC, Carlucci M, Cocorullo G, Corradi A, Franzato B, Lupo M, Mandalà V, Mirabella A, Pernazza G, Piccoli M, Staudacher C, Vettoretto N, Zago M, Lettieri E, Levati A, Pietrini D, Scaglione M, De Masi S, De Placido G, Francucci M, Rasi M, Fingerhut A, Uranüs S, Garattini S. Laparoscopic approach to acute abdomen from the Consensus Development Conference of the Società Italiana di Chirurgia Endoscopica e nuove tecnologie (SICE), Associazione Chirurghi Ospedalieri Italiani (ACOI), Società Italiana di Chirurgia (SIC), Società Italiana di Chirurgia d'Urgenza e del Trauma (SICUT), Società Italiana di Chirurgia nell'Ospedalità Privata (SICOP), and the European Association for Endoscopic Surgery (EAES). *Surg Endosc* 2012; **26**: 2134-2164 [PMID: 22736283 DOI: 10.1007/s00464-012-2331-3]
29 **Moore CB**, Smith RS, Herbertson R, Toevs C. Does use of intraoperative irrigation with open or laparoscopic appendectomy reduce post-operative intra-abdominal abscess? *Am Surg* 2011; **77**: 78-80 [PMID: 21396311]
30 **St Peter SD**, Adibe OO, Iqbal CW, Fike FB, Sharp SW, Juang D, Lanning D, Murphy JP, Andrews WS, Sharp RJ, Snyder CL, Holcomb GW, Ostlie DJ. Irrigation versus suction alone during laparoscopic appendectomy for perforated appendicitis: a prospective randomized trial. *Ann Surg* 2012; **256**: 581-585 [PMID: 22964730 DOI: 10.1097/SLA.0b013e31826a91e5]
31 **Schein M**. To drain or not to drain? The role of drainage in the contaminated and infected abdomen: an international and personal perspective. *World J Surg* 2008; **32**: 312-321 [PMID: 18080709 DOI: 10.1007/s00268-007-9277-y]
32 **Pessaux P**, Msika S, Atalla D, Hay JM, Flamant Y. Risk factors for postoperative infectious complications in noncolorectal abdominal surgery: a multivariate analysis based on a prospective multicenter study of 4718 patients. *Arch Surg* 2003; **138**: 314-324 [PMID: 12611581]
33 **Allemann P**, Probst H, Demartines N, Schäfer M. Prevention of infectious complications after laparoscopic appendectomy for complicated acute appendicitis--the role of routine abdominal drainage. *Langenbecks Arch Surg* 2011; **396**: 63-68 [PMID: 20830485 DOI: 10.1007/s00423-010-0709-z]
34 **Johnson AB**, Peetz ME. Laparoscopic appendectomy is an acceptable alternative for the treatment of perforated appendicitis. *Surg Endosc* 1998; **12**: 940-943 [PMID: 9632866]
35 **Klingler A**, Henle KP, Beller S, Rechner J, Zerz A, Wetscher GJ, Szinicz G. Laparoscopic appendectomy does not change the incidence of postoperative infectious complications. *Am J Surg* 1998; **175**: 232-235 [PMID: 9560127]
36 **So JB**, Chiong EC, Chiong E, Cheah WK, Lomanto D, Goh P, Kum CK. Laparoscopic appendectomy for perforated appendicitis. *World J Surg* 2002; **26**: 1485-1488 [PMID: 12297916 DOI: 10.1007/s00268-002-6457-7]
37 **Kirshtein B**, Bayme M, Domchik S, Mizrahi S, Lantsberg L. Complicated appendicitis: laparoscopic or conventional surgery? *World J Surg* 2007; **31**: 744-749 [PMID: 17361359 DOI: 10.1007/s00268-006-0467-9]
38 **Yau KK**, Siu WT, Tang CN, Yang GP, Li MK. Laparoscopic versus open appendectomy for complicated appendicitis. *J Am Coll Surg* 2007; **205**: 60-65 [PMID: 17617333 DOI: 10.1016/j.jamcollsurg.2007.03.017]
39 **Piskun G**, Kozik D, Rajpal S, Shaftan G, Fogler R. Comparison of laparoscopic, open, and converted appendectomy for perforated appendicitis. *Surg Endosc* 2001; **15**: 660-662 [PMID: 11591963 DOI: 10.1007/s004640020072]
40 **Vahdad MR**, Troebs RB, Nissen M, Burkhardt LB, Hardwig S, Cernaianu G. Laparoscopic appendectomy for perforated ap-

pendicitis in children has complication rates comparable with those of open appendectomy. *J Pediatr Surg* 2013; **48**: 555-561 [PMID: 23480912 DOI: 10.1016/j.jpedsurg.2012.07.066]
41 **Golub R**, Siddiqui F, Pohl D. Laparoscopic versus open appendectomy: a metaanalysis. *J Am Coll Surg* 1998; **186**: 545-553 [PMID: 9583695]
42 **Chung RS**, Rowland DY, Li P, Diaz J. A meta-analysis of randomized controlled trials of laparoscopic versus conventional appendectomy. *Am J Surg* 1999; **177**: 250-256 [PMID: 10219865]
43 **Miyano G**, Okazaki T, Kato Y, Marusasa T, Takahashi T, Lane GJ, Yamataka A. Open versus laparoscopic treatment for panperitonitis secondary to perforated appendicitis in children: a prospective analysis. *J Laparoendosc Adv Surg Tech A* 2010; **20**: 655-657 [PMID: 20822418 DOI: 10.1089/lap.2010.0079]
44 **Taqi E**, Al Hadher S, Ryckman J, Su W, Aspirot A, Puligandla P, Flageole H, Laberge JM. Outcome of laparoscopic appendectomy for perforated appendicitis in children. *J Pediatr Surg* 2008; **43**: 893-895 [PMID: 18485961 DOI: 10.1016/j.jpedsurg.2007.12.033]
45 **Jen HC**, Shew SB. Laparoscopic versus open appendectomy in children: outcomes comparison based on a statewide analysis. *J Surg Res* 2010; **161**: 13-17 [PMID: 20031168 DOI: 10.1016/j.jss.2009.06.033]
46 **Wang X**, Zhang W, Yang X, Shao J, Zhou X, Yuan J. Complicated appendicitis in children: is laparoscopic appendectomy appropriate? A comparative study with the open appendectomy--our experience. *J Pediatr Surg* 2009; **44**: 1924-1927 [PMID: 19853748 DOI: 10.1016/j.jpedsurg.2009.03.037]
47 **Markar SR**, Blackburn S, Cobb R, Karthikesalingam A, Evans J, Kinross J, Faiz O. Laparoscopic versus open appendectomy for complicated and uncomplicated appendicitis in children. *J Gastrointest Surg* 2012; **16**: 1993-2004 [PMID: 22810297 DOI: 10.1007/s11605-012-1962-y]
48 **Andersson RE**. Small bowel obstruction after appendicectomy. *Br J Surg* 2001; **88**: 1387-1391 [PMID: 11578297 DOI: 10.1046/j.0007-1323.2001.01869.x]
49 **Leung TT**, Dixon E, Gill M, Mador BD, Moulton KM, Kaplan GG, MacLean AR. Bowel obstruction following appendectomy: what is the true incidence? *Ann Surg* 2009; **250**: 51-53 [PMID: 19561482 DOI: 10.1097/SLA.0b013e3181ad64a7]
50 **Tsao KJ**, St Peter SD, Valusek PA, Keckler SJ, Sharp S, Holcomb GW, Snyder CL, Ostlie DJ. Adhesive small bowel obstruction after appendectomy in children: comparison between the laparoscopic and open approach. *J Pediatr Surg* 2007; **42**: 939-942; discussion 942 [PMID: 17560198 DOI: 10.1016/j.jpedsurg.2007.01.025]
51 **Little DC**, Custer MD, May BH, Blalock SE, Cooney DR. Laparoscopic appendectomy: An unnecessary and expensive procedure in children? *J Pediatr Surg* 2002; **37**: 310-317 [PMID: 11877640]
52 **Schmelzer TM**, Rana AR, Walters KC, Norton HJ, Bambini DA, Heniford BT. Improved outcomes for laparoscopic appendectomy compared with open appendectomy in the pediatric population. *J Laparoendosc Adv Surg Tech A* 2007; **17**: 693-697 [PMID: 17907991 DOI: 10.1089/lap.2007.0070]
53 **Phillips S**, Walton JM, Chin I, Farrokhyar F, Fitzgerald P, Cameron B. Ten-year experience with pediatric laparoscopic appendectomy--are we getting better? *J Pediatr Surg* 2005; **40**: 842-845 [PMID: 15937827 DOI: 10.1016/j.jpedsurg.2005.01.054]
54 **Meguerditchian AN**, Prasil P, Cloutier R, Leclerc S, Péloquin J, Roy G. Laparoscopic appendectomy in children: A favorable alternative in simple and complicated appendicitis. *J Pediatr Surg* 2002; **37**: 695-698 [PMID: 11987080]
55 **Fraser JD**, Aguayo P, Leys CM, Keckler SJ, Newland JG, Sharp SW, Murphy JP, Snyder CL, Sharp RJ, Andrews WS, Holcomb GW, Ostlie DJ, St Peter SD. A complete course of intravenous antibiotics vs a combination of intravenous and oral antibiotics for perforated appendicitis in children: a prospective, randomized trial. *J Pediatr Surg* 2010; **45**: 1198-1202 [PMID: 20620320 DOI: 10.1016/j.jpedsurg.2010.02.090]
56 **Sauerland S**, Lefering R, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev* 2004; (**4**): CD001546 [PMID: 15495014 DOI: 10.1002/14651858.CD001546.pub2]
57 **Towfigh S**, Chen F, Mason R, Katkhouda N, Chan L, Berne T. Laparoscopic appendectomy significantly reduces length of stay for perforated appendicitis. *Surg Endosc* 2006; **20**: 495-499 [PMID: 16437274 DOI: 10.1007/s00464-005-0249-8]
58 **Ikeda H**, Ishimaru Y, Takayasu H, Okamura K, Kisaki Y, Fujino J. Laparoscopic versus open appendectomy in children with uncomplicated and complicated appendicitis. *J Pediatr Surg* 2004; **39**: 1680-1685 [PMID: 15547834]
59 **Li P**, Xu Q, Ji Z, Gao Y, Zhang X, Duan Y, Guo Z, Zheng B, Guo X, Wu X. Comparison of surgical stress between laparoscopic and open appendectomy in children. *J Pediatr Surg* 2005; **40**: 1279-1283 [PMID: 16080932 DOI: 10.1016/j.jpedsurg.2005.05.011]
60 **Kurtz RJ**, Heimann TM. Comparison of open and laparoscopic treatment of acute appendicitis. *Am J Surg* 2001; **182**: 211-214 [PMID: 11587679]
61 **Sporn E**, Petroski GF, Mancini GJ, Astudillo JA, Miedema BW, Thaler K. Laparoscopic appendectomy--is it worth the cost? Trend analysis in the US from 2000 to 2005. *J Am Coll Surg* 2009; **208**: 179-185.e2 [PMID: 19228528 DOI: 10.1016/j.jamcollsurg.2008.10.026]
62 **Gorenoi V**, Dintsios CM, Schönermark MP, Hagen A. Laparoscopic vs. open appendectomy: systematic review of medical efficacy and health economic analysis. *GMS Health Technol Assess* 2007; **2**: Doc22 [PMID: 21289973]
63 **Moore DE**, Speroff T, Grogan E, Poulose B, Holzman MD. Cost perspectives of laparoscopic and open appendectomy. *Surg Endosc* 2005; **19**: 374-378 [PMID: 15624056 DOI: 10.1007/s00464-004-8724-1]
64 **Andersson RE**, Petzold MG. Nonsurgical treatment of appendiceal abscess or phlegmon: a systematic review and meta-analysis. *Ann Surg* 2007; **246**: 741-748 [PMID: 17968164 DOI: 10.1097/SLA.0b013e31811f3f9f]
65 **Ahmed I**, Deakin D, Parsons SL. Appendix mass: do we know how to treat it? *Ann R Coll Surg Engl* 2005; **87**: 191-195 [PMID: 15901381 DOI: 10.1308/1478708051649]
66 **Oliak D**, Yamini D, Udani VM, Lewis RJ, Arnell T, Vargas H, Stamos MJ. Initial nonoperative management for periappendiceal abscess. *Dis Colon Rectum* 2001; **44**: 936-941 [PMID: 11496072]
67 **Simillis C**, Symeonides P, Shorthouse AJ, Tekkis PP. A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon). *Surgery* 2010; **147**: 818-829 [PMID: 20149402]
68 **Vane DW**, Fernandez N. Role of interval appendectomy in the management of complicated appendicitis in children. *World J Surg* 2006; **30**: 51-54 [PMID: 16369706 DOI: 10.1007/s00268-005-7946-2]
69 **St Peter SD**, Aguayo P, Fraser JD, Keckler SJ, Sharp SW, Leys CM, Murphy JP, Snyder CL, Sharp RJ, Andrews WS, Holcomb GW, Ostlie DJ. Initial laparoscopic appendectomy versus initial nonoperative management and interval appendectomy for perforated appendicitis with abscess: a prospective, randomized trial. *J Pediatr Surg* 2010; **45**: 236-240 [PMID: 20105610 DOI: 10.1016/j.jpedsurg.2009.10.039]
70 **Blakely ML**, Williams R, Dassinger MS, Eubanks JW, Fischer P, Huang EY, Paton E, Culbreath B, Hester A, Streck C, Hixson SD, Langham MR. Early vs interval appendectomy for children with perforated appendicitis. *Arch Surg* 2011; **146**: 660-665 [PMID: 21339413 DOI: 10.1001/archsurg.2011.6]
71 **Schurman JV**, Cushing CC, Garey CL, Laituri CA, St Peter SD. Quality of life assessment between laparoscopic appendectomy at presentation and interval appendectomy for perforated appendicitis with abscess: analysis of a prospective randomized trial. *J Pediatr Surg* 2011; **46**: 1121-1125 [PMID: 21683209 DOI: 10.1016/j.jpedsurg.2011.03.038]

72 **Storm-Dickerson TL**, Horattas MC. What have we learned over the past 20 years about appendicitis in the elderly? *Am J Surg* 2003; **185**: 198-201 [PMID: 12620555]

73 **Masoomi H**, Mills S, Dolich MO, Ketana N, Carmichael JC, Nguyen NT, Stamos MJ. Does laparoscopic appendectomy impart an advantage over open appendectomy in elderly patients? *World J Surg* 2012; **36**: 1534-1539 [PMID: 22407087 DOI: 10.1007/s00268-012-1545-9]

74 **Paranjape C**, Dalia S, Pan J, Horattas M. Appendicitis in the elderly: a change in the laparoscopic era. *Surg Endosc* 2007; **21**: 777-781 [PMID: 17285390 DOI: 10.1007/s00464-006-9097-4]

75 **Vettoretto N**, Gobbi S, Corradi A, Belli F, Piccolo D, Pernazza G, Mannino L. Consensus conference on laparoscopic appendectomy: development of guidelines. *Colorectal Dis* 2011; **13**: 748-754 [PMID: 21651696 DOI: 10.1111/j.1463-1318.2011.02557.x]

76 **Harrell AG**, Lincourt AE, Novitsky YW, Rosen MJ, Kuwada TS, Kercher KW, Sing RF, Heniford BT. Advantages of laparoscopic appendectomy in the elderly. *Am Surg* 2006; **72**: 474-480 [PMID: 16808197]

77 **Hawn MT**, Bian J, Leeth RR, Ritchie G, Allen N, Bland KI, Vickers SM. Impact of obesity on resource utilization for general surgical procedures. *Ann Surg* 2005; **241**: 821-826; discussion 826-828 [PMID: 15849518]

78 **Mason RJ**, Moazzez A, Moroney JR, Katkhouda N. Laparoscopic vs open appendectomy in obese patients: outcomes using the American College of Surgeons National Surgical Quality Improvement Program database. *J Am Coll Surg* 2012; **215**: 88-99; discussion 99-100 [PMID: 22632913 DOI: 10.1016/j.jamcollsurg.2012.03.012]

79 **Corneille MG**, Steigelman MB, Myers JG, Jundt J, Dent DL, Lopez PP, Cohn SM, Stewart RM. Laparoscopic appendectomy is superior to open appendectomy in obese patients. *Am J Surg* 2007; **194**: 877-880; discussion 880-881 [PMID: 18005788 DOI: 10.1016/j.amjsurg.2007.08.043]

80 **Varela JE**, Hinojosa MW, Nguyen NT. Laparoscopy should be the approach of choice for acute appendicitis in the morbidly obese. *Am J Surg* 2008; **196**: 218-222 [PMID: 18519131 DOI: 10.1016/j.amjsurg.2007.08.067]

P- Reviewer: Delibegovic S, Piccinni G, Vettoretto N
S- Editor: Gou SX **L- Editor**: A **E- Editor**: Liu XM

Published by **Baishideng Publishing Group Inc**
8226 Regency Drive, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
http://www.wjgnet.com

ISSN 1007-9327