

Back to basics: A meta-analysis of stump management during open appendicectomy for uncomplicated acute appendicitis

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Abstract

AIM: To compare simple ligation vs stump invagination during open appendicectomy for uncomplicated acute appendicitis on the risk of postoperative complications.

METHODS: A meta-analysis was conducted on randomised controlled trials comparing the two stump closure methods in open appendicectomy. Databases searched were PubMed, EMBASE and Cochrane Library databases. Included were those studies focusing on inflamed and suppurative appendicitis while perforated and gangrenous appendix was excluded. We also excluded retrospective case-control studies, commentaries, historical technical articles, or trials involving laparoscopic appendicectomies. The outcome of the meta-analysis was to find eventual differences in the

incidence of postoperative ileus and wound infections between the two techniques of stump invagination.

RESULTS: Seven studies were included corresponding to 1468 patients. Postoperative complications consisted in wound infections (7%), ileus (4%), pyrexia (2%), vomiting (1%), obstructions from adhesions (0.1%). No cases of peritonitis, fecal fistulas (stump leaks), abdominal abscesses or wound dehiscences were reported. Postoperative ileus within the first 72 h was four times more frequent with stump invagination compared to simple ligation (OR: 4.06; 95%CI: 2.14-7.70; $P < 0.0001$). No significant differences were noted for wound infections (OR: 1.24; 95%CI: 0.83-1.87; $P = 0.30$) while for the remaining complications the incidence was extremely low in both groups. There was a high homogeneity on results (Q value for heterogeneity of postoperative ileus $P = 0.17$; Q value for heterogeneity of wound infections $P = 0.98$).

CONCLUSION: Stump invagination does not seem to prevent infective complications but is associated with an increased risk of postoperative ileus in uncomplicated cases. Appropriate studies on complicated appendicitis should now evaluate the influence of the two techniques in this higher-risk subgroup.

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Key words: Appendiceal stump; Open appendicectomy; Invagination; Appendicitis; Complications

Core tip: Despite the increased use of the laparoscopic approach, open appendicectomy is an operation still performed on a large scale worldwide. Two main approaches exist for the stump closure, the simple ligation and the stump invagination. Compared to the simple ligation the invagination of the stump aim to provide an extra safety measure for the prevention

of postoperative complications, but the study demonstrated that in cases of non-complicated appendicitis it increases the risks of postoperative ileus and does not decrease the wound infections rate.

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INTRODUCTION

In recent years the combined advantages of better diagnosis and reduced surgical trauma have progressively favoured the laparoscopic appendicectomy (LA) over open appendicectomy (OA) for the treatment of acute appendicitis. In numerous studies and meta-analyses LA has achieved less postoperative pain, reduced hospital stay and faster return to normal daily activities compared to OA at the cost of longer operating times^[1-3]. Despite these positive results OA is still frequently performed worldwide: 34% of appendicitis patients receive OA in the United Kingdom^[4], 45% (university teaching hospitals) to 75% (district general hospitals) in Ireland^[5], and more than 50% in Italy^[6,7]. Additionally, OA is still necessary when LA requires conversion to an open approach (*i.e.*, dense adhesions, diffuse peritonitis, difficulties in excision of the appendix due to perforation)^[8], or in special circumstances such as pregnancy where the avoidance of the pneumoperitoneum and CO₂ systemic absorption decrease the rate of fetal loss^[9].

One of the historical controversies of the open technique involves the management of the appendiceal stump following removal of the appendix. A long stump may produce recurrences (appendiceal stumpitis)^[10]. While an inadequate closure contaminates the abdominal cavity with fecal material (fecal fistula). In both cases, the postoperative outcome is endangered and re-operations with bowel resections may become necessary. Two approaches have been described over the years for the management of the appendiceal stump during OA. The first and simplest approach is the simple ligation (SL), described in 1884^[11,12]. The second consists in the ligation and invagination of the stump (SI) in the cecum^[11,12] by a purse-string suture or a Z-stitch^[13-18]. This was introduced to secure the stump in the bowel lumen so that any perforation or leakage would directly drain inside the gut and not in the abdominal cavity.

Both approaches have been compared in numerous trials for their ability to prevent postoperative infections, ileus and other complications but results from single studies have been contrasting. In the present article we decided to conduct a meta-analysis on those trials to evaluate the influence of SL and SI on the occurrence

of postoperative complications following OA.

MATERIALS AND METHODS

The meta-analysis has been reported according to the QUORUM and MOOSE guidelines^[19,20].

Study selection and data extraction

Included articles were (1) randomized controlled trials (RCTs) that (2) focused on the technique for stump management during OA for (3) uncomplicated acute appendicitis. We defined a randomized trial as one in which patients were assigned prospectively to SL or SI by a random allocation. We excluded those studies that (1) focused on complicated appendicitis or those that (2) involved complicated and uncomplicated cases without differentiation of the results between the two groups. Furthermore we excluded (3) retrospective case-control studies, (4) commentaries, (5) historical technical articles, and (6) trials involving LA.

English and non-English language studies were searched and selected in the PubMed, EMBASE and Cochrane Library databases. No time limits were used. Key words used were appendicectomy, ligation, invagination, stump, complications. Articles were searched by two Authors (Gravante G, Yahia S) and classified according to those based on uncomplicated appendicitis (inflamed or suppurative appendix), complicated appendicitis (gangrenous or perforated appendix) or both. Potentially relevant studies were identified by the title and the abstract and full papers were obtained and assessed in details. The analysis of the references list allowed also the retrieval of a further pool of articles that were collected and assessed.

The methodological quality of studies retrieved was assessed independently according to the Jadad Score^[21]. Briefly, studies were scored according to the presence of three key methodological features of randomization, blinding and accountability of all patients, including withdrawals and the score ranged from 0 to 5: those that received a score of four or five were considered as high-quality studies while those with a score equal to or less than three were of low quality. A specifically designed data form was used to collect all relevant data, including details of the experimental design, patients' demographics, technical aspects, outcome measures and complications. The outcome of the meta-analysis was to find eventual differences in the incidence of postoperative ileus and wound infections between the two techniques of stump invagination (SL *vs* SI).

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences Windows version 15.0 (SPSS, Chicago, Illinois, United States) and the Meta-analysis with Interactive eXplanations (MIX-version 1.6) program. Descriptive statistics for qualitative variables was performed with occurrences and relative frequencies,

Table 1 Characteristics of studies examined *n* (%)

Ref.	Stump closure	<i>n</i>	Age (yr)	Sex (male)	Jadad score ^[21]	Postoperative ileus	Wound infections	Postoperative pyrexia	Postoperative vomiting
Watter <i>et al</i> ^[12]	SL	44	18 (5-43)	21 (48)	1	-	8 (18.2)	-	-
	SI	59	22 (6-46)	29 (49)		-	11 (18.6)	-	-
Chaudhary <i>et al</i> ^[13]	SL	382	-	213 (56)	1	6 (1.6)	21 (5.5)	-	-
	SI	295	-	157 (53)		15 (5.1)	19 (6.4)	-	-
Jamal <i>et al</i> ^[23]	SL	40	23 ± 9	-	1	3 (7.5)	6 (15.0)	-	-
	SI	40	21 ± 6	-		11 (27.5)	9 (22.5)	-	-
Khan <i>et al</i> ^[24]	SL	50	24 ± 8	35 (70)	1	0	2 (4.0)	10 (20.0)	-
	SI	50	24 ± 9	32 (64)		1 (2.0)	3 (6.0)	15 (30.0)	-
Reza <i>et al</i> ^[25]	SL	184	27 ± 14	129 (70)	1	3 (1.6)	8 (4.2)	-	-
	SI	177	26 ± 13	124 (70)		8 (4.6)	7 (4.0)	-	-
Minhas <i>et al</i> ^[26]	SL	30	25 ± 2	17 (57)	0	0	2 (6.7)	-	3 (10.0)
	SI	30	25 ± 3	16 (53)		3 (10)	4 (13.3)	-	8 (26.7)
Chalya <i>et al</i> ^[22]	SL	43	24 ± 12	20 (47)	2	1 (2.3)	1 (2.3)	2 (4.7)	1 (2.3)
	SI	44	26 ± 15	21 (48)		5 (11.4)	2 (4.5)	3 (6.8)	2 (4.5)

SL: Simple ligation; SI: Stump invagination.

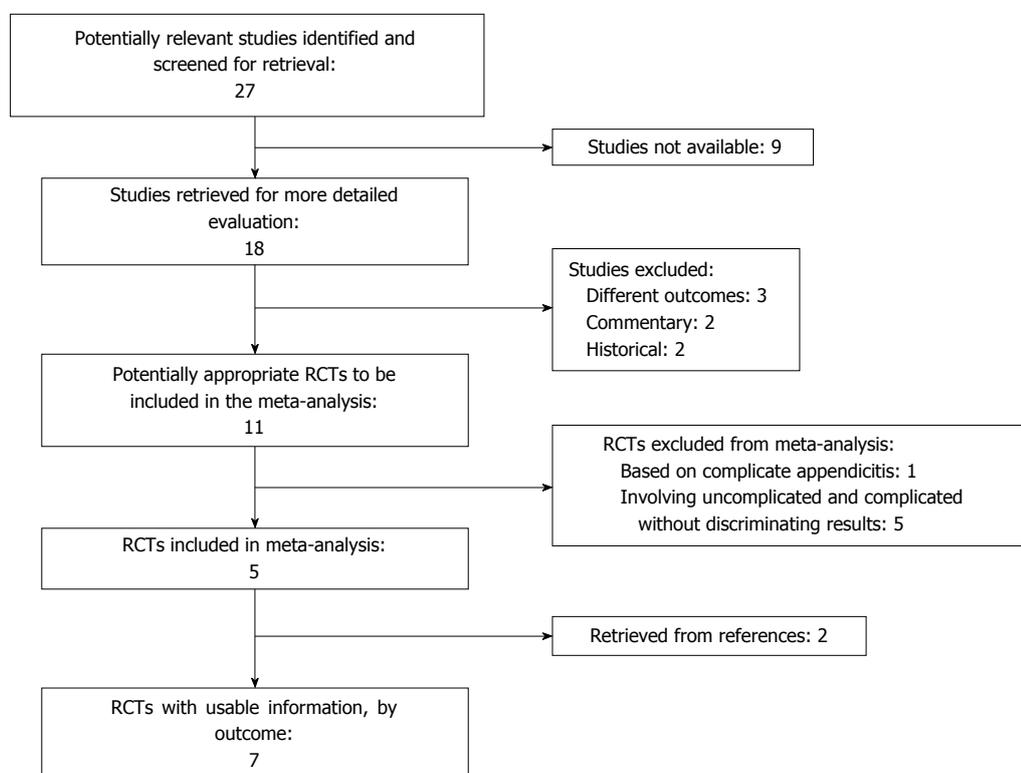


Figure 1 Flow-chart of the study selection process. RCTs: Randomized controlled trials.

those for continuous variables with the mean and standard deviation if parametric or median and range if non-parametric. Clinical outcomes and complications of patients in the SL and SI groups were evaluated with common tests used in meta-analyses: χ^2 test or Fisher's exact test for categorical variables. The weighted odds ratio (OR) for the occurrence of complications between SL and SI was also calculated. The model used for the meta-analysis was the fixed-effect and the weighting method was the Mantel Haenszel. Heterogeneity was assessed with the funnel plots and the Bartlett's test. Results were considered significant if the probability of

chance of occurrence was less than five percent ($P < 0.05$).

RESULTS

At the end of the selection process only seven articles met the inclusion criteria^[12,13,22-26] (Figure 1, Table 1) with 1468 patients presented, 773 in the SI and 695 in the SL group. One study only reported operating times, which were longer for the SI (45.3 ± 36.1 min) compared to the SL group (30.6 ± 33.4)^[22]. Postoperative complications consisted in wound infections ($n = 103$; 7%)^[12,13,22-26], il-

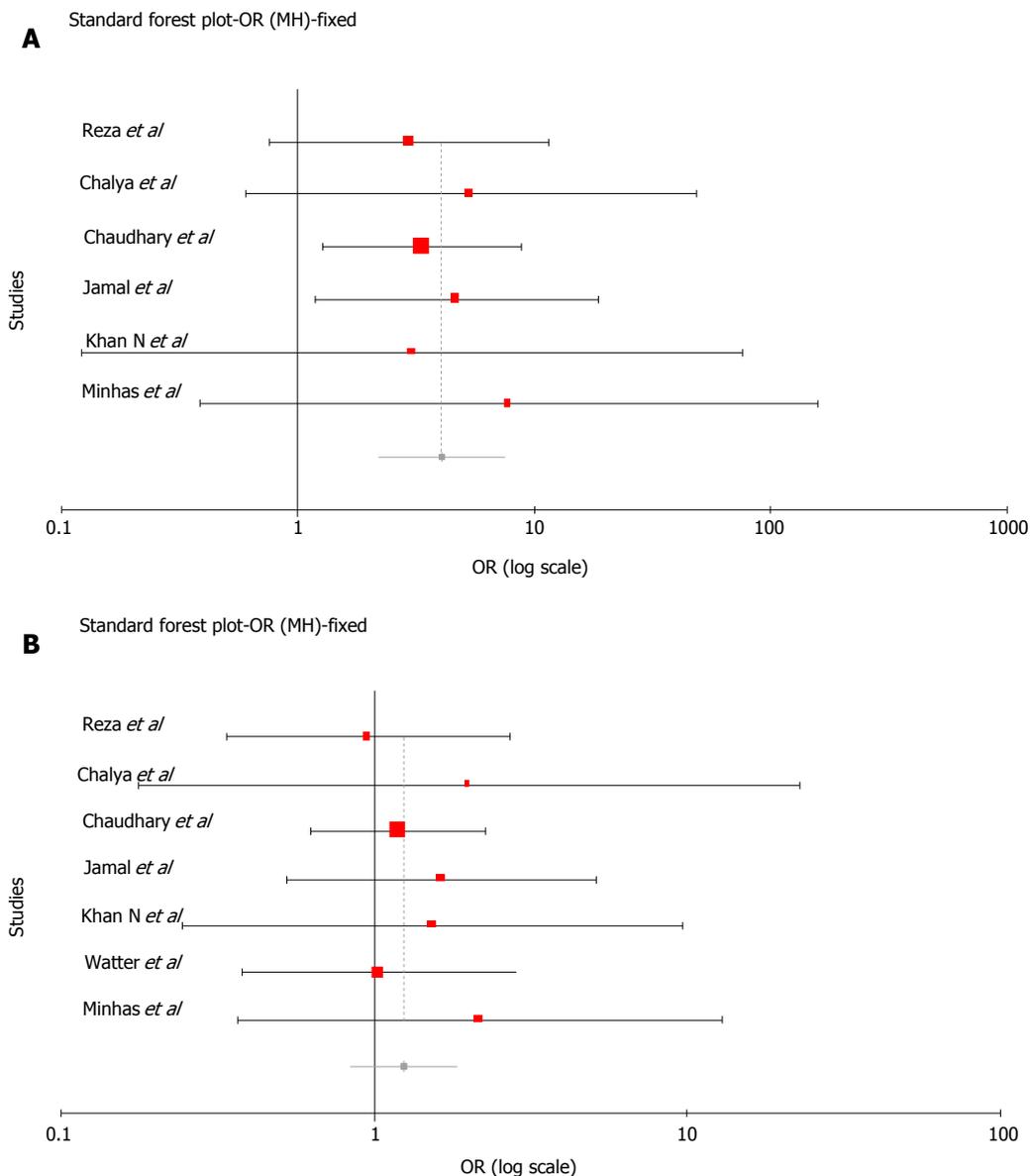


Figure 2 Forest plot graph showing results on the analysis of postoperative among simple ligation and stump invagination. A: Ileus; B: Wound infections.

eus ($n = 56$; 4%)^[13,22-26], pyrexia ($n = 39$; 2%)^[22,24], vomiting ($n = 14$; 1%)^[22,26], obstructions from adhesions ($n = 1$; 0.1%)^[12,13,22]. No cases of peritonitis^[13,22-24,26], fecal fistulas (stump leaks)^[24-26], abdominal abscesses^[12,13,22-26] or wound dehiscences^[25] were reported.

Six studies reported data on postoperative ileus^[13,22-26]. In all cases this resolved within 72 h from the operation. The incidence was 0%-7.5% in the SL group and 2.0%-27.5% in the SI group (Table 1). The analysis of pooled data showed that SL increased the risk of postoperative ileus of four times compared to SI (OR: 4.06; 95%CI: 2.14-7.70; $P < 0.0001$) (Figure 2A). Seven studies reported data on wound infections^[12,13,22-26]. The incidence was 2.3%-18.2% in the SL group and 4.0%-22.5% in the SI group (Table 1). The analysis of pooled data showed no significant differences in the risk of wound infections between SL and SI (OR: 1.24, 95%CI: 0.83-1.87; $P = 0.30$) (Figure 2B). The results of both complications

were homogeneous as outlined by the funnel plots that were highly symmetrical (Q value for heterogeneity of postoperative ileus $P = 0.17$; Q value for heterogeneity of wound infections $P = 0.98$ (Figure 3).

DISCUSSION

Since the introduction of appendicectomy the treatment of the appendiceal stump has been a crucial step to determine the outcome of the operation. The proper management of the stump is important to prevent serious postoperative complications such as fecal contamination and peritonitis. After the initial introduction, the SL approach was considered not sure enough by some. Authors for an adequate closure of the stump, therefore, the invagination method was performed to avoid leaving open mucosa free in the peritoneal cavity and to favour the serosa-to-serosa contact that was believed neces-

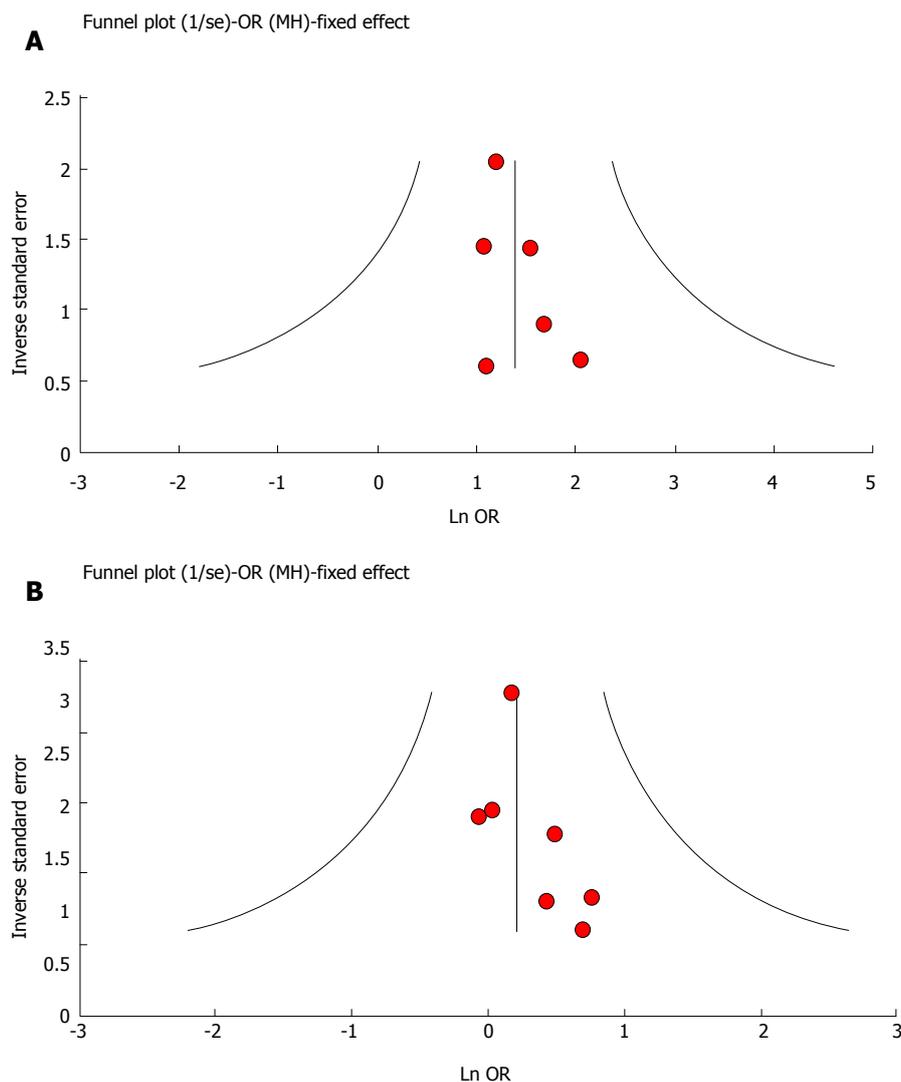


Figure 3 Funnel plot graph showing heterogeneity analysis on postoperative among simple ligation and stump invagination. A: ileus; B: Wound infections.

sary for a proper healing. SI became fashionable at the end of the last century since it was thought to prevent adhesions (by seroserosal healing) and stump blowout (especially when the base did not seem healthy enough to support the SL approach), or at least contain it, as the leak would drain into the cecum. Theoretical advantages of SI over SL included better control of stump hemorrhages, double secure closure of the cecal wall, reduced chances of peritoneal contamination from an infected stump and reduced risk of postoperative adhesions by minimizing the extent of raw surfaces^[18]. However, a word of caution went out as the purse string technique was accused of increasing the risk of ischemia around the SI closure. Therefore, SL was indicated only in those patients where a severe inflammation and induration of the cecum could have rendered the SI approach too dangerous^[27]. At the same time the SI approach can produce peculiar complications such as intramural abscesses and erosion of the cecal wall^[28,29], or fecal fistulas from reduced blood supply to the cecal wall and local ischemia^[30]. Furthermore, in the long-term it can simulate a

cecal polyp on radiological imaging and potentially lead to unnecessary invasive tests in the screening of bowel cancers^[27,31,32].

In order to select only articles with homogeneous and comparable group of patients, we included in our meta-analysis only uncomplicated cases of appendicitis. The incidence of postoperative ileus in perforated appendicitis is between 28%-50%^[33], higher than in uncomplicated appendicitis^[34], because local inflammation and infection are major contributors. Therefore, the analysis of patients with complicated appendicitis could have biased the results achieved because the risk of ileus could have been higher in the complicated group *vs* the uncomplicated one. Results of the meta-analysis show that the addition of the invagination to the classic direct closure is associated with an increased risk of postoperative ileus by four times in patients with no other risk factors. Numerous hypotheses could explain the ileus pathogenesis following SI but none of them was adequately investigated experimentally. In the only study that reported the data SI took longer, a possible cause of

postoperative ileus. Additionally, the greater manipulation necessary for the invagination, or the cecum extraction through the incision to make the SI possible, could also be responsible for a serosal damage potentially combined with local ischemia. A larger incision might be necessary to perform the SI, another potential cause of postoperative ileus. Finally, the anatomical trauma on the bowel peristaltic waves deformed by the seromuscular purse-string suture or the Z-stitch, or the longer manipulation of the intestine to perform this additional step could also contribute to it.

The SI did not seem to produce specific advantages over SL regarding the other postoperative complications. Wound infection rates were similar among groups and no further comparative analysis was possible for the remaining complications due to the paucity of studies available that reported on them and the extremely low incidences (*i.e.*, peritonitis or fecal fistulas). Especially for these rare but important complications larger studies could be necessary to draw any definitive conclusions on the effects of SL or SI on its occurrence. Furthermore, appropriate studies involving only complicated cases (perforated or gangrenous appendix) should now evaluate the influence of the two techniques on postoperative complications in this higher-risk subgroup.

In the LA era results of our meta-analysis might seem less relevant, especially because cannot be applied to laparoscopic procedures in which the stump is usually fixed with endoscopic devices (*i.e.*, Endoloops, staples). However OA remains a milestone procedure during surgical training and is still performed frequently, in some hospitals by the majority of surgeons in at least 50% of cases^{16,71}. For these reasons we focused our analysis on OAs and selected only those studies relevant for this purpose. However, one important limitation has to be acknowledged by the readers. All studies had a low Jadad score (less than 3) because of the inability to determine which methods of randomization were used in the original studies and the lack of double blinding of participants (the surgeons were always aware of the stump technique used)²¹. More specifically, the Jadad scores were 0 ($n = 1$), 1 ($n = 5$), and 2 ($n = 1$). Despite the low quality of each RCT *per se*, studies were highly selected in order to present homogeneous and comparable groups of patients as showed by the funnel plots of the two complications. Therefore results of our meta-analysis should now form the theoretical background for future randomized studies in order to confirm the relationship found between the technique of stump closure and postoperative complications.

COMMENTS

Background

In numerous studies and meta-analyses laparoscopic appendectomy (LA) has achieved less postoperative pain, reduced hospital stay and faster return to normal daily activities compared to open appendectomy (OA) at the cost of longer operating times. Additionally, over OA is still necessary when LA requires conversion to an open approach.

Research frontiers

The invagination of the stump (SI) approach can produce peculiar complications such as intramural abscesses and erosion of the cecal wall, or fecal fistulas from reduced blood supply to the cecal wall and local ischemia. Furthermore, in the long-term it can simulate a cecal polyp on radiological imaging and potentially lead to unnecessary invasive tests in the screening of bowel cancers.

Innovations and breakthroughs

SI does not seem to prevent postoperative infective complications and is associated with an increased risk of ileus within the first 72 h in OAs for non-complicated appendicitis. Appropriate studies involving only complicated cases should now evaluate the influence of the two techniques in this higher-risk subgroup and possibly find a more specific indication for the SI technique.

Applications

The meta-analysis should now form the theoretical background for future randomized studies in order to confirm the relationship found between the technique of stump closure and postoperative complications.

Peer review

The authors describe a safer technique stump ligation compared to stump invagination. This is a well written paper with correct analysis.

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