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Original Article

Is Laparoscopic Appendectomy Useful for the Treatment of Acute Appendicitis in Korea?: A Meta-Analysis

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We performed a meta-analysis using results in the Korean literatures to determine whether laparoscopic appendectomy (LA) or open appendectomy (OA) provide the better outcome in possible acute appendicitis patients. To perform the meta-analysis, an extensive literature search was conducted, giving priority to the Journal of the Korean Surgical Society, and domestic literature in its search database, published since January 1993, to ascertain the usefulness of LA in the treatment of acute appendicitis. The criteria used for the quality evaluation were as follows: 1) study subjects must have been evaluated clinically for suspected acute appendicitis, and 2) articles were included only if sufficient data (e.g. patient number, mean and standard deviation of patient outcome variables) were available regarding patient outcomes for LA or OA treated appendicitis. Of the 136 articles retrieved, 8 studies (1,258 patients) were selected for quantitative meta-analysis. Because insufficient data was available in some studies, operating time and hospitalization days were assessed for all 8 studies, but the time required to return to full functioning was assessed for only 3 studies. Overall effect size estimates were calculated using a random effect model for four patient outcomes (operating time, Q=38.6699, $p<0.001$; length of stay, Q=19.3876, $p<0.001$; postoperative hospital stay, Q=20.9164, $p<0.001$; and return time to full functioning, Q=41.5061, $p<0.001$). Because the overall effect size for operating time was -0.3218 (95% confidence interval [CI] -0.6108 to -0.0328), LA operating time was significantly greater than that of OA. In addition, a significant difference was found between the two modalities in terms of the length of hospital stay. Overall effect size in terms of the time required to return to full functioning was 1.9757 (95% CI 1.0066 to 2.9448), and LA reduced the time required by about 2 days versus OA. Considering the overall odds ratio (0.33) and 95% CI (0.20 to 0.55) the incidence of wound infection was significantly lower in LA than in OA. This review of the published evidence suggests that LA is more useful for treating acute appendicitis, especially when perforated appendicitis is suspected.

Key Words: Laparoscopic appendectomy, acute appendicitis, meta-analysis, Korean

INTRODUCTION

Acute appendicitis is an inflammation of the appendix, which is located at the beginning of the large intestine or colon. It is the most common cause of abdominal pain requiring emergency surgery, and can affect healthy people in all age groups.

Since the introduction of the surgical removal of the appendix through a small right lower quadrant incision by McBurney in 1894, appendectomy has remained the treatment of choice for acute appendicitis.[1] This traditional open form of appendectomy (OA) is a well-established procedure for patients with suspected acute appendicitis, and may be undertaken by; Transverse incision (Fowler-Weir; Davis-Rockey), Gridiron incision (McArthur-McBurney) and others.[2] The surgical techniques involved have remained substantially unchanged for over a century, as they combine

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therapeutic efficacy with low morbidity and mortality rates.[3]

Laparoscopic appendectomy (LA) was first performed by Kurt Semm in 1983 to treat gynecologic patients,[4] and was first used to treat patients with suspected acute appendicitis in the late 1980s.[5]

Laparoscopy is a surgical procedure that involves the insertion of a small fiberoptic camera into the abdomen in order to visualize the appendix directly. Nevertheless, the new method has only gained partial acceptance, because the advantages of laparoscopic appendectomy are not as obvious as those of laparoscopic cholecystectomy. The relative frequency of these procedures in the United States is uncertain, but it is estimated that one laparoscopic appendectomy is performed for every four open procedures.[6] Numerous retrospective and uncontrolled series have been performed on LA, and many prospective randomized studies have been published to date. In addition, meta-analyses have been conducted to evaluate the effectiveness of laparoscopy using LA and OA clinical trials.[7-12] These six studies indicated that the laparoscopic operation offers a lower risk of postoperative infection and a shorter period to full recovery than OA.

Appendectomy is the most common abdominal intervention in industrialized countries. In Korea, it is the most frequently performed surgery and accounts for about 90,000 to 100,000 claims per year.[13] Because acute appendicitis is one of the most common diseases in terms of inpatient insurance claims, it was included as one of the 'implementation' diseases of the Korean-DRG (K-DRG) payment system in 1997.[14] Laparoscopy was introduced to Korea by Dr. Kim S.J. in the early 1990s.[15,16] Post 1993,[17] various studies have been reported, but no meta-analysis has been undertaken to date.

For this reason, the objective of the present study was to examine domestic literature, which compares the major acute appendicitis operation methods, i.e., open appendectomy (OA) and laparoscopic appendectomy (LA), and by quantitative meta-analysis to determine the relative merits of OA and LA in Korea.

MATERIALS AND METHODS

Search strategy

The first search step involved a search of journals sites, i.e., the Medical Research Information Center (MedRIC) (http://www.medric.or.kr/) and the Research Information Center for Health (RICH) (http://www.richis.org/) from 1993 to 2002. In addition, we searched other potential sources giving priority to the Journal of Korean Surgical Society (http://www.surgery.or.kr/) and the Journal of the Korean Society of Coloproctology (http://scp.medric.or.kr/). The second step involved a manual search of the contents and the bibliographies cited in each retrieved study. The medical subject headings used for this search were; appendix, appendicitis, operation (method or procedure), open appendectomy, and laparoscopic appendectomy.

Qualitative meta-analysis

A total of 136 Korean articles, which contained information on the comparative usefulness of OA and LA were selected. Two observers independently extracted the results of the individual articles onto a data sheet; disagreements were resolved by discussion. A journal evaluating team was organized, and consisted of surgeons and meta-analysis specialists (including a biostatistics major). Systematic literature review and cross-checking were conducted based on the meta-analysis evaluation guidelines, which were as follows: 1) only original articles were included. 2) Articles must have contained sufficient numeric information upon patient outcomes variables, e.g., in terms of operation time, length of stays, post-operative hospital stays, return period to normal activity, and complications. 3) LA and OA must have been compared in the article. Of the 12 articles evaluated at the final stage, only 8 studies, which compared LA and OA met these inclusion criteria, and thus, only these were selected for the meta-analysis.

Quantitative meta-analysis

For this process the methods of Hedges and

Olkin,[18] and of MetaKorea (http://www.metakorea.or.kr/),[19] a web-based meta-analytic automation system, were utilized. In terms of effect size, the means and standard deviations (SDs) of each patient outcome variable, and sample size data, were used to calculate mean differences. When a standard deviation was missing in a study, the standard error (SE) was transformed into the standard deviation by employing the function SD $=(SE \times \sqrt{n})$ for a sample size of 'n'. Subgroup analyses were performed to determine a number of characteristics, e.g., the differences to outcome versus operation time according to the presence of complications. The Peto method[20] was only used for the meta-analysis of the outcomes of postoperative complications.

To integrate results, mean differences were used as effect sizes, and overall effect size, standard error, and 95% confidence interval (CI) were estimated according to the fixed/random effects models used for the quantitative meta-analyses. Concerning the fixed effects model, additional homogeneity tests were conducted. In the fixed effects model, parameters such as the operating time were fixed, and in the random effects model parameters were randomly changed in every study.[21]

Each overall effect size, standard error, and 95% CI in the fixed effects and random effects models were produced as follows.

▷ The function of effect size, standard error, and 95% CI in the fixed effects model

1. Weighted effect size $(\omega_i)=1/\text{var}(\hat{\theta}_i)$, where i=1,2,3,,,,k
2. Weighted mean $(\hat{\theta})=(\Sigma\hat{\theta}_i\omega_i)/(\Sigma\omega_i)$, where i=1,2,3,,,,k
3. Standard error of weighted mean $(SE(\hat{\theta}))=1/\sqrt{(\Sigma\omega_i)}$, where i=1,2,3,,,,k
4. 95% CI of weighted mean: $\hat{\theta} \pm 1.96 \times SE(\hat{\theta})$, where i=1,2,3,,,,k

▷ The function of effect size, standard error, and 95% CI in the random effects model

1. Weighted effect size $(\omega_i^*)=(\omega_i^{-1}+\hat{\chi}^2)^{-1}$, $\hat{\chi}^2=\max\{0, (Q-(k-1))/(\Sigma\omega_i-(\Sigma\omega_i^2/\Sigma\omega_i))\}$, where i=1,2,3,,,,k
2. Weighted mean $(\hat{\theta})=(\Sigma\omega_i^*\hat{\theta}_i)/(\Sigma\omega_i^*)$, where i=1,2,3,,,,k
3. Standard error of weighted mean $(SE(\hat{\theta}))=1/\sqrt{(\Sigma\omega_i^*)}$, where i=1,2,3,,,,k
4. 95% CI of weighted mean: $\hat{\theta} \pm 1.96 \times SE(\hat{\theta})$, where i=1,2,3,,,,k

The homogeneity test in each study was performed using:

$$Q=\Sigma(\hat{\theta}_i-\hat{\theta})^2 \quad \omega_i \sim \chi^2_{(k-1)}, \quad \omega_i=1/\text{var}(\hat{\theta}_i)$$

RESULTS

The general characteristics of the patients in the studies used for the meta-analysis are summarized in Table 1. In total, the eight studies incorporated 1,258 patients and of these, 441 had LA and 817 OA.[22-29] One study[26] was conducted upon children only, the others involved adults or all age groups. Female study populations ranged from 32% to 69.6%. Table 2 details pathological diagnoses by study. Of 441 LA patients, non-complicated cases accounted for 277 patients (62.8%) and complicated cases 113 (25.6%). Similarly, among 817 OA patients, 528 (64.6%) were uncomplicated and 231 (28.3%) were complicated. The negative appendectomy rate, i.e., the normal appendix (non-inflammatory lesion) percentage among patients operated upon, was 11.6% in LA and 7.1% in OA.

Because in some studies the data was insufficient, operation and hospitalization times were assessed in all 8 studies, but the time required to return to full functioning was assessed in only 3 studies[22,27,29] (Table 3). In order to check the possibility that the variation in effect sizes might have occurred by chance, a homogeneity test was performed. All of the following four patient outcomes variables proved to be significantly heterogeneous (operation time, Q=38.6699, $p<0.001$; length of stay, Q=19.3876, $p<0.001$; postoperative hospital stay, Q=20.9164, $p<0.001$; return time to full functioning, Q=41.5061, $p<0.001$) (Table 4). Hence, the overall effect size estimates were calculated using a random effect model for all patient outcomes variables [operation time, length of hospital stay (length of stay and postoperative hospital stay), return period to full functioning], except operation anesthetic time.

In terms of overall effect size, operation time was -0.3218 and the 95% confidence interval (CI) was less than zero (95% CI: -0.6108 to -0.0328). Since effect sizes in this meta-analysis were pro-

Table 1. General Characteristics by Studies Used for Meta-analysis (N=8)

Authors (No. of Reference)	Year	Operation Type	Number of Patient	Study Population	Age (years)		Age Distribution (%)			Female (%)
					Mean	Range	- 20	21 - 59	60 -	
So BW et al. (22)	1994	LA	75	All Ages	25.9	NR	44.0	56.0		52.0
		OA	150	All Ages	27.4	NR	41.3	58.7		50.7
Park HS et al. (23)	1995	LA	50	Adults	33.4	NR	22.0	68.0	10.0	36.0
		OA	50	Adults	34.8	NR	24.0	58.0	18.0	50.0
Kim MK et al. (24)	1996	LA	101	All Ages	23.7	8-57	47.5	52.5		64.4
		OA	100	All Ages	24.7	4-81	47.0	53.0		32.0
Sohn BH et al. (25)	1996	LA	17	Adults	39.9	NR	NR	NR	NR	47.1
		OA	18	Adults	47.6	NR	NR	NR	NR	61.1
Lee BE et al. (26)	1996	LA	48	Children	11.4	NR	100	-	-	41.7
		OA	107	Children	10.3	NR	100	-	-	43.9
Cho YU et al. (27)	1996	LA	53	Adults	30.9	NR	NR	NR	NR	45.3
		OA	113	Adults	38.8	NR	NR	NR	NR	48.7
Son GS et al. (28)	1998	LA	46	All Ages	28.5	9-67	NR	NR	NR	69.6
		OA	129	All Ages	34.1	11-71	NR	NR	NR	52.7
Lim DM et al. (29)	1999	LA	51	All Ages	30.3	NR	33.3	58.9	7.8	43.1
		OA	150	All Ages	29.7	NR	31.4	61.9	6.7	46.0
Total		LA	441		28.0		49.4	58.9	31.6	49.9
		OA	817		30.9		48.7	57.9	34.1	48.1

LA, laparoscopic appendectomy; OA, open appendectomy; NR, not reported.

duced from mean differences between the LA and OA groups, and resulted in positive or negative values, unlike the odds ratio, zero becomes the standard of statistical significance.[8,9,21] Thus, the LA operation time was significantly greater than the OA operating time. However, when the pathological diagnosis of acute appendicitis was divided into non-complicated cases and complicated cases, e.g., in the subgroup meta-analysis, no statistically significant difference was found between LA operation time and OA operation time. Also, the overall effect size of operation anesthetic time was -0.6702 (95% CI: -0.8702 to -0.4685) in the fixed effect model, thus the LA anesthetic time at operation was significantly greater than the corresponding OA anesthetic time. In addition, the two operation methods differed significantly in terms of the length of stay (pooled effect size: 1.1351, 95% CI: 0.7898 to 1.4803) and postoperative hospital stay (pooled effect size: 0.6712, 95% CI: 0.1697 to 1.1728). Thus, hospitalization stay for LA was significantly shorter than that for OA. Likewise, the overall effect size in terms of the time required to return to full functioning was 1.9757 (95% CI: 1.0066 to 2.9448), thus LA reduced the time to full functioning (by about 2 days) versus OA with about mean 13 days (Table 4).

Table 5 lists postoperative complications. The odds ratios (ORs) indicate the odds of events (complications) in the LA group, relative to the odds of the same event occurring in the OA group.[11,30] For example, in the first study,[22] among the entire population (LA: 75 and OA: 150),

Table 2. Pathological Diagnosis by Studies Used for Meta-analysis (N=8)

Authors (No. of Reference)	Year	Operation Type	Number of Patient	Pathological diagnosis				Normal†
				Non-complicated		Complicated		
				Catarrhal	Suppurative	Gangrenous	Perforated*	
So BW et al.(22)	1994	LA	75	20	22	-	33	-
		OA	150	39	41	-	70	-
Park HS et al.(23)	1995	LA	50	-	35	2	6	(7)
		OA	50	-	32	2	9	(7)
Kim MK et al.(24)	1996	LA	101	(20)	34	8	16	23
		OA	100	(15)	31	14	21	19
Sohn BH et al.(25)	1996	LA	17	-	-	-	17	-
		OA	18	-	-	-	18	-
Lee BE et al.(26)	1996	LA	48	-	40	1	7	-
		OA	107	-	89	3	15	-
Cho YU et al.(27)	1996	LA	53	-	27	8	5	13
		OA	113	-	63	10	27	13
Son GS et al.(28)	1998	LA	46	-	(38)	-	-	8
		OA	129	-	(110)	-	-	19
Lim DM et al.(29)	1999	LA	51	12	29	4	6	-
		OA	150	22	86	18	24	-
Total		LA	441	52	225	23	90	51
		OA	817	76	452	47	184	58

LA, laparoscopic appendectomy; OA, open appendectomy.
*Included ulcerophlegmonous, mesoappendiceal abscess, and periappendiceal abscess.
†None made inflammatory lesion or other lesion.

wound infection occurred in one LA patient and in 9 OA patients. Thus, this study-specific OR=(1 × 141)/(9 × 74)=0.21. And according to the fixed effect model described by Peto,[20] the overall OR of the operation methods in terms of wound infection was 0.33 (95% CI: 0.20 to 0.55). Considering the overall OR and the study-specific ORs, the incidence of wound infection were significantly lower in LA than in OA. However, in the case of intra-abdominal abscess, although two study-specific ORs were higher in LA than in OA,[24,27] the overall OR associated with operation method was 0.84 (95% CI: 0.30 to 2.39), which was not statistically significant.

DISCUSSION

Domestic comparisons for open and laparoscopic appendectomy for acute appendicitis on data collected after the mid-1990s are shown in Table 1. Since studies related to laparoscopic appendectomy have been published mainly in the Journal of the Korean Surgical Society, it appears that both the application of laparoscopic appendectomy and the number of studies that have compared it with open appendectomy have increased in Korea over the past decade. The materials used in the present study were limited to articles published in the Korean language, to

Table 3. Summary of Reported Patient Outcomes Variables by Studies

Authors (No. of Reference)	Operation Type	Pathological Type*	Operation Time (minutes)		Anesthesia Time (minutes)	Length of Stays (days)		Postoperative Hospital Stays (days)		Return Period to Normal Activity		
			Sub type	Total		Sub type	Total	Sub type	Total	No. of Patients	Sub type (days)	Total (days)
So BW et al. (22)	LA	Non-C	60.0	69.0	-	-	-	3.8	4.2	37 (49%)	5.8	6.2
		C	80.5					4.6			6.8	
	OA	Non-C	44.0	48.0	-	-	-	6.9	7.5	68 (45%)	11.2	12.6
		C	53.0					8.4			14.4	
Park HS et al. (23)	LA	-	-	49.7	82.0	-	5.1	-	-	-	-	-
	OA	-	-	44.9	72.8	-	7.2	-	-	-	-	-
Kim MK et al. (24)	LA	Non-C	57.2±21.6	55.4±19.8	-	4.8±1.0	5.3±1.5	-	-	-	-	-
		C	52.6±10.3			6.8±1.9						
	OA	Non-C	39.8±9.5	44.4±14.8	-	6.6±1.1	7.2±1.6	-	-	-	-	-
		C	56.4±18.4			8.9±1.7						
Sohn BH et al. (25)	LA	-	-	80.0±22.1	-	-	-		8.9±4.9		-	-
	OA	-	-	87.5±24.3	-	-	-		7.9±4.8		-	-
Lee BE et al. (26)	LA	Non-C	44.0±11.9	43.7±11.3	-	-	3.2±2.2	-	-	-	-	-
		C	41.5±4.4									
	OA	Non-C	47.7±20.0	49.0±21.4	-	-	6.4±1.6	-	-	-	-	-
		C	58.1±25.8									
Cho YU et al. (27)	LA	-	-	49.3±16.8	71.2±18.2	-	4.6±2.4	-	3.4±2.3	-	-	5.8±1.4
	OA	-	-	47.2±20.5	61.5±21.0	-	7.0±1.9	-	5.7±1.8	-	-	14.0±4.0
Son GS et al. (28)	LA	-	-	68.4		-	-	-	3.4	-	-	
	OA	-	-	53.7		-	-	-	3.8	-	-	
Lim DM et al. (29)	LA	-	-	55.6±17.0	84.4±22.8	-	4.69±1.2	-	-	42 (82.30%)	-	8.8±2.0
	OA	-	-	42.0±16.8	65.2±19.0	-	6.96±3.1	-	-	114 (76.00%)	-	12.9±4.3

*Non-C, Non-complicated appendicitis; C, Complicated appendicitis; LA, laparoscopic appendectomy; OA, open appendectomy.

avoid publication bias by language and to allow comparisons with 6 international articles published on this topic.[7-12]

Laparoscopic appendectomy, which was first performed in 1983, has been rapidly adopted in many industrialized countries, and been prospectively evaluated in many randomized control trials. Ten years after it was introduced to Korea in 1993, the Korean Surgical Society retrospectively evaluated LA in many case-control studies. Therefore, it should be emphasized that this study is more than a methodological application of meta-analysis, rather it summarizes the findings of high quality randomized clinical trials that were conducted to evaluate the merits of adopting a new procedure. Only when high quality studies are performed as such, can quantitative meta-analysis contribute comprehensively to the integration of results. Moreover, meta-analyses of observational studies present a particular challenge because of their inherent biases,[31] such results should be interpreted with caution.

In addition, we stratified our studies by complications, operating time, and hospital stay, to assess the impact of variation in the study populations prior to the analysis (Table 3), and then repeated the meta-analysis.[10] The results (Table 4, Table 5) obtained were essentially the same as

Table 4. Summary of Results from Quantitative Meta-analysis

Outcomes variables	No. of studies	No. of patients	Q statistic for heterogeneity test* (p-value)	Pooled effect difference† (OA - LA)	95% CI
OR time (skin to skin)	8	1,258	38.6699 ($p<0.001$)	-0.3218	-0.6108, -0.0328
Non-complicated cases	3	351	20.9219 ($p<0.001$)	-0.51	-1.2414, 0.2214
Complicated cases	3	188	16.7114 ($p<0.001$)	-0.0033	-0.9630, 0.9564
OR anesthetic time	3	467	4.6689 ($p>0.05$)	-0.6702	-0.8720, -0.4685
Length of stay	5	833	19.3876 ($p<0.001$)	1.1351	0.7898, 1.4803
Postoperative hospital stay	4	601	20.9164 ($p<0.001$)	0.6712	0.1697, 1.1728
Time to full functioning	3	592	41.5061 ($p<0.001$)	1.9757	1.0066, 2.9448

*$p>0.05$ indicates that pooled studies are homogeneous.
†Reported as absolute difference in mean values for continuous outcomes.
Negative differences favor open appendectomy (OA);
Positive differences favor laparoscopic appendectomy (LA).
OR, operating room; LA, laparoscopic appendectomy; OA, open appendectomy; CI, confidence interval.

Table 5. Summary and Meta-analysis* of Postoperative Complications from 8 Studies

Authors (No. of Reference)	Operation Type	Wound infection		Intra-abdominal abscess	
		No. (%)	OR	No. (%)	OR
So BW et al. (22)	LA	1 (1.3)	0.21	0 (0)	0
	OA	9 (6.0)		1 (0.7)	
Park HS et al. (23)	LA	0 (0)	0	0 (0)	0
	OA	2 (4.0)		0 (0)	
Kim MK et al. (24)	LA	1 (1.0)	0.32	3 (3.0)	3.03
	OA	3 (3.0)		1 (1.0)	
Sohn BH et al. (25)	LA	0 (0)	0	0 (0)	0
	OA	3 (16.7)		0 (0)	
Lee BE et al. (26)	LA	2 (4.2)	0.62	0 (0)	0
	OA	7 (6.5)		0 (0)	
Cho YU et al. (27)	LA	3 (5.7)	0.26	1 (1.9)	1.07
	OA	21 (18.6)		2 (1.8)	
Son GS et al. (28)	LA	1 (2.2)	0.24	0 (0)	0
	OA	11 (8.5)		2 (1.6)	
Lim DM et al. (29)	LA	0 (0)	0	1 (2.0)	0.48
	OA	13 (8.7)		6 (4.0)	
Total	LA	8 (1.8)	0.33*	5 (1.1)	0.84*
	OA	69 (8.4)	(0.20, 0.55)†	12 (1.5)	(0.30, 2.39)†
	Q statistic		2.1866		2.5802
	(p-value)		($p>0.05$)		($p>0.05$)

*Results of odds ratio meta-analysis in the fixed effect model by Peto method[20].
†95% confidence interval.
OR, odds ratio; LA, laparoscopic appendectomy; OA, open appendectomy.

Table 6. Comparison of Six Meta-analysis Original Articles about Laparoscopic versus Open Appendectomy in Acute Appendicitis

Author / Characteristics	Sauerland et al. (1998)	Golub et al. (1998)	Chung et al. (1999)	Garbutt et al. (1999)	Maynaud-Kraemer et al. (1999)	Temple et al. (1999)
Journal	Langenbeck's Arch Surg	J Am Coll Surg	Am J Surg	Surg Laparosc Endosc	Int J Technol Assess Health Care	Can J Surg
Authors' Country	Germany	U.S.A.	U.S.A.	U.S.A.	France	Canada
Search Period	1983~1998	1992~1997	1992~1997	1988~1997	(1992~1995)	1990~1997
Strategy	Cochrane Collaboration (E)	MEDLINE (E)	MEDLINE (E etc.)	MEDLINE (E)	MEDLINE (E, F, G)	MEDLINE (E)
Total No. of Articles	267	16	17	237	33	22
Evaluation Index						
Study design	randomized trials	Prospective RCT	Prospective RCT	RCT	RCT	RCT
Evaluation scale	Downs checklist (17 items)	10-point scale	Study design	-	McMaster U. method	10-point scale
Acceptable No. of Articles	28	16	17	11	8	12
Meta-analysis S/W Tools	Cochrane Collaboration RevMan 3.0	Hedges's technique etc.	Hedges & Olkin's technique etc.	STATA 5.0	Harvard School Program (J.Lau, 1995)	Cochrane Collaboration RevMan 3.0
Main Outcomes						
Operation time	+ 15.7 mins	+0.80	+0.92	+17.32		significantly increase
Complication rate						
Wound infection	-4.2% RD	0.30%	-0.31	-3.2%	significantly decrease	
Abscess	+0.9% RD	+2.2%	+0.21%	+0.8%		
Postop. pain	-0.5㎝ VAS	-0.38	-0.41	-1.19 points		
Length of stay	-15.0 h	-0.24 days	-0.35 days	-0.58 days		significantly decrease
Return to normal activity	-6.5 days	-0.65 days	-1.23 days	-5.48 days		significantly decrease
Readmission				+1.6%		
Return to feeding		-0.23 days		-3.4 h		

E, English; E etc., English + German + French + Spanish etc.; F, French; G, German.

those of other comprehensive analyses[7-12]: all pooled effects were in the same direction, and significant effects remained so, except for operating time for those with complications.

The published evidence suggests that LA might be useful for the treatment of acute appendicitis, especially when acute non-perforated appendicitis is a possibility. The present meta-analysis indicates that LA requires a longer operation time, but allows a shorter hospitalization stay and a more rapid return to full functioning than OA. Also, LA was found to be associated with fewer wound infections than OA. These results concur with not only those of the Consensus Development Conference undertaken by the European Association for Endoscopic Surgery in 1994,[32] but also with meta-analysis studies (Table 6) conducted in another countries (included Germany, USA, Canada, and France).

As a result of searching for meta-analysis

literature using MEDLINE, in association with the evaluation of the usefulness of laparoscopic appendectomy, between 1998 and 1999, we identified 6 suitable articles.[7-12] By chance, all of these meta-analyzed clinical trial studies were published after 1983 in English, German, or French, and compared LA and OA. However, the literature found using MEDLINE identified literature did not coincide, because of the different researchers and evaluation standards used. Although subgroup meta-analyses performed in these articles showed differences, the findings that LA was associated with a lower incidence of wound infection and with a more rapid return to normal activity were consistent. Publication bias by language or English language bias,[33] or the so-called 'tower of Babel bias',[34] was observed in most meta-analysis studies. However, the influence of publication bias is not expected to be large in the present study, because of the different search strategy and inclusion criteria.

Medical cost is a factor that was not addressed by the present study, because the costs of LA and OA are accounted for using different methods in Korea. Overall, the fee for open appendectomy was met by fee-for-service in the Korean Medical Insurance System from 1977, and since 1997 it transformed into the prospective demonstration payment system (K-DRG).[14] However, the charge for laparoscopic appendectomy has been met by patients, on a personal basis.

Thus, future studies are needed to analyze the cost-effectiveness of appendectomy. Also, due to the lack of high quality studies upon the application of new medical technologies involving laparoscopic appendectomy in Korea, randomized clinical trials are required in this area.

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