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ORIGINAL ARTICLE

Is laparoscopic Colorectal Surgery Beneficial for Elderly Patients? A Systematic Review and Meta-Analysis

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Abstract
Background Elderly patients who undergo major abdominal surgery are potentially at a higher risk of perioperative mortality and postoperative complications. Although laparoscopic surgery has been widely accepted as a less invasive surgical procedure for colorectal diseases, the benefits for elderly patients have not been validated.
Aim To compare postoperative outcomes and long-term survival between laparoscopic and open colorectal surgery in the elderly population.
Methods A literature search was electronically performed to identify all studies comparing postoperative outcomes between laparoscopic and open colorectal resections in the elderly population. Primary outcomes were postoperative mortality and complications, and the secondary outcome was long-term survival.
Results Overall, 30 studies (70,946 patients) met our inclusion criteria. Laparoscopic surgery was significantly associated with a decreased risk of perioperative mortality [odds ratio (OR), 0.55; 95 % confidence interval (CI), 0.45–0.68; $P<0.01$] and postoperative complications (OR, 0.55; 95 % CI, 0.48–0.63; $P<0.01$) compared with open surgery. There was no significant difference in long-term survival between the two procedures (OR, 0.89; 95 % CI, 0.72–1.07; $P=0.31$).
Conclusions Laparoscopic colorectal surgery in the elderly population has significant advantages in terms of short-term outcomes. Aggressive application of laparoscopic colorectal surgery should be considered for the elderly population.

Keywords Laparoscopic surgery · Colorectal · Elderly

Introduction

Aging has become an important issue worldwide and is expected to rapidly progress within the next 50 years. The proportion of individuals aged >65 years in the total world population has increased to 7.6 % in 2010 from 5.2 % in 1950, and it is expected to increase to 17.6 % in 2060.[1] With an increase in life expectancy, the number of elderly patients requiring surgery will also increase. Considering the increasing incidence of colorectal diseases, the frequency of colorectal surgery for elderly patients will increase compared with the previous frequency. Nevertheless, elderly patients are often regarded as high-risk patients because they are more likely to have significant comorbid conditions compared with younger patients.[2] Consequently, increasing age itself is also an important risk factor for postoperative morbidity and mortality. Physiologically, aging is associated with a gradual loss of functional reserve capacity, and its effects become most apparent during surgery because it decreases the tolerability for surgical stress in elderly patients.[3] It is reported that the 30-day mortality is approximately 6 % for patients aged ≥70 years and that at least 20 % of these patients develop one complication during hospitalization.[4] Mortality risk increases by 10 % every year after the age of 70.[4] Therefore, there are increasing demands for optimized surgical treatments for elderly patients.

Despite laparoscopic surgery (LPS) being a less invasive procedure and widely accepted surgical method worldwide,

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there is conflicting evidence regarding the safety and *benefits* of laparoscopic colorectal surgery in elderly patients. Several previous studies demonstrated that laparoscopic colon resection resulted in decreased postoperative pain, quicker return of bowel function, shorter hospital stay, better cosmesis, and a more rapid return to routine activities.[5–11] Furthermore, the benefits of LPS are more marked in elderly patients than in younger patients.[12,13] On the other hand, there are some concerns regarding its application in elderly patients because of physiological concerns such as specialized surgical positions (e.g., the Trendelenburg position) or pneumoperitoneum, which may result in a significant decrease in stroke volume and cardiac output and an increase in cardiac strain.[14] In several studies, the risk of cardiorespiratory complications was significantly higher in elderly patients, probably because of an extended surgical duration under prolonged general anesthesia and resultant postoperative atelectasis.[4,15,16]

In order to fully consider the application of LPS for elderly patients, the benefits of its decreased invasiveness need to be verified in this age group. The objective of this meta-analysis was to compare postoperative outcomes between LPS and open surgery (OS) in the elderly population. The findings of this study will help the further understanding of various postoperative outcomes from both surgical procedures and facilitate appropriate treatment selection strategies for elderly patients.

Methods

This review was written on the basis of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement.[17]

Literature Search Strategy

PubMed and Cochrane library databases were systematically searched, without language restriction, in October 2014 for manuscripts that compared LPS and OS in the elderly. Our search terms included three main components, colorectal (*colorectal* OR *colon* OR *colonic* OR *rectum* OR *rectal*) AND laparoscopy (*laparoscopy* OR *laparoscopic surgery*) AND open surgery AND elderly (*elderly* OR *older* OR *octogenarian*).

Inclusion and Exclusion Criteria

Postoperative complications and mortality were defined as primary outcomes in this study, while long-term survival was the secondary outcome. All studies that compared LPS and OS in elderly patients were included. Hand-assisted laparotomy was determined as LPS. Because most of the studies included conversion cases in the LPS group, we determined such cases as LPS cases in accordance with the concept of intention-to-treat. In addition to cohort studies comparing postoperative outcomes, case–control studies in which definitive inclusion and/or exclusion criteria that were presented were also included. The prevalence of postoperative complications (overall, wound infection, anastomotic leakage, pulmonary disease, cardiovascular disease, and mortality) within 30 days after surgery or during hospitalization and reported risk estimates [relative risks, odds ratios (ORs), or hazard ratios (HRs)] and 95 % confidence intervals (CIs) or sufficient data to estimate these were recorded. The length of hospital stay (LOS) after surgery was also recorded. As a secondary outcome, long-term survival data during follow-up were recorded. Studies that only compared young and elderly individuals or those that did not have data for both the LPS and OS groups were excluded. Reviews or meta-analyses were also excluded. All available studies were independently reviewed by two investigators (R.S. and K.O.), and discrepancies were discussed among the authors to achieve an agreement.

Assessment of Methodological Quality and Data Extraction

Data based on the characteristics of the study design, participants, and covariates were extracted together with the postoperative outcomes for the LPS and OS groups. The quality of included studies was independently reviewed by two assessors (R.S. and K.O.) according to the Newcastle–Ottawa Scale (NOS).[18,19] Scores ranged from 0 (lowest) to 9 (highest). Studies with scores of ≥7 were classified as higher quality studies, while those with scores of <7 were classified as lower quality studies.

Statistical Methods

The pooled ORs and 95 % CIs were calculated, and the outcomes of individual studies were compared using the DerSimonian and Laird random-effects model.[20] When one arm of a study contained no events, 0.5 was added to each cell of the 2×2 trial table to avoid reducing statistical power. If there was no event in either the LPS or OS groups, the study was discarded from the calculation. Forest plots were constructed for visual display of individual study ORs. Heterogeneity between studies was assessed with the I^2 statistic as a measure of the proportion of total variations in estimates due to heterogeneity, where I^2 values of 25, 50, and 75 % corresponded to cutoff points for low, moderate, and high degrees of heterogeneity, respectively. To assess for publication bias, we tested for funnel plot asymmetry using the regression test by Egger. Subgroup analysis for study characteristics and complication types was performed.

For long-term survival analysis, HR was extracted or computed from each study as an effect size, applying the statistical model described by Tierney et al.[21] Meta-regression was employed to assess the influence of key covariates, including year of publication, prospective study, Asian region, sample size, NOS type, definition of elderly age, conversion rate in the LPS group, percentage of females, an American Society of Anesthesiologists score of ≥3, and cancer type, on the generated heterogeneity.

All statistical analyses were performed using Stata version 12 (Stata Corp, College Station, TX, USA). For all comparisons, except those for heterogeneity, statistical significance was defined as $P<0.05$, and all tests were two-sided.

Results

Search Process

The outline of our search process is shown in Fig. 1; 1138 articles were found through electronic searches and 17 through manual searches. After removing duplicates from the title and abstract search, 1103 studies were excluded. Finally, 52 manuscripts were reviewed in full text, of which 30 met our search criteria. A total of 70,946 patients were included in our study. Details of included studies are listed in Table 1. There were 3 randomized control studies,[12,13,22] 3 prospective cohort studies,[16,23,24] 20 retrospective studies,[7,11,25–42] and 4 case-match control studies.[6,8–10] From the 30 included studies, 13 were classified as higher quality and 17 as lower quality according to the NOS (Table 2).

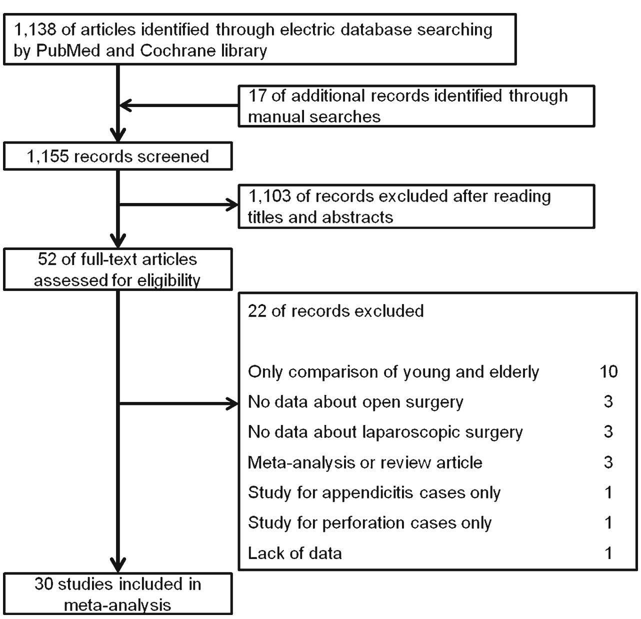

Fig. 1 Overview of the selection process

Short-Term Complications and Mortality

Overall Complications

Of all, 29 studies reported on the short-term complications after surgery and included a total of 42,200 participants, 5,641 of whom underwent LPS and 36,559 of whom underwent OS. The comparison between LPS and OS demonstrated that subjects with LPS had a significantly lower OR of short-term complications (OR, 0.55; 95 % CI, 0.48–0.63; $P<0.01$; Fig. 2). Although there was moderate heterogeneity among studies (I^2=45.6 %), Egger's test for funnel plot asymmetry identified no significant publication bias (bias=−0.59, P=0.10; Supplement 1).

Mortality

To assess the impact of LPS on mortality, 21 studies reporting mortality were identified; The OR was 0.55 (95 % CI, 0.45–0.68; $P<0.01$), demonstrating a significant association between LPS and decreased mortality (Fig. 3). Heterogeneity between the included studies was low (I^2=11.4 %).

Detailed Complications

The impact of LPS on the incidence of each type of complication is shown in Fig. 4.

Twenty-four studies reported the incidence of wound infection; the OR was 0.51 (95 % CI, 0.39–0.66; $P<0.01$), and the heterogeneity between included studies was low (I^2=25.0 %). Twenty-two studies reported the incidence of anastomotic leakage; the OR was 0.77 (95 % CI, 0.51–1.16; P=0.21), and the heterogeneity between included studies was low (I^2=9.5 %). Eighteen studies reported the incidence of cardiovascular diseases; the OR was 0.66 (95 % CI, 0.49–0.89; $P<0.01$), and the heterogeneity between included studies was low (I^2=20.7 %). Twenty-one studies reported the incidence of pneumonia; the OR was 0.63 (95 % CI, 0.46–0.86; $P<0.01$), and the heterogeneity between included studies was low (I^2=11.7 %). Fourteen studies reported LOS; the standardized mean difference was −0.34 (95 % CI, –0.39–−0.30, $P<0.01$), and the heterogeneity between included studies was high (I^2=86.3 %) (Fig. 5). Therefore, significant associations were found between LPS and a decreased incidence of postoperative wound infection, cardiovascular diseases, pneumonia, and decreased LOS, while associations were not significant for anastomotic leakage. In addition, an association was also found between LPS and decreased LOS.

Table 1 Overview of included studies

Author	Year	Design	Country	Enrolment	No. of patients	Age	Disease	Disease site
Fujii[22]	2013	Pros	Japan	2008–2012	200	75	Cancer	Both
Miyasaka[41]	2013	Retro	Japan	2007–2012	107	70	Cancer	Both
She[25]	2013	Retro	Hong-Kong	2000–2009	434	75	Cancer	Colon
Cummings[26]	2012	Retro	USA	1996–2002	27436	65	Cancer	Colon
White[27]	2012	Retro	Australia	2000–2009	114	79	Both	Rectum
Tan[11]	2012	Retro	Singapore	2005–2008	727	70	Both	Both
Altuntas[28]	2012	Retro	turkey	2000–2011	90	70	Cancer	Both
Suto[42]	2011	Retro	Japan	2000–2009	270	75	Cancer	Both
Issa[29]	2011	Retro	Israel	2005–2008	93	80	Cancer	Colon
Al-Refaie[30]	2011	Retro	USA	2005–2008	4162	80	Cancer	Both
Pinto[31]	2011	Retro	USA	2001–2008	199	80	Both	Both
Robinson[32]	2011	Retro	USA	2002–2009	242	65	Cancer	Both
Tomimaru[33]	2011	Retro	Japan	2004–2007	167	75	Cancer	Colon
Kennedy[34]	2011	Retro	USA	2005–2008	5914	65	Cancer	Colon
Faiz[35]	2011	Retro	UK	1996-2007	28746	75	Cancer	Colon
Lian[10]	2010	Retro	USA	1994–2008	194	80	Both	Colon
Allardyce[13]	2010	Pros	Australia	1998–2005	326	70	Cancer	Colon
Tei[36]	2009	Retro	Japan	2004–2007	129	71	Cancer	Both
Akiyoshi[37]	2009	Retro	Japan	2001–2008	87	75	Cancer	Rectum
Frasson[12]	2008	Pros	Italy	ns	201	70	Both	Both
Person[38]	2008	Retro	USA	1991–2006	209	65	Benign	Colon
Feng[39]	2006	Retro	China	2003–2004	153	80	Cancer	Both
Vignali[9]	2005	Retro	Italy	1999–2004	122	80	Cancer	Both
Senagore[40]	2003	Retro	USA	1999–2001	173	70	Both	Colon
Sklow[8]	2003	Retro	USA	1991–1999	78	75	Cancer	Colon
Law[7]	2002	Retro	Hong-Kong	2000–2001	154	70	Both	Both
Stocchi[6]	2000	Retro	USA	1992–1998	84	75	Both	Colon
Tuech[24]	2000	Pros	France	1993–1998	46	75	Benign	Colon
Delgado[16]	2000	Pros	Spain	1993–1998	126	70	Cancer	Both
Stewart[23]	1999	Pros	Austria	1992–1997	77	80	Both	Both

No. number, *pros* prospective study, *retro* retrospective study, *ns* not stated

Subgroup Analysis for Short-Term Complications

Study Design

The impact of study design on OR was assessed; the OR was 0.51 (95 % CI, 0.37–0.70; $P<0.01$) for RCTs and 0.55 (95 % CI, 0.47–0.64; $P<0.01$) for non-RCTs. The impact of LPS on a decreased incidence of postoperative short-term complications was consistent, regardless of study design (Fig. 6).

Study Quality

The impact of study quality on OR was assessed; the OR was 0.58 (95 % CI, 0.53–0.64; $P<0.01$) for higher quality studies and 0.62 (95 % CI, 0.52–0.73; $P<0.01$) for lower quality studies. The association of LPS with a decreased incidence of postoperative short-term complications was consistent, regardless of study quality (Fig. 6).

Region

To explore differences in ORs for short-term complications between Western and Asian regions, we categorized all studies into two groups, those published in Western countries and those published in Asian countries. The OR was 0.59 (95 % CI, 0.54–0.64; $P<0.01$) for Western countries and 0.60 (95 % CI, 0.48–0.74; $P<0.01$) for Asian countries. The association of LPS with a decreased incidence of postoperative short-term complications was consistent, regardless of region (Fig. 6).

Table 2 Quality assessment according to the Newcastle–Ottawa scale

Author	Representativeness	Selection of a nonexposed cohort	Ascertainment	Demonstration of selection	Comparability	Assessment	Duration of follow-up	Adequacy	Total score	
Fujii[22]	0	1	1	1	2	1	1	1	8	Higher
Miyasaka[41]	0	1	1	1	2	0	0	1	6	Lower
She[25]	0	0	1	1	0	0	0	1	3	Lower
Cummings[26]	1	1	1	1	2	1	1	1	9	Higher
White[27]	1	1	1	1	0	0	1	1	6	Lower
Tan[11]	0	1	1	1	0	0	1	1	5	Lower
Altuntas[28]	0	1	1	1	2	0	1	1	7	Higher
Suto[42]	0	1	1	1	0	0	0	1	4	Lower
Issa[29]	0	1	1	1	2	0	1	1	7	Higher
Al-Refaie[30]	1	1	1	1	2	1	1	1	9	Higher
Pinto[31]	0	1	1	1	0	0	1	1	5	Lower
Robinson[32]	0	1	1	1	0	0	1	1	5	Lower
Tomimaru[33]	0	1	1	1	2	1	1	1	8	Higher
Kennedy[34]	1	1	1	1	2	1	1	1	9	Higher
Faiz[35]	1	1	1	1	0	1	1	1	7	Higher
Lian[10]	1	1	1	1	2	1	1	1	9	Higher
Allardyce[13]	1	1	1	1	0	1	0	1	6	Lower
Tei[36]	0	1	1	1	0	1	1	1	6	Lower
Akiyoshi[37]	0	1	1	1	0	1	1	1	6	Lower
Frasson[12]	0	1	1	1	2	1	1	1	8	Higher
Person[38]	0	1	1	1	0	1	0	1	5	Lower
Feng[39]	0	1	1	1	0	0	0	1	4	Lower
Vignali[9]	1	1	1	1	2	1	1	1	9	Higher
Senagore[40]	0	1	1	1	0	0	1	1	5	Lower
Sklow[8]	0	1	1	1	2	1	0	1	7	Higher
Law[7]	0	1	1	1	0	1	1	1	6	Lower
Stocchi[6]	0	1	1	1	2	0	1	1	7	Higher
Tuech[24]	0	1	1	1	0	1	0	1	5	Lower
Delgado[16]	0	1	1	1	2	1	1	1	8	Higher
Stewart[23]	0	1	1	1	0	0	1	1	5	Lower

Age Definition

The definition of elderly age differed among studies; however, in the present study, the definition of age had no influence on short-term complications. Four studies defined elderly patients as those aged over 65 years; the OR of these studies was 0.60 (95 % CI, 0.53–0.67; $P<0.01$). The OR for 17 studies that defined elderly patients as those aged over 70, 71, or 75 years was 0.66 (95 % CI, 0.60–0.78; $P<0.01$). The OR of 8 studies that defined elderly patients as those aged over 79 or 80 years was 0.54 (95 % CI, 0.47–0.62; $P<0.01$; Fig. 6). These results suggest that OS was a significant risk factor for short-term complications, regardless of age, and was of most relevance for the oldest patients.

Meta-regression Analysis

We explored covariates affecting the heterogeneity of ORs among the included studies. The meta-regression analysis identified year of publication (coefficient, 0.04; 95 % CI, 0.01–0.07; $P=0.02$) as a significant source of heterogeneity (Supplement 2). Furthermore, the inclusion of rectal lesions was also shown to have a marginally significant effect as a source of heterogeneity (coefficient, –0.23; 95 % CI, −0.49–0.04; $P=0.09$).

Long-Term Survival

To assess the impact of LPS on long-term survival, 3 studies reporting long-term survival were identified. All studies

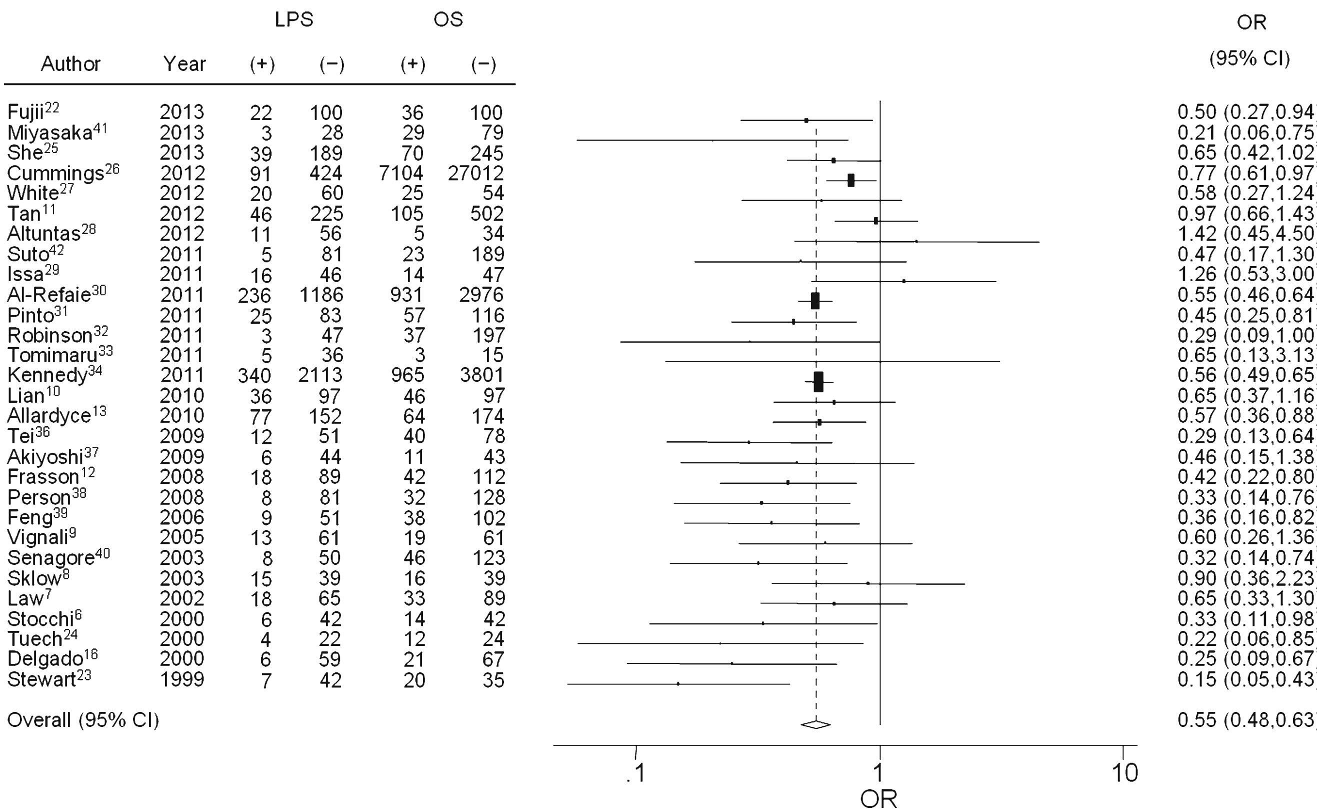

Fig. 2 Forest plot for odds ratios of overall postoperative complications. *LPS* laparoscopic surgery, *OS* open surgery, *CI* confidence interval, *OR* odds ratio

included only patients with colorectal cancer. The HR was 0.89 (95 % CI, 0.72–1.07; P=0.31), demonstrating no significant association between LPS and long-term survival (Fig. 7). Heterogeneity between the included studies was low (I^2=0.0 %).

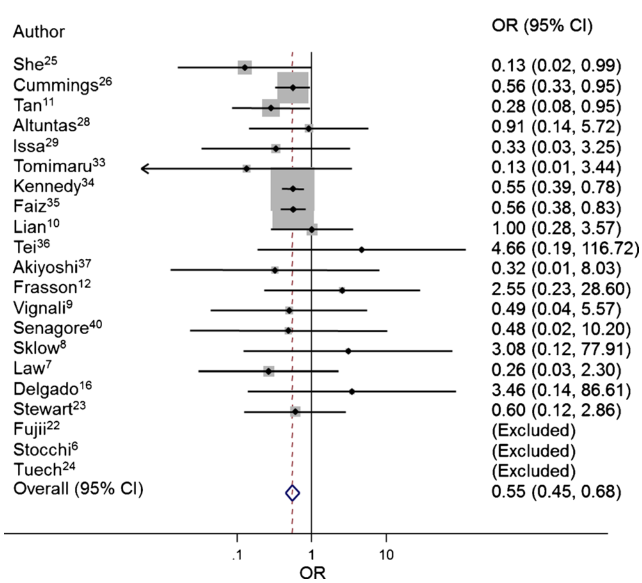

Fig. 3 Forest plot for odds ratios of postoperative mortality. *CI* confidence interval, *OR* odds ratio

Discussion

This meta-analysis demonstrated that laparoscopic colorectal surgery for elderly patients has had a clear and positive impact in terms of a significant decrease in postoperative morbidity and mortality compared with conventional open colorectal surgery. Furthermore, this procedure was associated with faster postoperative recovery and the protection of postoperative complications, regardless of the type of postoperative complication. With regard to long-term survival outcomes, there was no significant difference between LPS and OS. Considering the rapidly aging population, an overview of surgical outcomes for elderly patients is useful to understand the intraoperative physiology of elderly patients better and design an age-appropriate treatment plan. Consequently, these findings favor the use of laparoscopic colorectal surgery, even for elderly patients.

One of the difficulties in assessing the outcomes of colorectal surgery in elderly patients is that there is no consistent definition of the elderly patient population in the published series.[15] In fact, the definitions of elderly age in included studies varied from 65 to 80 years. In this meta-analysis, subgroup and meta-regression analyses were conducted to evaluate the influence of a variety of definitions of age on postoperative morbidity, showing that it had no significant influence on postoperative morbidity. This finding suggests that the

Factors (No. of Study)	LPS E/T	OS E/T	I^2	OR (95%CI)	P value
Wound infection (24)	84/1700	226/2523	25	0.51(0.39,0.66)	<0.001
Anamostomotic leak (22)	36/1589	65/2420	9.5	0.77(0.51,1.16)	0.208
Cardiovascular disease (18)	66/1400	169/2216	20.7	0.66(0.49,0.89)	0.006
Pneumonia (21)	59/1531	144/2356	11.7	0.63(0.46,0.86)	0.003

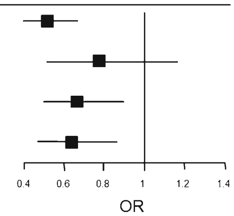

Fig. 4 Forest plot for odds ratios of each type of postoperative complication. *LPS* laparoscopic surgery, *OS* open surgery, *CI* confidence interval, *OR* odds ratio, *E/T* events/total cases

decreased invasiveness of LPS remains an advantage regardless of patient age. In a study including 535 patients, Frasson et al.[12] reported that LPS improved the short-term postoperative outcome in patients aged ≥70 years compared with that in patients aged <70 years and concluded that the benefits of LPS are more pronounced in the elderly. These findings therefore favor the aggressive application of laparoscopic surgery in elderly patients.

Although several large randomized control studies have shown the non-inferiority of LPS over OS in terms of long-term survival, this topic remains controversial in elderly patients.[43–45] This is the first meta-analysis comparing long-term survival between LPS and OS in elderly patients, showing no statistically significant difference between the two procedures. However, this result should be cautiously interpreted because there was a potential imbalance in patient characteristics between LPS and OS; furthermore, no well-designed study has been conducted till date. In elderly patients, surgeons hesitate to perform extended lymphadenectomy, considering the limitations in physical function. Occasionally, elderly patients have greater expectations for a good quality of life than for long-term survival. Investigations assessing the outcomes of better function and improved quality of life will attribute these to appropriate treatment strategies for elderly patients with colorectal cancer.

Recently, Antoniou et al.[46] have reported a meta-analysis concluding that LPS has a significant advantage in postoperative morbidity and mortality, consistent with our result. Although they performed sensitivity analysis, the definition of elderly patients, which is considered as one of the critical factors, was not mentioned. Given the appropriate application of LPS, our finding that there is no significant difference among age definitions is useful. In addition, the impact on long-term survival was not discussed. Therefore, our analysis is considered to include more comprehensive and significant result about the benefits of LPS in the elderly.

There are a number of recognized risks of LPS in terms of physiological concerns adherent to postoperative morbidity; increased intraperitoneal pressure caused by pneumoperitoneum, adverse effects of high carbon dioxide levels, and patient

	LPS		OS		
Author	mean	SD	mean	SD	Standardised Mean diff. (95% CI)
Fujii[22]	11.7	9.2	14.4	12.7	-0.24 (-0.52,0.03)
Cummings[26]	8.3	6.2	10.6	7.6	-0.30 (-0.40,-0.21)
Altuntas[28]	8.5	7.5	10.2	7.8	-0.22 (-0.65,0.20)
Issa[29]	7.6	3.1	8.8	3.6	-0.36 (-0.77,0.05)
Al-Refaie[30]	7.5	6.8	9.7	7.7	-0.30 (-0.36,-0.23)
Tomimaru[33]	14.2	9.4	18	8.3	-0.42 (-1.03,0.19)
Frasson[12]	9.5	3.8	13	9.4	-0.47 (-0.75,-0.19)
Person[38]	6.4	4.8	8.7	3.9	-0.54 (-0.82,-0.26)
Feng[39]	21.2	11.8	25.5	16.6	-0.28 (-0.62,0.05)
Vignali[9]	9.8	5.3	12.9	10	-0.39 (-0.75,-0.03)
Senagore[40]	4.2	3	9.3	7.6	-0.77 (-1.11,-0.43)
Sklow[8]	6.1	0.3	7.8	0.6	-3.58 (-4.31,-2.86)
Stocchi[6]	6.5	4	10.2	4.4	-0.88 (-1.33,-0.43)
Delgado[16]	6	2	7	3	-0.39 (-0.74,-0.03)
Overall (95% CI)					-0.34 (-0.39,-0.30)

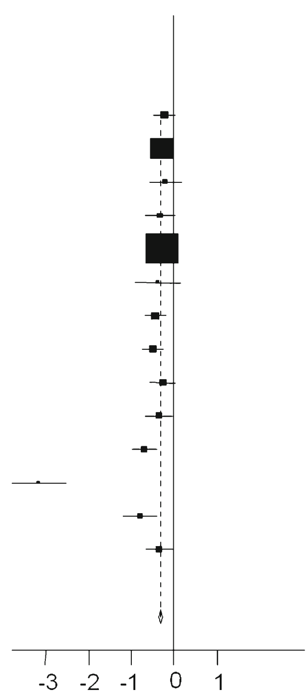

Fig. 5 Forest plot for the effects of laparoscopy on length of hospital stay. *LPS* laparoscopic surgery, *OS* open surgery, *CI* confidence interval, *SD* standard deviation

Factors (No. of Study)	LPS E/T	OS E/T	I²	OR (95%CI)	P value
Study design					
RCT(3)	117/341	142/386	0	0.51(0.37,0.70)	<0.001
non-RCT(26)	988/5278	9716/36195	43.8	0.55(0.47,0.64)	<0.001
Study quality					
higher(12)	804/4292	9211/34269	15	0.58(0.53,0.64)	<0.001
lower(17)	301/1327	647/2212	54	0.62(0.52,0.73)	<0.001
Region					
Western(19)	940/4749	9470/35139	55.3	0.59(0.54,0.64)	<0.001
Asian(10)	165/870	388/1442	14.2	0.60(0.48,0.74)	<0.001
Age definition					
65(4)	442/2665	8138/31138	8.3	0.60(0.53,0.67)	<0.001
70(17)	301/1328	570/1955	46.3	0.66(0.60,0.78)	<0.001
80(8)	362/1626	1150/3488	11.2	0.54(0.47,0.62)	<0.001

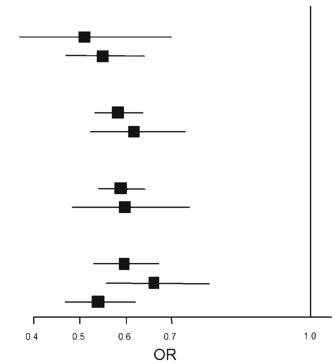

Fig. 6 Forest plot for odds ratios of postoperative complications in subgroups. *LPS* laparoscopic surgery, *OS* open surgery, *CI* confidence interval, *E/T* events/total cases, *RCT* randomized control study

positions are all well-known disadvantages of LPS.[47–49] Although elderly patients are less likely to tolerate these risks because of their limited cardiopulmonary capacity, this meta-analysis demonstrated that these risks are clearly decreased by LPS, probably because of advanced anesthetic improvements and perioperative care.[50] Furthermore, serum inflammatory cytokines were reported to be significantly low with LPS, suggesting that LPS can better preserve immune function compared with OS.[51–53]

In a systematic review, the incidence of morbidity and mortality after colorectal cancer surgery was reported to increase with advancing age.[54] This finding is considered to be associated with higher comorbidities adherent to surgical risk in elderly patients and indicates the need for optimized perioperative management for elderly patients. A shorter LOS and the lower morbidity rate are important for elderly patients in terms of rapid postoperative recovery of bowel function, oral food intake, and physical activity.[7–9,55] Given that elderly patients are at a high risk of decreased postoperative activities of daily

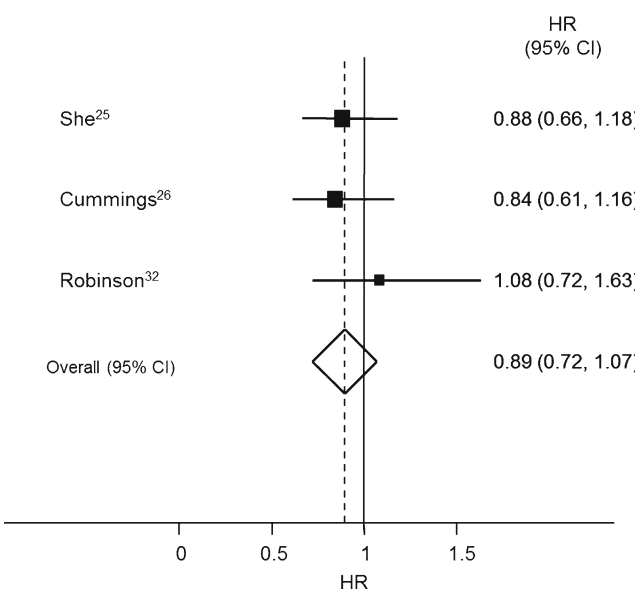

Fig. 7 Forest plot for odds ratios of long-term survival. *CI* confidence interval, *HR* hazard ratio

living (ADL), a shorter LOS greatly favors faster ADL recovery by supporting the postoperative rehabilitation of elderly patients and avoiding the risk of postoperative delirium.[56]

Although significant benefits were shown in this meta-analysis, whether or not LPS is recommended regardless of patient comorbidities remains controversial. There have been recent attempts to determine the surgical indications for elderly patients according to preoperative conditions. Actually, the issue of selection bias is critical and needs more than a passing remark. Only three of the studies included in this analysis were randomized (the numbers of patients enrolled were 727 in RCT and 70,219 in non-RCT). However, even RCT is necessarily not the best way to eliminate selection bias in study of elderly patients, because patients with severe comorbidities are actually excluded. Therefore, a case series study describing these exclusion criteria would be helpful to generalize the conclusions. The Portsmouth Physiologic and Operative Severity Score for the enumeration of Mortality and Morbidity (P-POSSUM) is one of the scoring systems that potentially reflects patient conditions and predicts the risk of postoperative complications.[36] Hereafter, a novel guideline not only for surgical indications but also for surgical procedure (i.e., LPS or OS) selection according to the postoperative complication risk is required to achieve the standardization of treatment for elderly patients. Furthermore, because we focused on the benefits of LPS itself, oncological factors such as surgical curability, length of the resected specimen, and number of dissected lymph nodes in cancer patients were not analyzed. The Colorectal Cancer Collaborative Group has reported that older patients with colorectal cancer are more likely to present with later-stage disease compared with their younger counterparts.[54] To clarify the oncological accuracy of LPS in elderly patients with colorectal cancer, further studies are required that consider these influencing factors.

In conclusion, this meta-analysis showed significant short-term advantages of LPS in the elderly population. LPS should be aggressively applied for elderly patients. Further studies are required to examine long-term survival compared between LPS and OS in the elderly population.

Conflicts of Interest None declared

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