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Review Article

Laparoscopic gastrectomy for gastric cancer in the elderly

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Abstract: This review is conducted to determine the safety and efficacy of laparoscopic gastrectomy in elderly patients with gastric cancer. Studies published between March 1965 and August 2015 were systematically searched. Three types of study were included, including 1) studies comparing elderly patients versus younger patients undergoing laparoscopic gastrectomy for gastric cancer, 2) studies comparing laparoscopic gastrectomy versus open gastrectomy in elderly patients with gastric cancer, and 3) any case series of laparoscopic gastrectomy in elderly patients with gastric cancer. Twenty-six studies were included and composed of 24 comparative studies and 2 case series. When comparing elderly patients with younger patients undergoing laparoscopic gastrectomy, most comparative studies did not show significant difference in postoperative morbidity and mortality rate between the two groups, either the age threshold of the elderly was 70 or 75 years old. When comparing laparoscopic with open gastremtomy in the elderly, laparoscopic gastrectomy lead to a lower incidence of postoperative complications, a faster recovery of gastrointestinal function and a shorter hospital stay compared with open gastrectomy, with similar pathological and long-term oncological outcomes. Laparoscopic gastrectomy in elderly patients with gastric cancer is relatively safe and feasible at least when the age threshold of the elderly was 75 years old or less. Moreover, laparoscopic gastrectomy leads to less postoperative complications and faster postoperative recovery than open gastrectomy. More studies are needed to investigate the safety and efficacy of laparoscopic gastrectomy in the eldest elderly patient (aged ≥ 80 years old or more) in the future.

Keywords: Aged, gastrectomy, gastric neoplasms, laparoscopic, systematic review

Introduction

Gastric cancer ranks fifth in terms of incidence and third in terms of cancer-related deaths worldwide [1]. As the world population is rapidly aging, the number of elderly patients with gastric cancer is expected to increase and larger numbers of elderly patients with gastric cancer will be candidates for gastric resection. Radical gastrectomy with lymph node dissection is the mainstay of therapy for patients with resectable gastric cancer, and complete resection (R0) provides the only hope for long-term survival [2, 3]. However, the elderly patients have less functional reserve [4] and usually have more comorbidities [5] compared with younger patients, which may lead to worse postoperative outcomes [6, 7]. For this reason, initially, surgeons were recommended to perform limited surgery for gastric cancer in the elderly patients, especially for those with preoperative comorbidities [8, 9]. On the other hand, however, more and more studies have come up with conversed conclusions, which showed that the elderly patient can safely undergo a major operation and that chronological age is not a contraindication for radical gastrectomy for gastric cancer [10, 11]. This suggestion has become possible mainly due to the improvement in surgical techniques and perioperative care [12, 13].

Laparoscopic gastrectomy is a less invasive surgical technique than open gastrectomy, resulting in less blood loss, reduced frequency of analgesic administration, rapid recovery of gastrointestinal function, shorter hospitalization and lower complication rates [14, 15].

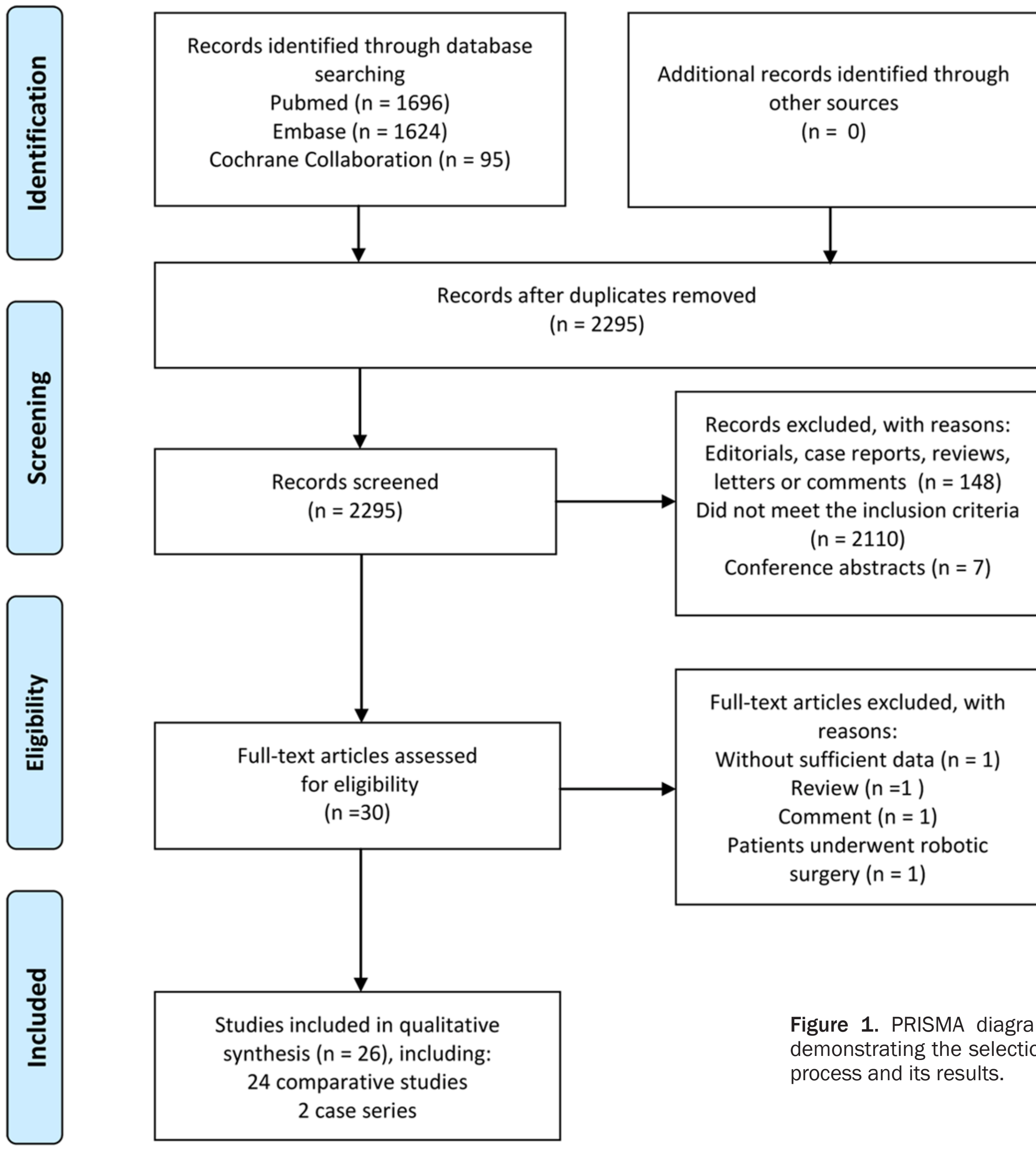

Figure 1. PRISMA diagram demonstrating the selection process and its results.

Therefore, laparoscopic gastrectomy should be beneficial for the elderly in terms of reduced surgical trauma. However, the CO_2 pneumoperitoneum have been well reported to influence cardiovascular or respiratory functions during laparoscopic procedures [16-18]. For fear of that, surgeons are hesitated to perform laparoscopic surgery on the elderly patients who generally have more cardiovascular and respiratory comorbidities. Moreover, laparoscopic gastrectomy generally costs longer time than open gastrectomy [14], and has been reported to result in less harvested lymph nodes compared with open gastrectomy [14]. Elderly patients have a lower tolerance for long operative time, rendering us to speculate whether the lower tolerance for operative time would result in an inadequate lymph node dissection and even a poorer oncological outcome in the elderly patients who underwent laparoscopic gastrectomy. Above all, the safety and efficacy of laparoscopic gastrectomy in elderly patients is still uncertain.

In this systematic review, we summarized the published work on laparoscopic gastrectomy for gastric cancer in the elderly people.

Table 1. Description of the included studies and basic characteristic of the patients

Authors, publish years	Country	Study quality	Groups	Patient numbers, n (%)	Age, years, (mean ± SD)	Gender (M/F)	BMI, kg/m^2, (mean ± SD)	ASA (I/II/III)	Co-morbidity n (%)
Yasuda 2004 [22]	Japan	Low	≥ 70 y, L	45 (34.6)	75.7 ± 4.5	26/19	NR	NR	25 (55.6)
			< 70 y, L	57 (43.8)	59·5 ± 7·3	33/24	NR	NR	16 (28.1)
			≥ 70 y, O	28 (21.5)	77·2 ± 5·8	17/11	NR	NR	19 (67.9)
Mochiki 2005 [23]	Japan	Low	≥ 70 y, L	30 (25.2)	75.2 ± 0.5	20/10	NR	NR	13 (43%)
			< 70 y, L	73 (61.3)	56.6 ± 1.0	49/24	NR	NR	4 (5.4%)
			≥ 70 y, O	16 (13.4)	74.3 ± 0.7	14/2	NR	NR	4 (25%)
Suzuki 2015 [24]	Japan	Low	≥ 75 y, L	38 (35.5)	78.5 (75-90)[a]	28/10	22.5 (17.1-32.8)[a]	NR	28 (73.7)
			< 65 y, L	41(38.3)	58 (22-63)[a]	27/14	22.6 (18.2-30.4)[a]	NR	12 (29.3)
			≥ 75 y, O	28 (26.2)	77 (75-88)[a]	18/10	23.0 (17.1-28)[a]	NR	24 (85.7)
Tokunaga 2008 [25]	Japan	High	≥ 75 y, L	49 (17.0)	78.9 ± 3.9	30/19	22.92 ± 3.96	5/38/6	80[b]
			< 75 y, L	240 (83.0)	59.1 ± 9.7	135/105	22.79 ± 3.06	131/99/10	190[b]
Cho 2009 [26]	Korea	High	≥ 70 y, L	226 (20.3)	73.7 ± 3.7	142/84	23.2 ± 3.1	NR	122 (54.0)
			< 70 y, L	890 (79.4)	58.4 ± 7.1	585/305	23.6 ± 2.9	NR	337 (37.9)
Hwang 2009 [27]	Korea	High	≥ 70 y, L	117 (18.5)	74.1 ± 3.8	78/39	23.3± 3.3	NR	88[b]
			< 70 y, L	515 (81.5)	55.6 ± 10.0	328/188	23.7 ± 3.1	NR	194[b]
Kunisaki 2009 [28]	Japan	High	≥ 75 y, L	26 (20)	78.8 ± 2.8	21/5	22.7 ± 3.6	12/12/2	14 (53.8)
			< 75 y, L	104 (80)	60.8 ± 10.0	64/40	22.5 ± 2.9	81/21/2	23 (22.1)
Yamada 2010 [29]	Japan	Low	≥ 80 y, L	18 (24.3)	82.0 ± 1.5	13/5	22.3 ± 3.9	5/12/1	16[b]
			70-79 y, L	56 (75.7)	73.0 ± 2.0	44/12	22.5 ± 3.0	20/32/4	34[b]
Kim 2012 [30]	Korea	High	≥ 65 y, L	93 (29.4)	70.2 ± 4.0	61/32	22.7 ± 2.5	32/54/7	61[b]
			< 65 y, L	223 (70.6)	51.3 ± 8.8	137/86	22.9 ± 2.6	138/81/6	87[b]
PARK 2013 [31]	Korea	High	> 70 y, L	80 (20.7)	NR	45/35	23.4 ± 3.1	NR	37 (46.2)
			≤ 70 y, L	307 (79.3)	NR	210/87	24.0 ± 3.2	NR	69 (22.5)
Oki 2013 [32]	Japan	Low	> 75 y, L	20 (14.5)	80.8 ± 3.2	10/10	22.5 ± 2.9	3/13/4	26[b]
			≤ 75 y, L	118 (85.5)	60.5 ± 9.1	65/53	22.3 ± 3.1	55/55/8	73[b]
Kim 2013 [33]	Korea	High	> 70 y, L	79 (20.3)	74.7 ± 4.7	54/25	23.7 ± 3.2	21/49/9	57 (72.2)
			< 70 y, L	310 (79.7)	53.4 ± 9.7	201/109	24.1 ± 3.0	194/102/14	116 (37.4)
Mohri 2015 [34]	Japan	High	≥ 70 y, L	71 (33.8)	76.6 ± 5.2	52/19	22.9 ± 3.0	21/48/2	45 (63.4)
			< 70 y, L	139 (66.2)	58.5 ± 8.8	84/55	22.6 ± 3.8	88/46/5	49 (35.3)
Kim 2014 [35]	Korea	High	≥ 75 y, L	98 (9.3)	77.6 ± 2.6	58/40	23.0 ± 3.2	NR	66 (67.3)
			65-74 y, L	285 (27.0)	69.3 ± 2.9	186/99	23.2 ± 3.0	NR	141 (49.5)
			< 65 y, L	672 (63.7)	51.3 ± 8.9	398/274	23.5 ± 2.8	NR	171 (25.4)
Miyasaka 2014 [36]	Japan	Low	≥ 85 y, L	9 (3.4)	86.7 ± 2.3	3/6	22.6 ± 2.8	1/6/2	8 (56)

			< 85 y, L	253 (96.6)	67.3 ± 9.5	185/68	22.4 ± 3.0	86/147/20	147 (64)
Kosuga 2015 [37]	Japan	High	≥ 75 y, L	55 (18.8)	79.5 ± 4.0	35/20	22.2 ± 3.0	NR	34 (61.8)
			< 75 y, L	237 (81.2)	60.5 ± 9.7	145/92	22.8 ± 3.3	NR	102 (43.0)
Yang 2015 [38]	China	Low	≥ 70 y, L	53 (24.8)	75.5 ± 4.2	38/15	23.7 ± 4.2	5/34/14	31 (58.5)
			< 70 y, L	161 (75.2)	54.2 ± 9.8	112/49	23.3 ± 3.3	36/116/9	33 (20.5)
Fujisaki 2015 [39]	Japan	High	≥ 75 y, L	70 (36.3)	80.1 ± 4.1	44/26	22.3 ± 2.6	57/13[c]	36 (51.4)
			< 75 y, L	123 (63.7)	64.8 ± 7.5	79/44	22.6 ± 3.2	114/9[c]	55 (44.7)
Meng 2012 [40]	China	Low	≥ 65 y, L	116 (45.5)	71.4 ± 4.7	88/28	21.9 ± 3.1	NR	57 (49.1)
			≥ 65 y, O	139 (54.5)	71.5± 5.0	107/32	22.3± 3.1	NR	75 (54.0)
Hu 2013 [41]	China	High	≥ 65 y, L	109 (46.8)	72.4 ± 4.8	74/35	NR	NR	56 (51.4)
			≥ 65 y, O	124 (53.2)	71.8 ± 4.9	83/41	NR	NR	68 (54.8)
Li 2014 [42]	China	Low	≥ 70 y, L	54 (50)	78.6 ± 6.5	36/18	NR	NR	46 (85.2)
			≥ 70 y, O	54 (50)	76.5 ± 7.2	30/24	NR	NR	44 (81.5)
Qiu 2014 [43]	China	High	≥ 70 y, L	30 (46.9)	74.4 ± 3.1	25/5	21.6 ± 2.7	1/21/8	34[b]
			≥ 70 y, O	34 (53.1)	75.6 ± 3.0	22/12	21.6 ± 3.0	1/24/9	34[b]
Lu 2015 [44]	China	High	≥ 65 y, L	252 (50)	113/73/36/30[d]	208/44	25/200/27[e]	143/100/9	125 (49.6)
			≥ 65 y, O	252 (50)	111/76/37/28[d]	213/39	28/198/26[e]	135/104/13	128 (50.8)
Shin 2015 [45]	Korea	High	≥ 65 y, L	60 (48.8)	71.6 ± 5.0	22/38	24.6 ± 8.0	23/37/0	NR
			≥ 65 y, O	63 (51.2)	72.2 ± 4.6	23/40	23.7 ± 3.2	14/49/0	NR
Singh 2008 [46]	UK	-	≥ 75 y, L	20	80 (75-88)[a]	14/6	NR	1/13/6	NR
Kumagai 2014 [47]	Japan	-	≥ 70 y, L	189	76 (70-90)[a]	124/65	22.2 ± 3.4	68/106/15	121 (64.0)

[a]median (range); [b]number of co-morbidity; [c]ASA1,2/3; [d]age 65-69 y/70-74 y/75-79 y/≥80 y; [e]BMI: < 18.5/18.5-25/≥ 25. L: laparoscopic gastrectomy; O: open gastrectomy.

Methods

Search strategy

Studies published between March 1965 and August 2015 were searched in PubMed, Embase, and the Cochrane databases (latest literature search in 24 August 2015). No language restrictions were applied. Article titles and abstracts were screened, and full texts were reviewed independently by 2 reviewers (DDH and CJZ), discrepancies were resolved by discussion between the reviewers. We used the following search strategy for PubMed, "(gastric cancer or gastric tumor or gastric carcinoma or stomach cancer or stomach tumor or stomach carcinoma or "stomach neoplasms" [Mesh]) AND (laparoscopic or laparoscopically or laparoscopy or "laparoscopy" [MeSH] or minimally invasive*) AND ("Aged, 80 and over" [mesh] or "aged" [mesh] or sexagenarian* [tiab] or septuagenarian* [tiab] or octogenarian* [tiab] or nonagenarian* [tiab] or elderly [tiab] or aged [tiab] or older [tiab] or "old* patient* [tiab]" or "age* patient* [tiab]")".

Inclusion and exclusion criteria

Three types of study were included, including 1) studies comparing elderly patients versus younger patients undergoing laparoscopic gastrectomy for gastric cancer, 2) studies comparing laparoscopic gastrectomy versus open gastrectomy in elderly patients with gastric cancer, and 3) any case series of laparoscopic gastrectomy in elderly patients with gastric cancer. Studies of laparoscopy-assisted gastrectomy or totally laparoscopic gastrectomy were both included, but studies of robotic surgery were excluded. Editorials, case reports, reviews, letters and comments were also excluded. An age threshold of at least 65 years or greater was used to define the elderly population according to the statements of the World Health Organization [19]. Selection process for studies included in the systematic review was listed in **Figure 1**.

Data extraction and outcome measures

All included studies were reviewed, and all relevant data were extracted independently by 2 reviewers (DDH and CJZ). Discrepancies were resolved by discussions between the reviewers. Extracted information from each eligible study included 1) study information, including name of the first author, year of publication and number of patients in each group; 2) patient basic characteristic, including age, gender, body mass index (BMI), the American Society of Anesthesiology (ASA) grade, comorbidities, tumor-node-metastasis (TNM) stage of tumor and histological type of tumor; 3) intraoperative outcomes, including operative time, blood loss, conversions to open gastrectomy, type of surgery, extent of lymph node dissection and retrieved lymph nodes; 4) short-term postoperative outcomes, including operative mortality, postoperative complications, time to first passage of flatus and postoperative hospital stays; 5) long-term survival outcomes, including overall survival (OS), disease-specific survival (DSS) and disease-free survival (DFS); 6) other outcomes, such as quality of life and postoperative cognitive function. Complications graded as III-IV are classified as severe complications according to the Clavien-Dindo classification [20].

Assessment of risk of bias

The quality of included comparative studies was independently reviewed by two assessors (D.D.H. and C.J.Z.) according to a modified methodological index for non-randomized studies (MINORS) scale [21]. Scores ranged from 0 (lowest) to 16 (highest). Studies with scores ≥ 12 were classified as high quality studies, while those with scores < 12 were classified as low quality studies [21]. Disagreement was resolved through discussions.

Results

Description of studies

Twenty-six studies met the inclusion criteria (**Table 1**), including 24 comparative studies [22-45] and 2 case series [46, 47]. Among these studies, 15 studies [25-39] compared the elderly with younger patients who underwent laparoscopic gastrectomy (EL versus YL), 6 studies [40-45] compared laparoscopic with open gastrectomy in the elderly patients (EL versus EO), and 3 studies [22-24] conducted both of the two comparisons (EL versus YL; EL versus EO). All studies were retrospectively designed, except for one prospective study from Korea [45]. Twelve studies were from Japan [22-25, 28, 29, 32, 34, 36, 37, 39, 47], 7

Table 2. Quality assessment of the included studies based on modified MINORS Scale

Author Publishing year	Consecutive Patients	Prospective Data Collection	Reported Endpoints	Unbiased Outcome Evaluation	Appropriate Controls	Contemporary Groups	Groups Equivalent[a]	Sample Size[b]	Score
Yasuda 2004	2	1	1	0	1	2	1	1	9
Mochiki 2005	2	1	1	0	2	2	2	1	11
Suzuki 2015	2	1	1	0	2	2	1	1	10
Tokunaga 2008	2	2	2	0	2	2	2	1	13
Cho 2009	2	1	2	0	2	2	2	2	13
Hwang 2009	2	1	1	0	2	2	2	2	13
Kunisaki 2009	2	1	2	2	2	2	2	1	14
Yamada 2010	2	1	2	0	2	2	1	0	10
Kim 2012	2	2	2	0	2	2	2	2	14
Park 2013	2	1	2	0	2	2	1	2	12
Oki 2013	2	1	1	0	2	2	2	1	11
Kim 2013	2	2	2	2	2	2	1	2	15
Mohri 2015	2	2	1	0	2	2	2	1	12
Kim 2014	2	2	2	1	1	2	2	2	14
Miyasaka 2014	2	1	2	0	2	2	1	0	10
Kosuga 2015	2	1	1	0	2	2	2	2	12
Yang 2015	2	1	2	0	1	2	1	2	11
Fujisaki 2015	2	2	2	1	2	2	1	2	14
Meng 2012	2	1	1	0	1	2	2	2	11
Hu 2013	2	1	2	0	2	2	2	2	13
Li 2014	1	1	2	0	1	2	2	2	11
Qiu 2014	2	1	2	0	2	2	2	1	12
Lu 2015	1	2	2	0	2	2	2	2	13
Shin 2015	2	2	1	2	2	2	1	2	14

[a]Factors considered were: 1) gender, operative method, lymphadenectomy and TNM/stage in studies comparing elderly and younger patients; and 2) age, gender, comorbidities, BMI, lymphadenectomy, and TNM/stage in studies comparing laparoscopic and open gastrectomy. [b]Sample size refers to: 1) number of elderly patients in the studies comparing elderly and younger patients; and 2) number of patients underwent laparoscopic surgery in the studies comparing laparoscopic and open gastrectomy.

from Korea [26, 27, 30, 31, 33, 35, 45], 6 from China [38, 40-44], and 1 from UK [46], respectively. Fifteen comparative studies [25-28, 30, 31, 33-35, 37, 39, 41, 43-45] were ranked as "high" quality studies and 9 [22-24, 29, 32, 36, 38, 40, 42] were ranked as "low" quality studies (**Table 2**).

Basic characteristic of the patients

In the studies that compare the elderly patients with younger patients who underwent laparoscopic gastrectomy (EL versus YL) [22-39], EL group generally had more comorbidities and higher ASA grade than YL group (**Table 1**). EL group also had a greater proportion of histologically well-differentiated tumors in most studies. BMI and gender were comparable between the two groups in most studies, and the two groups were similar in terms of tumor stage in all studies that reported this information.

In the studies that compare laparoscopic with open gastrectomy in the elderly patients (EL versus EO) [22-24, 40-45], age, gender, BMI, and comorbidities were similar between the two groups in all studies that reported these information. Tumor stage and histological type was comparable between the two groups in most studies, except for 1 study in which EO group had a larger tumor size, poorer histological type, greater depth of tumor invasion and larger proportion of lymph node metastasis [22].

Intraoperative outcomes

Conversions: A total of 47 conversions occurred in patients undergoing laparoscopic gastrectomy (**Table 3**). Of the 18 studies comparing EL with YL group [22-39], 16 reported the information of conversions [22-34, 37-39]. Only 1 study reported a higher conversion rate in the elderly

Table 3. Intraoperative outcomes

Authors, publish years	Groups	Mean operative time, minutes, (mean ± SD)	Conversionsn (%)	Blood loss, g or ml, (mean ± SD)	retrieved lymph nodes (mean ± SD)	Surgery type (with extent of lymph node dessection)
Yasuda 2004	≥ 70 y, L	240 ± 48	0	163 ± 331 g	NR	LADG; ODG (with D1)
	< 70 y, L	247 ± 56	0	176 ± 137 g	NR	
	≥ 70 y, O	207 ± 70	-	296 ± 225 g	NR	
Mochiki 2005	≥ 70 y, L	198.1 ± 7.3	0	170.3 ± 18.5 g	NR	LADG; ODG (with D1+β)
	< 70 y, L	215.0 ± 6.1	0	248.6 ± 23.5 g	NR	
	≥ 70 y, O	183.2 ± 6.5	-	416.9 ± 36.3 g	NR	
Suzuki 2015	≥ 75 y, L	295 (211-424)[a]	0	80 (10-1198) g	NR	LADG; ODG (with D1; D1+; D2)
	< 65 y, L	280 (161-449)[a]	0	55 (10-240) g	NR	
	≥ 75 y, O	238.5 (160-470)[a]	-	296 (63-3,281) g	NR	
Tokunaga 2008	≥ 75 y, L	215.7 ± 45.6	0	75.5 ± 181.5 ml	30.5 ± 8.9	LADG; LAPPG (with D1+; D2)
	< 75 y, L	242.8 ± 58.2	4 (1.7)	65.3 ± 133.4 ml	36.1 ± 11.3	
Cho 2009	≥ 70 y, L	216.0 ± 74.4	0	NR	29·8 ± 14·3	LSG (with D1; D1+; D2)
	< 70 y, L	228.0 ± 79.0	2 (0.2)	NR	31·4 ± 13·2	
Hwang 2009	≥ 70 y, L	180.9 ± 49.0	0	68.8 ± 54.3 ml	NR	LAPG; LATG; LASG (with D1+β; D2)
	< 70 y, L	186.3 ± 59.6	0	71.1 ± 141.49 ml	NR	
Kunisaki 2009	≥ 75 y, L	234.6 ± 54.5	2 (7.7)	84.7 ± 82.0 ml	25.1 ± 8.8	LADG (with D1+α; D2)
	< 75 y, L	268.8 ± 66.5	6 (5.8)	145.6 ± 130.2 ml	27.6 ± 11.7	
Yamada 2010	≥ 80 y, L	255 ± 37	0	78.5 ± 58.5 ml	25.9 ± 13.2	LADG; LAPG; LATG (with D1+)
	70-79 y, L	271 ± 36	0	60.0 ± 40.0 ml	30.0 ± 13.1	
Kim 2012	≥ 65 y, L	203.6 ± 71.7	1 (1.1)	159.7 ± 150.8 ml	21.8 ± 12.5	LADG (with D1+; D2)
	< 65 y, L	200.7 ± 55.6	1 (0.4)	154.3 ± 163.2 ml	25.1 ± 13.1	
PARK 2013	> 70 y, L	33/47[b]	3 cases in all patients	285.7 ± 141.3 ml	27.5 ± 12.8	LADG (with D1+; D2)
	≤ 70 y, L	150/157[b]		289.7 ± 175.4 ml	29.8 ± 13.3	
Oki 2013	> 75 y, L	342.6 ± 102.0	0	104.8 ± 93.5 g	NR	TLDG (with D1+; D2)
	≤ 75 y, L	318.46 ± 66.3	2 (1.7)	121.7 ± 146.09 g	NR	
Kim 2013	> 70 y, L	158.5 ± 38.6	0	NR	32.9 ± 14.7	TLG (with D2)
	< 70 y, L	154.6 ± 37.1	0	NR	36.3 ± 12.9	
Mohri 2015	≥ 70 y, L	307.0 ± 55.9	5 (7.0)	222.7 ± 232.0 g	NR	LADG; LAPG; LATG; LAPPG (with D1+; D2)
	< 70 y, L	334.4 ± 57.4	2 (1.4)	204.4 ± 238.2 g	NR	
Kim 2014	≥ 75 y, L	193.1 ± 62.1	NR	NR	33.5 ± 12.3	LADG; LATG (with D1+; D2)
	65-74 y, L	204.8 ± 60.4	NR	NR	34.7 ± 14.2	
	< 65 y, L	204.0 ± 55.5	NR	NR	37.5 ± 13.9	
Miyasaka 2014	≥ 85 y, L	342 ± 81	NR	81.7 ± 93.5 ml	NR	LADG (with D1; D2)
	< 85 y, L	323 ± 92	NR	63.9 ± 84.0 ml	NR	
Kosuga 2015	≥ 75 y, L	328.7 ± 94.0	2 (3.6)	117.1 ± 146.3 ml	27.1 ± 12.0	LADG; LAPG; LATG; LAPPG (with D1+; D2)
	< 75 y, L	337.1 ± 90.4	5 (2.1)	87.7 ± 124.5 ml	30.7 ± 14.4	
Yang 2015	≥ 70 y, L	249.8 ± 44.9	4 (7.5)	100.0 ± 73.3 ml	26.4 ± 9.7	LADG; LATG; LAPG; ODG; OTG; OPG[c]
	< 70 y, L	260.8 ± 55.9	9 (5.6)	104.8 ± 89.4 ml	30.0 ± 12.4	
Fujisaki 2015	≥ 75 y, L	314.0 ± 82.0	0	93.0 ± 145.6 ml	NR	LDG; LTG (with D1; D1+; D2)
	< 75 y, L	313.4 ± 70.5	1 (1.4)	97.6 ± 154.0 ml	NR	
Meng 2012	≥ 65 y, L	237.8 ± 44.2	0[d]	85.2 ± 90.0 ml	29 ± 11	LATG; LASG OTG; OSG (with D2)
	≥ 65 y, O	241.4 ± 42.2	-	225.3 ± 210.2 ml	27 ± 10	
Hu 2013	≥ 65 y, L	231.2 ± 51.4	0[d]	102.5 ± 34.3 ml	31.4 ± 14.2	LADG; LATG; LAPG; ODG; OTG;OPG (with D2)
	≥ 65 y, O	208.5 ± 53.6	-	181.7 ± 73.8 ml	32.6 ± 11.7	
Li 2014	≥ 70 y, L	179.4 ± 22.5	NR	103.0 ± 34.4 ml	27.8 ± 3.9	LDG; LTG; LPG; ODG; OTG; OPG (with D2)
	≥ 70 y, O	173.0 ± 28.8	NR	140.6 ± 44.4 ml	26.7 ± 4.6	
Qiu 2014	≥ 70 y, L	259.5 ± 53.76	0	120 ± 52.7 ml	30.2 ± 12.0	LADG; LATG; ODG; OTG (with D2)
	≥ 70 y, O	236.09 ± 45.3	-	227.3 ± 146.9 ml	28.1 ± 11.8	
Lu 2015	≥ 65 y, L	194 ± 56	NR	92 ± 124 ml	32 ± 11	LATG; OTG (with D2; modified D2)
	≥ 65 y, O	267 ± 74	NR	204 ± 170 ml	29 ± 10	
Shin 2015	≥ 65 y, L	141.3 ± 37.8	0[d]	111.2 ± 58.9 ml	NR	LADG; TLDG; TLTG; OSG; OTG[c]
	≥ 65 y, O	146.3 ± 34.9	-	207.1 ± 178.2 ml	NR	

Singh 2008	≥ 75 y, L	212 (149-390)[a]	0	NR	4-29	LADG; LASG; LATG (with D1; D1+; D2)
Kumagai 2014	≥ 70 y, L	218 ± 60	NR	76 ± 182 ml	NR	LADG (with D1+; D2)

[a]median (range); [b]operative time >240 minutes/≤ 240 minutes; [c]extent of lymph node dessection not reported; [d]patients underwent conversions were excluded from analytic cohorts. LDG: laparoscopic distal gastrectomy; LPG: laparoscopy proximal gastrectomy; LTG: laparoscopy total gastrectomy; LSG: laparoscopy subtotal gastrectomy. LAG: laparoscopy-assisted gastrectomy; LADG: laparoscopically assisted distal gastrectomy; LAPG: laparoscopy-assisted proximal gastrectomy; LAPPG: laparoscopy-assisted pylorus preserving gastrectomy; LATG: laparoscopy-assisted total gastrectomy; LASG: laparoscopic-assisted subtotal gastrectomy. TLG: totally laparoscopic gastrectomy; TLDG: totally laparoscopic distal gastrectomy; TLTG: totally laparoscopic total gastrectomy. ODG: open distal gastrectomy; OPG: open proximal gastrectomy; OTG: open total gastrectomy; OSG open subtotal gastrectomy.

group (P = 0.045) [34], in which conversions occurred due to technically difficult dissection and adjacent organ injury in both groups. The other 15 studies showed no difference in the conversion rate. The reasons for conversion included difficulty in dissection or anastomosis, severe adhesion, adjacent organ injury, uncontrollable bleeding, and the need for further lymph node dissections based on the positive results of frozen pathological examination. No conversions were due to difficulties maintaining general anesthesia during pneumoperitoneum. For studies comparing EL with EO group [22-24, 40-45], 2 studies [42, 44] did not reported the information of conversions, and the other 7 studies reported no conversions occurred in either groups.

Operative time: Eighteen studies [22-39] compared the mean operative time between EL group and YL group, in which 4 studies reported shorter operative time in the EL group [25, 26, 28, 34]. The other studies 14 studies noted no difference. Nine studies [22-24, 40-45] compared the mean operative time between EL group and EO group, in which 2 studies [22, 41] reported longer operative time in the EL group, 1 reported longer operative time in the EO group [44], and the other 6 studies showed no significant difference between the two groups.

Blood loss: Fifteen studies [22-25, 27-32, 34, 36-39] compared the blood loss between EL group and YL group, in which only 1 study [23] reported less blood loss in the EL group. The other 14 studies did not showed significant difference between the two groups. Nine studies [22-24, 40-45] compared the blood loss between EL group and EO group, and all these studies reported less blood loss in the EL group.

Extent of lymph node dissection: Thirteen studies [22-28, 30, 34-37, 39] compared the extent of lymph node dissection between EL group and YL group, most of these studies did not showed significant difference between the two groups, except one study in which all the 9 eldest elderly patients (aged ≥ 85 years old) received D1 lymph node dissection [36]. Five studies [24, 40-43] compared the extent of lymph node dissection between EL group and EO group, in which only 1 study [24] showed significant difference between the two groups. In this study, patients in the EO group underwent more D1+ lymph node dissection compared with EL group.

Retrieved lymph nodes: Ten studies [25, 26, 28-31, 33, 35, 37, 38] compared the retrieved lymph nodes dissection between EL group and YL group, in which 4 studies [25, 30, 33, 35] reported less retrieved lymph nodes in the EL group. The other 6 studies showed no significant difference between the two groups. Five studies [40-44] compared the retrieved lymph nodes between EL group and EO group, in which only 1 study reported less retrieved lymph nodes in the EL group. The other 4 studies noted no significant difference.

Short-term postoperative outcomes

Operative mortality: Twenty-five trials [22-39, 41-47] reported the incidence of operative mortality (including 30-day mortality and in-hospital mortality). No studies report a higher incidence of mortality in the EL group than that of the YL group. Similarly, no difference in mortality was shown between the EL group and EO group (**Table 4**).

Postoperative complications: Twenty-five trials [22-44, 46, 47] reported the incidence of postoperative complications. Eighteen studies [22-39] compared postoperative complications between EL group and YL group, in which 3 studies [24, 33, 35] reported higher postoperative complication rate in the EL group. The other studies noted no difference. Eight studies [22-

Table 4. Postoperative outcomes

Authors, publish years	Groups	Operative mortality, n (%)	Complications, n (%)					Time to first flatus, days, (mean + SD)	Mean hospital stays, days, (mean + SD)
			Total	Cardio vascular	Respi ratory	Leak	Severe		
Yasuda 2004	≥ 70 y, L	0	9 (20.0)	NR	NR	NR	NR	3.7 ± 0.8	16.3 ± 5.3
	< 70 y, L	0	10 (17.5)	NR	NR	NR	NR	3.1 ± 0.8	18.9 ± 9.8
	≥ 70 y, O	1 (3.6)	13 (46.4)	NR	NR	NR	NR	4.2 ± 1.1	23.9 ± 14.5
Mochiki 2005	≥ 70 y, L	0	4 (13.3)	NR	1 (3.3)	0	NR	NR	19.2 ± 1.9
	< 70 y, L	0	10 (13.6)	NR	1 (1.4)	2	NR	NR	16.5 ± 0.7
	≥ 70 y, O	0	4 (25.0)	NR	0	1 (6.3)	NR	NR	28.4 ± 3.5
Suzuki 2015	≥ 75 y, L	0	11 (28.9)	2 (5.3)	1 (2.6)	0	NR	NR	15 (10-68)[a]
	< 65 y, L	0	4 (9.8)	1 (2.4)	0	0	NR	NR	13 (90-30)[a]
	≥ 75 y, O	0	17 (60.7)	4 (14.3)	3 (10.7)	2 (7.1)	NR	NR	25 (14-83)[a]
Tokunaga 2008	≥ 75 y, L	0	4 (9)	0	1 (2.0)	NR	NR	2.6 ± 1.1	12.7 ± 4.1
	< 75 y, L	0	26 (11)	1 (0.4)	3 (1.3)	NR	NR	2.4 ± 0.9	13.0 ± 10.8
Cho 2009	≥ 70 y, L	2 (0·9)	38 (16·8)	NR	6 (2.7)	NR	9 (4·0)	3·4 ± 1·0	8·3 ± 2·8
	< 70 y, L	7 (0·8)	113 (12·7)	NR	9 (1.0)	NR	26 (2·9)	3·3 ± 1·0	7·9 ± 2·4
Hwang 2009	≥ 70 y, L	0	21 (17.9)	NR	3 (2.6)	NR	10 (8.5)	4.13 ± 2.6	7.5 ± 3.4
	< 70 y, L	0	65 (12.6)	NR	6 (1.2)	NR	37 (7.2)	3.43 ± 1.0	6.4 ± 1.5
Kunisaki 2009	≥ 75 y, L	0	3	NR	NR	0	NR	2.9 ± 1.2	14.3 ± 8.8
	< 75 y, L	0	4	NR	NR	2	NR	2.4 ± 1.0	14.2 ± 11.7
Yamada 2010	≥ 80 y, L	0	7 (38.9)	NR	0	1	7 (38.9)	(2-7)[b]	8.0 ± 1.0
	70-79 y, L	0	9 (16.1)	NR	2 (3.6)	0	9 (16.1)	(1-5)[b]	7.5 ± 1.5
Kim 2012	≥ 65 y, L	1 (1.1)	17 (18.3)	NR	2 (2.2)	1 (1.1)	4 (4.3)	NR	13.1 ± 15.2
	< 65 y, L	0	31 (13.9)	NR	2 (0.9)	2 (0.9)	2 (0.9)	NR	9.7 ± 4.2
PARK 2013	> 70 y, L	1 (1.3)	17 (21.3)	1 (1.3)	3 (3.8)	1 (1.3)	NR	3.4 ± 0.8	9.4 ± 2.2
	≤ 70 y, L	0	47 (15.4)	2 (0.7)	4 (1.3)	1 (0.3)	NR	3.4 ± 1.0	9.1 ± 2.4
Oki 2013	> 75 y, L	0	8 (40.0)	1 (5.0)	NR	NR	2 (10.0)	NR	25.5 ± 36.4
	≤ 75 y, L	0	28 (23.7)	0	NR	NR	10 (8.5)	NR	14.7 ± 6.5
Kim 2013	> 70 y, L	0	14 (17.7)	NR	NR	1 (1.3)	1 (1.3)	3.4 ± 0.9	9.7 ± 7.5
	< 70 y, L	0	23 (7.4)	NR	NR	1 (0.3)	5 (1.6)	3.0 ± 0.7	7.5 ± 4.5
Mohri 2015	≥ 70 y, L	0	13 (18.3)	NR	NR	0	7 (9.9)	NR	13.6 ± 10.1
	< 70 y, L	0	30 (21.6)	NR	NR	7 (5.0)	11 (7.9)	NR	16.3 ± 16.0
Kim 2014	≥ 75 y, L	0	18 (18.4)	1 (1.0)	1 (1.0)	1 (1.0)	5 (5.1)	2.9 ± 1.1	7.2 ± 1.3[c]
	65-74 y, L	2 (0.7)	26 (9.1)	0	4 (1.4)	3 (1.1)	5 (1.8)	3.0 ± 1.1	7.0 ± 1.5[c]
	< 65 y, L	0	62 (9.2)	0	9 (1.3)	5 (0.7)	13 (1.9)	2.8 ± 1.1	7.2 ± 2.1[c]
Miyasaka 2014	≥ 85 y, L	0	1 (11)	0	0	0	NR	NR	12.4 ± 5.4
	< 85 y, L	1	52 (21)	4	8	7	NR	NR	13.1 ± 15.8
Kosuga 2015	≥ 75 y, L	0	12 (21.8)	0	4 (7.3)	0	4 (7.3)	2.8 ± 1.2	15.3 ± 6.3
	< 75 y, L	0	39 (16.5)	1 (0.4)	2 (0.8)	0	11 (4.6)	2.5 ± 0.9	14.9 ± 11.9
Yang 2015	≥ 70 y, L	1 (1.9)	16 (3.2)	2 (3.8)	4 (7.5)	2 (3.8)	4 (7.5)	3.8 ± 1.0	18.4 ± 7.9
	< 70 y, L	1 (0.6)	32 (19.9)	0	3 (1.9)	9 (5.6)	14 (8.7)	3.7 ± 0.9	16.7 ± 8.3
Fujisaki 2015	≥ 75 y, L	1 (1.4)	8 (11.4)	1 (1.4)	2 (2.9)	1 (1.4)	NR	5.0 ± 5.9	12.8 ± 7.8
	< 75 y, L	0 (0.0)	10 (8.1)	0 (0.0)	0 (0.0)	2 (1.6)	NR	4.1 ± 3.7	10.3 ± 4.9
Meng 2012	≥ 65 y, L	NR	18 (15.5)	1 (0.9)	4 (3.4)	6 (5.2)	NR	3.5 ± 1.2	15.9 ± 11.8
	≥ 65 y, O	NR	39 (28.1)	5 (3.6)	8 (5.8)	6 (4.3)	NR	4.3 ± 1.2	20.5 ± 9.2
Hu 2013	≥ 65 y, L	0	11 (10.1)	NR	3 (2.8)	1 (0.9)	NR	2.8 ± 0.6	10.7 ± 7.5
	≥ 65 y, O	0	26 (21.0)	NR	9 (7.3)	2 (1.6)	NR	4.0 ± 1.2	14.2 ± 6.5
Li 2014	≥ 70 y, L	0	8 (14.8)	1 (1.9)	3 (5.6)	3 (5.6)	NR	3.2 ± 0.8	7.0 ± 1.3
	≥ 70 y, O	1 (1.9)	16 (29.6)	1 (1.9)	6 (11.1)	5 (9.3)	NR	3.6 ± 0.7	9.4 ± 1.5
Qiu 2014	≥ 70 y, L	0	7 (23.3)	0	3 (10.0)	0	NR	2.9 ± 0.8	13.0 ± 4.2
	≥ 70 y, O	0	16 (47.1)	3 (8.8)	7 (20.6)	1 (2.9)	NR	4.6 ± 1.2	16.9 ± 4.1
Lu 2015	≥ 65 y, L	1 (0.4)	43 (17.1)	2 (0.8)	15 (5.9)	4 (1.6)	14 (5.6)	3.7 ± 1.0	14.4 ± 6.0
	≥ 65 y, O	2 (0.8)	59 (23.4)	3 (1.2)	20 (7.9)	5 (2.0)	22 (8.7)	4.0 ± 1.0	16.6 ± 8.9
Shin 2015	≥ 65 y, L	0	NR	NR	NR	NR	NR	3.9 ± 0.7	7.8 ± 1.5
	≥ 65 y, O	0	NR	NR	NR	NR	NR	4.4 ± 0.9	8.4 ± 1.1
Singh 2008	≥ 75 y, L	0	3 (15.0)	NR	NR	NR	2 (10.0)	4 (3-21)[a]	8 (4-61)[a]
Kumagai 2014	≥ 70 y, L	0	47 (24.9)	NR	NR	5 (2.7)	20 (10.6)	NR	11 (7-55)[a]

[a]median (range); [b]range; [c]patients without complications.

24, 40-44] compared total postoperative complications between EL group and EO group, in which 6 studies [22, 24, 40-43] reported lower complication rate in the EL group. The other 2 studies noted no difference.

Ten studies [26, 27, 29, 30, 32-35, 37, 38] compared severe complications between EL group and YL group, in which only 1 study [30] reported higher severe complication rates in the EL group (4.3% versus 0.9%, P = 0.001). However, the cases severe complications are limited in this study (4 cases in the EL group, 2 cases in the NEL group). One studies [44] compared severe complications between EL group and EO group and no difference was found.

Thirteen studies [23, 24, 28-31, 33-39] compared the incidence of leakage between EL group and YL group, none of these studies showed difference between the two groups. Eight studies [23, 24, 40-44] compared the incidence of leakage between EL group and EO group, and also no studies showed difference between the two groups.

Nine studies [24, 25, 31, 32, 35-39] compared the incidence of cardiovascular complications between EL group and YL group, and none of these studies showed difference between the two groups. Five studies [24, 40, 42-44] compared the incidence of cardiovascular complications between EL group and EO group, and also none of these studies showed any difference.

Thirteen studies [23-27, 29-31, 35-39] compared the incidence of respiratory complications between EL group and YL group, in which only 1 study [37] showed a higher incidence of respiratory complications in the EL group. Seven studies [23, 24, 40-44] compared the incidence of respiratory complications between EL group and EO group, and none of these studies showed any differences between the two groups.

Postoperative hospital stays: Eighteen studies compared postoperative hospital stays between EL group and YL group [22-39], in which 7 studies [24, 26, 27, 30, 32, 33, 39] reported longer postoperative hospital stays in the EL group. Nine studies [22-24, 40-45] compared postoperative hospital stays between EL group and EO group, and all these studies reported shorter postoperative hospital stays in the EL group.

Recovery of gastrointestinal function: Twelve studies [22, 25-29, 31, 33, 35, 37-39] compared the time to first flatus between EL group and YL group, in which 4 studies [22, 27, 33, 37] reported a longer time to first flatus in the EL group. Seven studies [22, 40-45] compared the time to first flatus between EL group and EO group, and all these studies reported a shorter time to first flatus in the EL group.

Long-term postoperative outcomes

Three studies compared long-term survival outcomes between the EL and YL group [23, 28, 34]. Kunisaki et al [28] showed no significant differences in 5-year OS or DSS between the two groups. Mohri et al [34] reported a lower 5-year OS in the EL group, but the 5-year DSS was similar between the two groups in this study. Mochiki et al [23] reported a similar 5-year OS and DFS between the two groups.

Four studies compared long-term survival outcomes between the EL and EO group [40-42, 44]. All these studies showed similar long-term survival between the 2 groups. Meng et al [40] reported a similar overall survival time for the two groups. Hu et al [41] reported a similar 5-year OS, and Lu et al [44] and Li et al [42] both reported a similar 3-year OS for the two groups.

Other outcomes

Mohri et al [34] compared the quality of life between the EL and YL group, and showed a similar postoperative recovery of quality of life between the two groups, assessed at 7 days and 3, 6, and 12 months after surgery. Whereas Hu et al [41] reported a better short-term (30 days) quality of life in the EL group than that in the EO group. Shin et al [45] investigated the impact of surgical approach on postoperative delirium in elderly patients undergoing gastrectomy for gastric cancer, and found that laparoscopic gastrectomy did not reduce either postoperative delirium or cognitive decline compared with open gastrectomy.

Discussion

This is the first systematic review concerning laparoscopic gastrectomy for elderly patients with gastric cancer. It demonstrated that laparoscopic gastrectomy can be safely performed in the elderly patient with similar postoperative morbidity and mortality compared with younger patients. In addition, laparoscopic gastrectomy leads to a lower incidence of postoperative complications and a faster postoperative recovery compared with open gastrectomy in the elderly patients, with similar pathological outcomes and long-term survival outcomes.

Elderly versus younger

We first compared the elderly patients with the younger patients undergoing laparoscopic gastrectomy (EL versus YL). The mean operative time and blood loss were comparable between the two groups in most studies, which indicated a similar extent of surgery. In accordance, the extent of lymph node resection and retrieved lymph nodes were also similar between the two groups. We therefore concluded that advanced age did not result in shorter operative time or a smaller extent of surgery, and that the elderly patients generally underwent similar extent of laparoscopic gastrectomy and could achieved similar pathological outcomes compared with the younger patients.

Most studies showed no difference between the two groups with regard to postoperative complications, despite elderly patients had a higher ASA grade and more comorbidities than younger patients. This may be attributed to the improvement in surgical techniques and perioperative care [12, 13].

In this review, we especially focused on severe complications. On the one hand, severe complications directly result in operative mortality [48], on the other hand, severe complications are strongly related to lower long-term survival rates after gastrectomy [49, 50]. It has been reported that the 5-year OS rates after curative gastrectomy for gastric cancer was 9.6% in patients with Grade III complications, significantly lower than the 43.0% in patients without complications [49]. Thus, if elderly patients do have a higher incidence of severe complications than younger patients, we should reconsider the suitability of laparoscopic gastrectomy in the elderly patients. In this review, 10 studies [26, 27, 29, 30, 32-35, 37, 38] compared severe complications between EL group and YL group, in which only 1 study [30] reported higher severe complication rates in the EL group (4.3% versus 0.9%, P = 0.001). In this study, severe complications in the elderly group included 1 case of anastomotic leakage and 3 cases of intraluminal bleeding, while in the non-elderly group, it include 2 cases of anastomotic leakage. No explanation for such difference was given in this study. We speculated that such difference could be attributed to the surgeons' technique or selection bias in this study.

Anastomosis leakage was another focus of this review since it has been reported to influence the long-term survival after major gastrointestinal surgery [51]. In this review, no study displayed any difference in the incidence of anastomosis leakage between the two groups.

To demonstrate the influence of CO_2 pneumoperitoneum on the cardiovascular and respiratory function in the elderly patients undergoing laparoscopic gastrectomy, we further analyzed cardiovascular and respiratory complications. No studies displayed any difference in cardiovascular complications between the two groups. While only 1 of the 13 studies reported a higher incidence of respiratory complications in the elderly patients [37]. Therefore, CO_2 pneumoperitoneum did not seem to increase the cardiovascular and respiratory complications in the elderly. This finding was consistent with the study by Suzuki et al [24], which showed a transitory but not critical cardiopulmonary impairment caused by pneumoperitoneum. Moreover, of all the included studies, no conversion was due to difficulties maintaining general anesthesia during pneumoperitoneum, which further demonstrated that pneumoperitoneum can be tolerated either by the elderly or by the younger patients.

Three studies compared long-term survival outcomes between the EL and YL group [23, 28, 34]. The long-term oncological outcomes, either reflected by 5-year DSS or 5-year DFS, were similar between elderly and younger groups in these studies. This could be attributed to the similar pathological outcomes (numbers of retrieved lymph nodes) between the two groups. The 5-year OS rate was lower in the elderly group in one study [34]. However, this finding was not surprising since elderly people have a lower life expectancy. In the future studies, more attentions should be paid on long-term survival for elderly patients undergoing laparoscopic gastrectomy to achieve more valid conclusions.

The definition of elderly patients varied among these studies, 8 studies defined elderly patients using the age threshold of 70 years old, 7 studies of 75 years old, 1 study of 65 years old, 1 study of 80 years old, and 1 study of 85 years old (**Table 1**). As the life expectancy is increasing globally, reaching an average of 75 years in China [52], it is important to figure out the cut-off value of age below which the elderly patients can safely undergo a major operation. In this review, for the 8 studies [22, 23, 26, 27, 31, 33, 34, 38] which defined elderly patients using the age threshold of 70 years old, 1 study [33] reported a higher total complication rate in the elderly group. Whereas for the 7 studies [24, 25, 28, 32, 35, 37, 39] which defined elderly patients using the age threshold of 75 years old, 2 studies [24, 35] reported a higher total complication rate in the elderly group. Moreover, severe complications did not increase in the elderly group, either the age threshold for elderly patients was 70 or 75 years old. One study [29] compared the patients aged ≥ 80 years old with those aged 70-79 years old and showed no difference in mortality and total or severe complication rate between the two groups. However, this study had a small sample size, with only 18 patients aged ≥ 80 years old. One study [36] compared the patients aged ≥ 85 years old with those aged < 85 years old, and similarlly, no difference was shown in the mortality or morbidity rate. However, this study included only 9 patients in the elderly groups, and all the 9 patients received D1 lymph node dessection, whereas 55.7% patients in the younger group received D1 lymph node dessection (P = 0.012). One study [30] which defined elderly patients as those aged ≥ 65 years old reported higher severe complication rate in the elderly group. However, since most other studited the safety of laparoscopic gastrectomy, we considered the inconsistent result of this study may be due to bias. Based on these current studies, we concluded that laparoscopic gastrectomy in elderly patients with gastric cancer is relatively safe and feasible when the age threshold of the elderly was 75 years old or less. More studies with large sample size are necessary to demonstrate the safety and feasibility of laparoscopic gastrectomy in the eldest elderly patients (aged ≥ 80 years old or more) in the future.

Laparoscopic versus open

The present review demonstrated that laparoscopic gastrectomy lead to a lower incidence of postoperative complications, a shorter length of hospital stay and a faster recovery of gastrointestinal function compared with open gastrectomy in the elderly patients with gastric cancer, which was consistent with the finding of a most recent meta-analysis not specifically for the elderly patients [15]. Few operative mortality was reported and no difference was shown between the two groups. No studies showed significant difference in the cardiovascular or respiratory complications, indicating that CO_2 pneumoperitoneum caused by laparoscopic gastrectomy did not increase cardiorespiratory morbidities compared with open gastrectomy in the elderly people. Similarly, neither leakage nor severe complications differed between the two groups. This is not surprising because the laparoscopic technique, although less invasive, results in the same organ and lymph node resection as the open procedure.

All the 9 studies [22-24, 40-45] showed less blood loss in the laparoscopic group compared with open group, reflecting the less invasiveness caused by laparoscopic surgery. The amount of blood loss has been associated with increased perioperative morbidity and mortality [53, 54]. Reduction in the operative blood loss can explain the less complication rate and the faster postoperative recovery in the laparoscopic group in the present study.

Oncological safety is the most critical issue when proposing the laparoscopic surgery for gastric cancer. The oncological adequacy is evaluated by pathological outcomes and long-term survival outcomes. As for pathological outcomes, most studies showed similar extent of lymph node resection and similar numbers of harvested lymph nodes between the open and laparoscopic groups, which was consistent with a recent meta-analysis not specifically for elderly patients [15]. As for long-term survival outcomes, all the 4 studies [40-42, 44] that compared long-term survival between the open and laparoscopic group showed similar long-term survival between the two groups. This is also consistent with previous studies not specifically for elderly patients, including a large-scale, multicenter, retrospective clinical study [55] and two recent meta-analyses [15, 56]. However, all these 4 included studies were retrospectively designed and the sample size in each study was generally small. Therefore, large prospective studies are needed to further evaluate the long-term survival of laparoscopic gastrectomy in elderly patients with gastric cancer.

Limitations

This review demonstrated the safety and efficacy of applying laparoscopic gastrectomy in the elderly patients with gastric cancer, but this conclusion could not be generalized to all elderly patients for the following reasons. First, studies that include elderly patients may contain inherent selection bias. Most vulnerable and frail elderly patients with gastric cancer may be spontaneously excluded from some surgical indications. Therefore, whether or not laparoscopic gastretomy can be applied in the elderly regardless of patient comorbidities remains controversial. Preoperative optimization and perioperative monitoring should still be recommended for elderly patients, particularly for those with comorbidities. Second, few studies analyzed the eldest elderly patient (aged ≥ 80 years old or more). Therefore, the safety and efficacy of laparoscopic gastretomy in these patients stills need further investigation.

Although most studies did not show statistically significant difference with regard to postoperative morbidity rate between the elderly and younger patients, a trend of higher morbidity rate in the elderly patients still existed in most studies. A pooled or meta-analysis may show significant difference between the two groups. However, we did not do pooled or meta-analysis in this systematic review due to inconsistent definition of the elderly population and the different inclusion criteria. This is also one of the limitations of this systemic review. However, we stratified the included studies by their different age thresholds of the elderly to further investigate the influence of age on laparoscopic gastrectomy.

Most studies included in this review were retrospective studies, and no randomized controlled trials were identified. More high quality studies with large sample size are required to better illustrate the safety and efficacy of laparoscopic gastrectomy for gastric cancer in the elderly population.

Conclusions

The present systematic review demonstrated that laparoscopic gastrectomy in elderly patients with gastric cancer is relatively safe and feasible at least when the age threshold of the elderly was 75 years old or less. However, more studies are required to investigate the safety and efficacy of laparoscopic gastrectomy in the eldest elderly patient (aged ≥ 80 years old or more) in the future. Moreover, compared with open gastrectomy, laparoscopic gastrectomy lead to a lower incidence of postoperative complications, faster recovery of gastrointestinal function, shorter hospital stays, and similar pathological and long-term survival outcomes in the elderly patients. However, considering the inherent selection bias of studies that include elderly patients, this conclusion may not be readily generalized to all elderly patients. Preoperative optimization and perioperative monitoring should be recommended for elderly patients, paticularly for those with comorbidities.

Disclosure of conflict of interest

None.

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