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Review Article

A comparison of surgical procedures and postoperative cares for minimally invasive laparoscopic gastrectomy and open gastrectomy in gastric cancer

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Abstract: Minimally invasive, laparoscopic gastrectomy (LG) has assumed an ever-expanding role in gastric cancer treatment. Accumulating data so far seem to suggest that LG is at least a viable alternative of conventional open gastrectomy (OG) in different contexts. However, even though reviews and meta-analyses have compared the advantages and limitations of each option, it is still controversial whether LG is a better alternative to OG, especially in advanced gastric cancer (AGC). The major goal of this study is to evaluate the readouts of LG, in comparison with OG. A literature search was performed for studies published from 2009 to 2013. Medical records of 20868 gastric cancer patients from 32 independent studies were reviewed and analyzed. All 32 studies concluded that LG is at least comparable with OG. LG is superior to OG in offering less blood loss, shorter hospital stay, and lower risk of complications, although LG is probably inferior in operative time, and not different from OG in mortality. Considering the merits and the potential future technical improvement, it is reasonable to speculate that LG may eventually replace OG in most clinical contexts.

Keywords: Minimally invasive laparoscopic gastrectomy, open gastrectomy, gastric cancer, postoperative cares

Introduction

Gastric cancer is the second leading cause of cancer specific mortality worldwide. Although chemotherapy may improve the survival of gastric cancer patients, gastrectomy with regional lymphadenectomy remains the only potentially curative treatment available. The introduction of Billroth's procedure of gastrectomy and reconstruction in 1881 led to the conventional open gastrectomy (OG). One significant milestone was that Dr. George Schlatter accomplished the first total gastrectomy in October 1897 for a patient with gastric cancer. Since then, the technique of conventional OG improved gradually. OG is currently well established and accepted.

All OG operations were performed through a midline laparotomy. OG could be partial (distal or proximal), subtotal or total. It normally performed with regional lymphadenectomy. The decision to select a specific subtype of OG is mainly based on the location and stage of the cancer, assessed preoperatively by CT, esophageal ultrasound, or intraoperatively by either laparoscopy or laparotomy. The remaining stomach (partial gastrectomy) or the esophagus (total gastrectomy) is to be re-connected through anastomosis, such as Billroth I or II procedure.

Laparoscopic surgery (LG), also called minimally invasive surgery or keyhole surgery, is a relatively new technique, comparing to OG. The first laparoscopy-assisted Billroth-I gastrectomy and totally laparoscopic Billroth-II gastrectomy for early gastric cancer was reported by Kitano et al [1] and Goh et al. [2], respectively, in early 1990s. This surgery is normally performed through small incisions (usually 0.5-1.5 cm) as opposed to the larger incisions needed in OG. The currently used surgical systems, such as the da Vinci Surgical System, use a console located away from the patient to control a camera, vacuum pump, saline cleansing solution, cutting tools, etc. through multiple small incisions. A larger incision may also be made so

that a hand can be introduced into the peritoneal cavity for hand-assisted laparoscopic gastrectomy.

LG has undergone significant technical development over the years. In contrast to OG, LG is still actively evolving to better meet a variety of clinical needs. The major trend is that LG is assumed an ever-expanding role in gastric cancer treatment. For example, when it was first established, LG was performed mostly for selected patients with early gastric cancer (EGC), but the scope and the number of performed LGs has increased dramatically over the past 20 years. LG is now routinely performed for a variety of different conditions. For very early phase of mucosal cancer without lymph node metastasis, laparoscopic wedge resection (LWR) or intragastric mucosal resection (IGMR) surgery were established. For early gastric cancer with risk of regional lymph node metastasis, laparoscopic pylorus-preserving gastrectomy, distal or proximal, or Ivor-Lewis esophagogastrectomy is normally performed with regional lymphadenectomy. For the more advanced gastric cancers (AGC), subtotal or total gastrectomy with radical lymphadenectomy is often performed to completely remove the tumor.

Surgeons used to prefer laparoscopic-assisted or hand-assisted gastrectomy rather than totally laparoscopic procedures due to the technical difficulties associated with intracorporeal anastomosis and the difficulties in removal of the large surgical specimen of gastrectomy. However, recent advancement in surgical stapling technology makes it possible for intracorporeal anastomosis, but an enlarged trocar site that is protected with a plastic wound retractor is still needed to remove a big surgical specimen.

Studies so far seem to suggest that LG offers faster recovery of bowel movement, reduced intraoperative blood loss, reduced postoperative pain, shortened postoperative hospital stay, and better cosmetic outcomes than OG. However, LG with the involvement of extraperigastric lymph nodes is considered to be technically more demanding than OG. Some studies even reported that LG is associated with an increased incidence of surgery related complications, such as anastomotic leakage. Furthermore, the use of LG in AGC remains a controversial topic.

A number of studies tried to address the controversy by specifically comparing the LG with conventional OG in different stages of gastric cancer. However, conflicting results were found for various reasons. Thus, more carful studies are warrant to further assess the recent performance of LG in different clinical contexts.

The aim of this study is to perform an updated critical evaluation of recently published original studies to determine whether LG is a better overall alternative of OG. Our major focus is to compare the end points of surgical procedures and postoperative cares of LG and OG, such as operative time, blood loss, harvested lymph nodes (HLN), postoperative complications, length of hospital stay and hospital mortality.

Materials and methods

Search strategy

A literature search was performed for studies published from 2009 to 2013. Searching terms were: "gastrectomy'', ''laparoscopy assisted versus open distal gastrectomy'' and ''minimally invasive versus conventional gastrectomy''. The ''related articles'' function was used to broaden the search, and all abstracts, studies, and citations were reviewed irrespective of language. Inclusion criteria were: comparative studies examining laparoscopic and open techniques for patients treated by a surgical team or center. Included studies had to have accurate description for surgical techniques used. Studies where patients had more than one laparoscopic technique or conversion to open technique were excluded.

Surgical techniques

Laparoscopic proximal gastrectomy: five abdominal trocars are normally introduced. The entire stomach and the distal esophagus are mobilized circumferentially for a segment of 5 to 6 cm into the mediastinum. The mid-aspect of the stomach is divided starting on the lesser curvature and completed on the greater curvature of the stomach. The esophagus is divided with the ultrasonic scissor approximately 2 cm above the gastroesophageal junction. A celiac lymphadenectomy is performed. The right gastroepiploic artery is maintained. The anvil of the circular stapler is inserted into the esophageal stump and secured with a purse-string suture. A gastrotomy is created in the distal gastric

remnant. An esophagogastric anastomosis is performed using a circular stapler. The surgical specimen is removed through an enlarged trocar site that is protected with a plastic wound retractor.

Laparoscopic distal gastrectomy: Similarly to laparoscopic proximal gastrectomy, the gastrohepatic and gastrocolic ligaments are divided for gastric mobilization. The right gastric and right gastroepiploic vessels are divided with the linear stapler. The first portion of the duodenum is divided using a linear stapler. The site of proximal gastric resection depends on the site of the cancer and its extension. The proximal gastric division line is performed with sequential application of multiple linear staplers, leaving a large gastric pouch. In distal, prepyloric cancers, the left gastric vessels are preserved but a celiac lymphadenectomy is performed. Gastrointestinal continuity is performed in a Roux-en-Y fashion. The gastrojejunal anastomosis is performed with a linear stapler. The surgical specimen is removed through an enlarged trocar site that is protected with a plastic wound retractor. The remaining gastrotomy is sutured closed.

Laparoscopic subtotal gastrectomy: The entire stomach is mobilized including the gastric fundus by division of the short gastric vessels. The first portion of the duodenum is divided with a linear stapler. A small gastric pouch is constructed immediately below the gastroesophageal junction. An anvil is placed into the gastricpouch and secured with a purse-string suture. The left gastric vessels are preserved, but a celiac lymphadenectomy is performed. Gastrointestinal continuity is restored in a Roux-en-Y fashion as described above. The gastrojejunostomy is performed with a circular stapler. The surgical specimen is removed through an enlarged trocar site that is protected with a plastic wound retractor.

Laparoscopic total gastrectomy: Five abdominal trocars are introduced. The entire stomach is mobilized. The first portion of the duodenum is divided with a linear stapler. The distal esophagus is mobilized circumferentially for a segment of 5 to 6 cm into the mediastinum. The esophagus is divided with the ultrasonic scissor approximately 2 cm above the gastroesophageal junction. The anvil of the circular stapler is inserted into the esophageal stump and secured with a purse-string suture. A celiac lymphadenectomy was performed with division of the left gastric vessels. Gastrointestinal continuity is restored in a Roux-en-Y fashion. The jejunum is divided at 30 cm distal to the ligament of Treitz. The length of the Roux limb is measured at 40 cm whereby a jejunojejunostomy is constructed. The Roux limb is routed either antecolic or retrocolic. A circular stapler is used to construct the esophago-jejunal anastomosis. The surgical specimen is removed through an enlarged trocar site that is protected with a plastic wound retractor.

Postoperative care

If there were no abnormal abdominal symptoms, patients were allowed water on the day of flatus passage or 1 day thereafter. Soft diets were usually started on the day after drinking water. Patients who tolerated a soft diet for 2 days were discharged. The time oral intake started and the time of discharge varied slightly, depending on the patient's condition.

Results

Search results

Table 1 summarized the main characteristics and conclusions of 32 independent studies that compared LG and OG published between 2009 and 2013. It is highly interesting to notice that all available 32 studies concluded that LG is at least comparable with OG in terms of safety and short- and long-term results. More importantly, 15/32 studies concluded that LG offered favorable results over OG at least in one measurable readout, either during the surgical procedure or in postoperative care. Only 2 small studies (totally cover 85 LG and 85 OG) pointed to the potential disadvantages of LG over OG. These data strongly suggested that LG is at least comparable with OG in overall performance, regardless the subtypes of the surgery, or the stages of patients.

Compare the readouts of surgical procedures

To further clarify the advantages and the disadvantages of LG over OG, we next extracted and compared the data related to surgical procedures, i.e., operative time, blood loss and harvested lymph nodes, from above-mentioned. Unfortunately, not all three readouts that we

Table 1. Characteristics of the selected 32 clinical trials

References/ Year/country	Type of gastrectomy	LG/No. patients	OG/No. patients	Main conclusions
[3]/2013/Japan	EGC	3937	5451	No differences in early mortality or morbidity, LG has slight reduction in postoperative length of stay.
[4]/3013/China	Distal	54	54	LG and OG achieve similar short- and long-term results.
[5]/2013/Japan	D2 for AGC	186	150	LG may offer a favorable alternative to OG.
[6]/2013/Korea	total gastrectomy	35	35	Postoperative complications were observed more frequently in LG.
[7]/2013/Japan	Distal	31	32	LG results in less postoperative pain, decreased surgical invasiveness and fewer postoperative inconveniences.
[8]/2013/Korea	EGC	1,013	1,112	LG showed a shorter operation time, a shorter postoperative hospital stay, a lower overall complication rate, and a comparable survival rate. In total gastrectomy, LG was associated with a higher complication rate.
[9]/2013/China	AGC	83	83	LG with D2 lymphadenectomy is a safe and feasible for AGC without serosal invasion.
[10]/2013/Korea	Total	120	228	LG has better short-term outcomes and similar long-term outcome.
[11]/2013/Korea	Distal or total, D2	1,058	816	LG is an oncologically safe, with comparable long-term outcomes with OG.
[12]/2013/Korea	Total or distal subtotal	74	36	LG showed comparable oncologic outcomes to OG.
[13]/2013/Japan	Proximal	22	68	LG may lead to faster recovery, better cosmesis, and improved quality of life in the short-term.
[14]/2013/Korea	T3N2M0	139	207	LG is a safe, less invasive and results in faster recovery than OG.
[15]/2013/Japan	AGC, T4	66	135	LG should be considered as a feasible alternative to OG for the treatment of AGC.
[16]/2013/Italy	Subtotal or total	41	41	LG is a safe with favorable short-term outcomes, comparing to OG.
[17]/2013/China	Total	117	117	LG is feasible for AGC short- and long-term oncologic outcomes are comparable with OG.
[18]/2012/China	Wedge resection	68	88	LG could get preferable short-term outcomes and similar long-term relapse-free survival compared with OG.
[19]/2012/Japan	Distal or pylorus-preserving	129	136	LG for EGC is feasible in terms of the incidence and severity of intra-abdominal complications.
[20]/2012/Japan	EGC, AGC	158	174	LG with D1, D1+ for EGC is equivalent to OG in curability. LG with D2 for AGC is comparable to OG with regard to short- and long-term results.
[21]/2012/Chile	EGC, AGC	31	31	The 3-year overall and stage-by-stage survival was comparable for LG and OG.
[22]/2012/Canada	AGC, proximal, total, subtotal, or distal	21	182	LG is safe for AGC with outcomes similar to OG.
[23]/2012/Korea	Distal	1002	629	LG is less invasive than the OG in terms of morbidity, and fewer complications.
[24]/2012/Korea	AGC	89	345	LG for AGC might be considered to be a minimally invasive surgery in selected cases.
[25]/2012/China	PG,DG or TG +D2	131	78	LG D2 is equivalent to OG in the number of HLNs, regardless of tumor location.
[26]/2012/Korea	Distal, pT2 cancer	52	67	LG might be considered as an alternative treatment for some pT2 gastric cancer.
[27]/2011/China	AGC	346	313	LG for AGC is safe and effective. it did not differ significantly from OG in terms of survival rate or recurrence, and has the advantages less bleeding, rapid postoperative recovery, and fewer complications.
[28]/2011/Italy	AGC	22	25	LG is as effective as OG in AGC.
[29]/2011/Italy	Locally AGC	30	30	LG is for AGC and associated with additional benefits as a decreased length of hospital stay, a decreased narcotic use and fewer complications.
[30]/2011/Italy	Distal, total	109	269	LAG is a feasible and safe procedure and has several advantages despite a higher rate of morbidity.
[31]/2010/China	Distal	50	50	LG seems to be a safe and feasible for EGC, with potential disadvantages.
[32]/2010/Korea	Distal	179	161	There was no significance difference in the morbidity and mortality between the 2 groups.
[33]/2010/Korea	EGC	42	162	There was no significance difference in the morbidity and mortality between the 2 groups.
[34]/2009/Korea	Distal	45	83	LG with extended lymphadenectomy for AGC is a feasible and safe and has several advantages.

Table 2. Comparison of the end-points of surgical procedures

References	Operative time (min)		Blood loss (ml)		HLN (No.)		Main conclusions
	LG	OG	LG	OG	LG	OG	
[4]	259.3*	199.8	160.2*	257.8	27.9	27.7	LG has longer operative time, less blood loss.
[5]	369.7*	263.6	154.3*	388.7	NA	NA	LG has longer operative time but less blood loss.
[6]	230.4	212.7	NA	NA	No statistical differences		No difference.
[7]	182.8*	113.0	64.4*	167.8	31.6	33.8	LG has longer operative time but less blood loss.
[8]	NA	NA	75.4*	142.3	NA	NA	LG has less blood loss.
[9]	212.7	226.4	78.4*	200.4	30.2	28.0	LG has less blood loss.
[10]	250*	194	215	194	52.3	52	LG has longer operative time.
[12]	155.1	161.8	NA	NA	35.1	31.6	No difference.
[13]	233*	201	20	242	17	20	LG has longer operative time but less blood loss.
[14]	144	13	NA	NA	37	34	No difference.
[15]	291*	235	107*	495	35.92	36.59	LG has longer operative time but less blood loss.
[16]	223.5*	158.2	118.7*	312.4	37	39	LG has longer operative time but less blood loss.
	298.1*	185.5					
[17]	292.8*	242.1	196.9*	358.2	35.2	37.4	LG has longer operative time but less blood loss.
[18]	90*	125	50*	180	NA	NA	LG has longer operative time but less blood loss.
[20]	EGC 370*	283	158*	386	26	21	LG has longer operative time but less blood loss.
	AGC 376*	300	166*	456	32	35	
[23]	187.09*	167.35	87.68*	152.11	40.24*	46.91	LG has longer operative time, less blood loss, less HLN.
[24]	228.3*	183.6	NA	NA	NA	NA	LG has longer operative time.
[25]	259.1*	213.9	111.1*	230.1	26.1	24.2	LG has longer operative time but less blood loss.
[26]	207.7*	159.9	NA	NA	39.1	39.3	LG has longer operative time.
[27]	211	204	128*	301	33.2	32.8	LG has less blood loss.
[30]	272*	230	170*	372	31*	27	LG has longer operative time, less blood loss, more HLN.
[31]	249.1*	152.9	NA	NA	29.3*	36.4	LG has longer operative time, less HLN.
[32]	NA	NA	108.67*	200.41	D1+ β 58	47	LG has less blood loss.
					D2 120	115	
[33]	187.6*	139.0	NA	NA	D1+ β 21	99	LG has longer operative time.
					D2 21	63	
[34]	255.5*	208.3	333.3*	440.6	35.6	38.3	LG has longer operative time, less blood loss.

*P < 0.05.

are looking for were listed in all above-mentioned 32 studies. As a result, only 25 out of 32 studies were included in the subsequent studies.

Table 2 summarized the findings of the 25 studies. Of them, 3 studies (covered 248 LG & 278 OG) found that LG and OG have no statistical difference in terms of these three readouts [3-5], 8 studies(covered 919 LG & 1100 OG) found that LG has longer operative time, less blood loss and similar HLN [6-16], 4 studies (covered 1621 LG & 1669 OG) found that LG has less blood loss, similar operative time and HLN [17-21], 4 studies (covered 303 LG & 802 OG) found that LG has longer operative time, similar blood loss and HLN [21-24], only 1 study (covered 1003 LG & 629 OG) found that LG has longer operative time, less blood loss and less HLN [25], and 1 study (covered 179 LG & 161 OG) found that LG has longer operative time, less blood loss and more HLN [26], and 1 study (covered 50 LG & 50 OG) found that LG has longer operative time, less HLN and similar blood loss [27]. The overall consensus is that LG has longer operative time, less blood loss and similar HLN, comparing to OG.

Postoperative complications, hospital stay and hospital mortality

Similarly, we next extracted the data related to postoperative complications, i.e., postoperative complications, hospital stay and hospital mortality from above-mentioned studies.

Table 3 summarized the findings of the 25 studies. Of them, 13 studies (covered 819 LG & 1141 OG)found that LG and OG have no statistical difference in terms of these three readouts

Table 3. Comparison of the end-points of postoperative complications

References	Complication rate		Hospital stay (d)		Hospital mortality		Main conclusions
	LG	OG	LG	OG	LG	OG	
[3]	11.9%*	15.6%	13*	15	0.36%	0.59%	LG has less complication and shorter hospital stay.
[4]	42.1%	50%	9.5	11.1	0	0	No difference.
[5]	17.2%	24.4%	16.3*	24.3	1.1%	0	LG has shorter hospital stay.
[6]	22.8%	20%	NA	NA	NA	NA	No difference.
[7]	3.2%	15.6%	9.1	10.0	NA	NA	No difference.
[8]	17.5%*	24.4%	8.7*	11.3	NA	NA	LG has less complication and shorter hospital stay.
[9]	12.0%	14.5%	14.2*	17.2	1.2%	2.4%	LG has shorter hospital stay.
[10]	18.3%	16.2%	9.3*	11.7	0	0	LG has shorter hospital stay.
[12]	14.9%	13.9%	8.6*	10.6	NA	NA	LG has shorter hospital stay.
[13]	27%	32%	11	10	NA	NA	No difference.
[14]	10%*	21.7%	7	8	NA	NA	LG has less complication.
[15]	13.6%*	25.0%	8.4*	18.1	0	0	LG has less complication and shorter hospital stay.
[16]	14.6%	12.2%	8.1	11.5	2.4%	4.9%	No difference.
[17]	11.1%	16.3%	7.4*	10.7	NA	NA	LG has shorter hospital stay.
[18]	5.9%*	22.7%	8*	10	NA	NA	LG has less complication and shorter hospital stay.
[19]	7%	8.1%	9	9	NA	NA	No difference.
[20]	EGC 17.2%	25%	NA	NA	0	0	No difference.
	AGC 25%	23.7%			0	1.7%	
[23]	25.3%*	40.1%	6.75*	9.28	NA	NA	LG has less complication and shorter hospital stay.
[24]	14.8%	17.1%	7.0*	10.4	NA	NA	LG has shorter hospital stay.
[25]	9.9%	7.7%	NA	NA	NA	NA	No difference.
[26]	9.6%	8.96%	7.0	7.0	NA	NA	No difference.
[27]	6.9%	13.1%	7.9*	10.7	0.29%	0.64%	LG has shorter hospital stay.
[30]	26%*	19.3%	13	15	2.75%	1.5%	LG has more complication?
[31]	14%	13%	NA	NA	0	0	No difference.
[32]	11.62%	15.08%	NA	NA	1.12%	0	No difference.
[33]	2.4%	8.6%	7.6	9.8	2.4%	0	No difference.
[34]	15.6%	12.0%	9.8	11.1	2.2%	1.2%	No difference.

*$P < 0.05$ represents the values in LG group compared to the OG group.

[3, 6, 8, 9, 11, 14-16, 20, 23, 24, 27, 28], 5 studies (covered 6086 LG & 7415 OG) found that LG has less complication, shorter hospital stay and similar hospital mortality [10, 13, 17, 25, 29], 7 studies (covered 1015 LG & 1272 OG) found that LG has shorter hospital stay, similar complication rateand similarhospital mortality [4, 7, 12, 18, 19, 21, 22], 1 study (covered 139LG & 207 OG) found that LG has less complication rate, similar hospital stay and hospital mortality [5]. Only one study (covered 109 LG & 269 OG) found that LG has more complication rate, similar hospital stay andhospital mortality [26].

The overall consensus seems to be that LG is at least comparable in terms of postoperative complication, hospital stay and hospital mortality. In majority of cases, LG has less complication and shorter hospital stay.

Discussion

Actually, in these years LG has been significantly applied in both domestic and international hospitals in clinical. Recent years, many studies, such as randomized controlled trials, reviews, original studies, have been gradually indicated the merits of LG method in the therapy of early gastric cancer. There are many characteristics or merits of LG, including less pain, lower complications rate and recovery of ambulation and bowel movement [6, 30], which suggests that the LG method is feasible and safe for the surgical operation in cancers [15, 20, 31].

Dulucq et al. [32] performed a prospective study and concluded that postoperative complications and length of hospital stay in the LG group were decreased compared to those in

the OG group. In this study, we reviewed and concluded that the complications, length of hospital stay and hospital mortality were all significantly shorter in LG group compared to in the OG group ($P < 0.05$), which also showed the merits of LG during the postoperative recovery for the patients.

Except for the advantages, there are also some disadvantages of LG method compared to that of OG method, especially for the increased operative time [16, 27, 33, 34]. Actually, there are no obvious distinguishes between LG and OG method. The main reasons for disadvantages for LG method influencing the operative time is the other aspects, including operator experience, familiarity with instruments and degree of assistant compliance. Some studies [18, 35] performed by the experienced surgeons indicated that there were no significant differences between LG and OG method for the operative time. In tumor resection operation, the identification of tumor margins and tumor localization are very important for the complete resection in clinical. However, the laparoscopic gastric cancer D2 lymph node dissection is difficult and needs skilled expertise. Therefore, whether the LG technique could be used in gastric cancer resection is still controversial in clinical.

In clinical, whether LG could achieve effective radical cancer excision equal to that by OG needs to be confirmed by performing long-term outcome. A few prospective studies [36-38] concluded that the long-term data of LG and OG method were similar, however, the scope of lymph node dissection was identical. Due to the application of LG increased gradually, and application of OG decreased gradually in the past years, however, the LG usage had a shorter follow-up time. Thus, the prolonged follow-up for the tumor resection patients could result in more reliable and valuable survival analysis results.

In conclusion, our current study together with previous reports indeed strongly suggested that LG is superior to OG and offers less blood loss, shorter hospital stay, and lower risk of complications. Further, LG is not different from OG in mortality. Although LG is probably inferior in longer operative time, but considering the merits and the potential future technical improvement, LG may become more popular and eventually replace OG, regardless the subtypes of the surgery, or the stages of patients.

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Disclosure of conflict of interest

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