Introduction

Laparoscopic distal gastrectomy (LDG) has become widespread as a treatment of early gastric cancer in the distal stomach especially in Eastern Asia with the short-term advantages such as less blood loss and prompter postoperative recovery (1). LDG has recently been applied to advanced gastric cancer, and several large-scale randomized controlled trials comparing open and laparoscopic distal gastrectomy for advanced gastric cancer in the distal stomach have been performed in Korea and Japan (2,3) to evaluate feasibility and long-term oncologic outcome of LDG. However, the use of laparoscopic total gastrectomy (LTG) remains limited because of the high technical demands of esophagojejunostomy (4-6) and the complexity of lymphadenectomy at the splenic hilum (5,7,8-21). Because of the variation of the vascular anatomy in the splenic hilum and with the concern of pancreas-related complications, splenic hilar lymphadenectomy is technically challenging even for skilled surgeons. Based on the evidence that prophylactic combined resection of spleen in total gastrectomy increased the risk of postoperative morbidity with no survival impact, surgeons have preferred laparoscopic spleen-preserving splenic hilar lymphadenectomy (LSPL) for advanced tumors without metastasis to splenic hilar nodes or invasion to the greater curvature of the stomach, and reports with LSPL have been increasing rather than LTG with splenectomy. In this paper, recent reports with laparoscopic spleen hilar lymphadenectomy were reviewed.

Keywords: Laparoscopic total gastrectomy (LTG); splenic hilar lymphadenectomy; advanced gastric cancer; spleen-preserving; splenectomy

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of the stomach, or with direct invasion to distal pancreas, LTG with splenectomy, sometimes with combined resection of distal pancreas has been performed (19-21). In this paper, the recent reports of LTG with splenic hilar lymphadenectomy were reviewed.

**Inclusion/exclusion criteria for the review**

For the review of laparoscopic splenic hilar lymphadenectomy, an English literature search was performed on the PubMed database using the terms “gastric cancer” AND “laparoscopic” AND “splenic hilar lymphadenectomy” along with their synonyms or abbreviations on December 23, 2015. Case series including less than 10 patients, or technical reports without surgical outcomes were excluded to keep the quality of the review. The endpoints were clinical indication, the length of the operation, blood loss, conversion, overall morbidity, mortality, length of the hospital stay, and number of harvested lymph nodes (in total and in the splenic hilum). As a result, 15 studies were included in this review. Tumor stage was classified according to the 7th edition of TNM classification (26). Postoperative complications were classified according to the Clavien-Dindo classification system (27).

**Laparoscopic spleen-preserving splenic hilar lymphadenectomy (LSPL) (Table 1)**

Since Hyung et al. (8) firstly reported the initial case series of LSPL with the acceptable feasibility, the number of patients included in the following studies has increased. Some technical reports provided better anatomical understandings. We have proposed efficient lymphadenectomy technique with ‘medial approach’ (5) by identifying the membranous border between the perigastric tissue and the surface of the retroperitoneum. The concept following the perigastric fascias and the intrafascial space based on embryological and anatomical background was also helpful (11). Together with the technical progress, comparative study of laparoscopy-assisted total gastrectomy (LATG) with LSPL and open total gastrectomy for clinical T1-T2 tumors (9) was performed. Longer operation time, less blood loss, and earlier postoperative recovery were found in LATG with LSPL, which was consistent with the previous results of LDG (1). Gradually this operative procedure was applied to more advanced tumors (10-12,14-19), unless they had definite lymph node enlargement in the splenic hilum or direct tumor invasion of the gastrosplenic ligament. Among the 13 studies with LSPL, the indication was up to T2 in three studies, and up to T3 in five and T4a in five studies, respectively. The overall morbidity rate was 6–19%, which was acceptable, but Lu et al. (15) revealed in the study with 325 cases, that BMI exceeding 25 kg/m², tumor location in the greater curvature, and No.10 LN metastases were significantly associated with increased rates of major perioperative complications, and further consideration of optimal indication seemed required. Because there are anatomical variations in the splenic hilum, preoperative evaluation by three-dimensional (3D) CT angiography was helpful to accomplish LSPL safely (12,14,16,18). Kinoshita et al. (16) used integrated 3D anatomic simulation software, which was also helpful in enhancing the quality of surgery. Robotic approach might be also helpful in completing technically-demanding LSPL procedure with current laparoscopic instruments (13).

Regarding the surgical outcomes of LSPL among the 13 studies, the operation time and blood loss ranged from 162 to 359 minutes, and 18 to 201 g, respectively. The length of hospital stay ranged from 7 to 13 days. The mortality rate was extremely low, and with the low overall morbidity rate (6–19%), LSPL seemed technically feasible with acceptable short-term surgical outcome.

**LTG with splenectomy (Tables 2,3)**

Because prophylactic combined resection of spleen increased the risk of postoperative morbidity (22,23) with no survival benefit (24,25) in open total gastrectomy, the reports on LTG with splenectomy were limited (19-21). There were only small case series so far. The indication was for advanced tumors such as T3-T4aN1-2 (19), or tumors invading the greater curvature of the upper third of the stomach, pancreatic parenchyma, or spleen (20), in which splenectomy was mandatory to accomplish R0 resection. These reports showed technical feasibility of this procedure, but the number of the patients included in the studies were limited. Further larger study is required for precise evaluation of this procedure.

**Discussion**

Splenic hilar lymphadenectomy should be employed in the treatment of advanced proximal gastric cancer to complete D2 dissection, and LTG with LSPL or splenectomy are selected. Because combined splenectomy increased
<table>
<thead>
<tr>
<th>Author (ref)</th>
<th>Year</th>
<th>n</th>
<th>Clinical indication</th>
<th>Operation time (min)</th>
<th>Blood loss (g)</th>
<th>Conversion (%)</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
<th>Hospital stay (days)</th>
<th>Harvested LNs (n)</th>
<th>Splenic hilar LNs (n)</th>
<th>Novelty</th>
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<tbody>
<tr>
<td>Hyung et al., (8)</td>
<td>2008</td>
<td>15</td>
<td>cT1–2, cN0–1</td>
<td>211</td>
<td>68</td>
<td>0</td>
<td>13.0</td>
<td>0</td>
<td>7.0</td>
<td>57.0</td>
<td>2.7</td>
<td>Novel technical report</td>
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<tr>
<td>Okabe et al., (7)</td>
<td>2010</td>
<td>53^a</td>
<td>Stage IA–IIIB</td>
<td>359</td>
<td>187</td>
<td>1.9</td>
<td>19.0</td>
<td>0</td>
<td>13.0</td>
<td>51.0</td>
<td>2.6</td>
<td>Laparoscopic medial approach technique</td>
</tr>
<tr>
<td>Guan et al., (9)</td>
<td>2013</td>
<td>41</td>
<td>cT1–2</td>
<td>236</td>
<td>104</td>
<td>2.4</td>
<td>4.9^c</td>
<td>0</td>
<td>9.7</td>
<td>23.0</td>
<td>1.1</td>
<td>Earlier recovery than open total gastrectomy</td>
</tr>
<tr>
<td>Mou et al., (10)</td>
<td>2013</td>
<td>12</td>
<td>Stage IIA–IIIC</td>
<td>268</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.4</td>
<td>24.0</td>
<td>4.8</td>
<td>Technically feasible for advanced cancer</td>
</tr>
<tr>
<td>Huang et al., (11)</td>
<td>2014</td>
<td>54</td>
<td>T2–3</td>
<td>162</td>
<td>42</td>
<td>0</td>
<td>9.3^c</td>
<td>0</td>
<td>10.3</td>
<td>40.0</td>
<td>3.0</td>
<td>Technically feasible following the perigastric fascia</td>
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<tr>
<td>Li et al., (12)</td>
<td>2014</td>
<td>108</td>
<td>T2–3</td>
<td>169</td>
<td>46</td>
<td>0</td>
<td>12.0</td>
<td>0</td>
<td>11.9</td>
<td>44.0</td>
<td>3.0</td>
<td>With multislice spiral CT angiography</td>
</tr>
<tr>
<td>Son et al., (13)</td>
<td>2014</td>
<td>58</td>
<td>T1b–T2</td>
<td>210</td>
<td>201</td>
<td>0</td>
<td>8.6</td>
<td>0</td>
<td>7.9</td>
<td>43.0</td>
<td>0.8</td>
<td>Robotic versus laparoscopic</td>
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<tr>
<td>Wang et al., (14)</td>
<td>2014</td>
<td>312</td>
<td>T2–T4a</td>
<td>174</td>
<td>50</td>
<td>NE</td>
<td>15.0</td>
<td>0</td>
<td>12.3</td>
<td>43.0</td>
<td>2.9</td>
<td>With 3-dimensional CT</td>
</tr>
<tr>
<td>Lu et al., (15)</td>
<td>2015</td>
<td>325</td>
<td>T2–T3</td>
<td>174^d, 224^e</td>
<td>NE</td>
<td>0</td>
<td>2.5^f</td>
<td>0.6</td>
<td>12.0^i, 20.0^a</td>
<td>NE</td>
<td>NE</td>
<td>Risk factors of perioperative complications</td>
</tr>
</tbody>
</table>

Table 1 (continued)
**Table 1 (continued)**

<table>
<thead>
<tr>
<th>Author (ref)</th>
<th>Year</th>
<th>n</th>
<th>Clinical indication</th>
<th>Operation time (min)</th>
<th>Blood loss (g)</th>
<th>Conversion (%)</th>
<th>Morbidity&lt;sup&gt;b&lt;/sup&gt; (%)</th>
<th>Mortality (%)</th>
<th>Hospital stay (days)</th>
<th>Harvested LNs (n)</th>
<th>Splenic hilar LNs (n)</th>
<th>Novelty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinoshita et al., (16) 2015</td>
<td>20</td>
<td>Up to T3N1M0</td>
<td>318</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8.0</td>
<td>43.0</td>
<td>2.0</td>
<td>With 3-dimensional anatomic simulation software</td>
<td></td>
</tr>
<tr>
<td>Wang et al., (17) 2015</td>
<td>16</td>
<td>T2–T4a</td>
<td>329</td>
<td>136</td>
<td>0</td>
<td>6.0</td>
<td>0</td>
<td>9.6</td>
<td>28.0</td>
<td>4.3</td>
<td>Technically feasible with omnibearing method</td>
<td></td>
</tr>
<tr>
<td>Zheng et al., (18) 2015</td>
<td>317</td>
<td>Up to T4a</td>
<td>175</td>
<td>54</td>
<td>NE</td>
<td>6.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NE</td>
<td>12.0–13.0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>40.0–44.0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.5–3.0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Analysis of splenic hilar vascular anatomy</td>
<td></td>
</tr>
<tr>
<td>Usui et al., (19) 2015</td>
<td>159</td>
<td>T2–3, N0</td>
<td>339</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8.4</td>
<td>40.0</td>
<td>1.3</td>
<td>In comparison with combined splenectomy</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>, including cases with D1+ LN dissection; <sup>b</sup>, grade II or more by Clavien-Dindo classification; <sup>c</sup>, grade not mentioned; <sup>d</sup>, without major perioperative complications (n=310); <sup>e</sup>, with major perioperative complications (n=15); <sup>f</sup>, grade IIIa or higher; <sup>g</sup>, with subgroup analysis by variation of vascular anatomy; LN, lymph node; NE, not evaluated.

**Table 2** Laparoscopic total gastrectomy with splenectomy

<table>
<thead>
<tr>
<th>Author (ref)</th>
<th>Year</th>
<th>n</th>
<th>Clinical indication</th>
<th>Operation time (min)</th>
<th>Blood loss (g)</th>
<th>Conversion (%)</th>
<th>Morbidity&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>Mortality (%)</th>
<th>Hospital stay (days)</th>
<th>Harvested LNs (n)</th>
<th>Splenic hilar, LNs (n)</th>
<th>Novelty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nakata et al., (20) 2015</td>
<td>18</td>
<td>T1bN1–2</td>
<td>388</td>
<td>45</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>12</td>
<td>51</td>
<td>NE</td>
<td>Technically feasible</td>
<td></td>
</tr>
<tr>
<td>Usui et al., (19) 2016</td>
<td>19&lt;sup&gt;h&lt;/sup&gt;</td>
<td>T3–T4a, N1–2</td>
<td>357</td>
<td>210</td>
<td>NE</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>41</td>
<td>2.4</td>
<td>Technically feasible</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>, including cases with D1+ LN dissection; <sup>h</sup>, 12 cases were hand-assisted; LN, lymph node; NE, not evaluated.
the risk of postoperative morbidity and mortality in randomized clinical trials and could not show survival benefit compared with spleen preservation (22-25), routine or prophylactic splenectomy is not recommended by National Comprehensive Cancer Network guidelines (28). Recently, a large, multicenter, randomized controlled trial with 505 patients comparing splenectomy with spleen preservation on the proximal gastric cancer was performed (29,30). Proximal gastric adenocarcinoma of T2-4/N0-2/M0 not invading the greater curvature was eligible, and splenectomy resulted in higher morbidity, larger blood loss, and no survival advantage. The 5-year overall survivals were 75.1% and 76.4% in the splenectomy and spleen-preserving arms respectively, and the non-inferiority of spleen preservation was confirmed. They concluded that prophylactic splenectomy should be avoided not only for operative safety but also for survival benefit.

Even with the evidence described above, further advanced tumors such as those with direct invasion of the gastroesophageal ligament, pancreatic parenchyma, or spleen need to be resected by total gastrectomy with splenectomy, sometimes with combined resection of distal pancreas. Laparoscopic resection of such advanced tumors is technically demanding because huge tumor prevents laparoscopic view, or handling of the tumor is sometimes difficult, and care must be taken not to manipulate the tumor. Technical improvement for better short-term outcomes and validation of oncological outcomes with longer follow-up data would be required.

L TG with LSPL has gradually become popular with acceptable surgical outcomes, but careful interpretation is required. These excellent surgical results were provided by laparoscopic expert surgeons. Even if prophylactic splenectomy was denied, D2 lymphadenectomy for advanced gastric cancer is still a standard (31) for advanced gastric cancer. LTG with LSPL is still technically difficult for many surgeons and cannot be a standard at this moment. Further technical progress or acceptance of more simplified concept of lymphadenectomy, such as ‘D2-No.10’ lymphadenectomy for some limited cases might be required for LTG to be a first choice for advanced gastric cancer.

Conclusions

With the short-term advantage over open gastrectomy, laparoscopic gastrectomy has been applied not only in early but also advanced gastric cancer, or more complicated procedures such as LTG with LSPL or splenectomy.
With the development of laparoscopic devices, advanced knowledge of laparoscopic view, and accumulated technical experiences, such laparoscopic advanced surgery could be feasible in near future. And by overcoming a critical validation of oncological outcomes, it still has a chance to be a procedure of choice as a treatment for advanced gastric cancer.

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Footnote
Conflicts of Interest: The authors have no conflicts of interest to declare.

References

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