Esophagogastric junction adenocarcinomas: individualization of resection with special considerations for Siewert type II, and Nishi types EG, E=G and GE cancers

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Abstract

For Siewert type II adenocarcinoma of the esophagogastric junction (AEG II), or similar tumors classified as Nishi EG, E=G, GE, the type of surgical resection and reconstruction should be individualized. Criteria for decision making mainly focus on the oral extent of esophageal infiltration, the cT and cN category and the functional status of the patient. For cT1/cT2 adenocarcinomas, which are non-poorly cohesive, intestinal type of Lauren Grading 1 or 2 without clinical signs of lymph node metastasis at the distal stomach, a limited transhiatal proximal gastrectomy with double tract reconstruction is recommended. For advanced adenocarcinomas, subtotal esophageal and proximal gastric resection with gastric pull-up or distal esophageal resection with total gastrectomy and esophagojejunostomy are competing procedures. Criteria for choosing the appropriate type of surgery are discussed.

Keywords Gastric cancer · Esophageal cancer · Adenocarcinoma of the esophagogastric junction · Siewert classification · Nishi classification

Introduction

The present analysis focuses on the optimal type of surgical resection for Siewert type II adenocarcinoma of the esophagogastric junction (AEG), which is still under debate. Compared to AEG I (Barrett's esophageal adenocarcinoma (AC) and AEG III (subcardial gastric AC), AEG II is defined as an AC with the tumor epicenter located between 1 cm above to 2 cm below the anatomical esophagogastric junction (EGJ) [1, 2]. It is also called true cardia cancer. In Japan, the Nishi classification for this entity is also based on the center of the tumor, which is located between 2 cm above to 2 cm below the anatomical EGJ [3]. The Japanese Esophageal Society

subclassification of Nishi's proposal has 5 types, depending on the relative extent of esophageal or gastric involvement (E, EG, E=G, GE and E) and true cardia cancer is mostly represented by the EG, E=G or GE type Nishi tumors [4].

The Siewert and the Nishi classification refer to the center of the tumor, but do not take into account the proximal and distal extent of the cancer, as such it has limited importance for the decision of the extent of surgical resection. A large AC with the center at 0 cm can infiltrate the esophagus much longer than a small tumor with the same center or a center even more proximally located. The extent of esophageal infiltration is more important than the gastric involvement as the abdomino-transhiatal approach to the esophagus is limited, whereas the stomach is much better exposed. The exposure of the distal esophagus is essential for achieving an appropriate esophageal resection margin and for constructing a safe anastomosis in the lower mediastinum by the transhiatal approach. If either or both conditions are not possible an additional transthoracic approach is necessary.

Another important issue of the AEG II/Nishi tumors is their lymphatic drainage as they are exactly localized at the junction of the thoracic and abdominal cavity, and between the esophagus and stomach. The optimal extent of

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lymphadenectomy in the mediastinum and the upper abdomen is still based on low evidence.

The aims of surgical resection of AEG II/Nishi tumors are:

- complete resection of the primary lesion with negative proximal, distal and lateral margins (R0 resection)
- avoiding unnecessary resection of normal esophagus or stomach
- adequate mediastinal and abdominal lymphadenectomy
- approach with low invasiveness (thorax/abdomen)
- achieving a safe and easy reconstruction with good long-term function, balancing safety, oncological clearance and quality-of-life issues.

This review presents arguments for an individualized surgical treatment of AEG II/Nishi type tumors. Endoscopic resection for early mucosal cancers is not discussed. Further this review does not discuss the relative merits of minimally invasive versus open surgery, because many procedures can be performed in both ways.

New aspects of lymphatic metastasis

In 1002 AEG tumors reported by Siewert and associates, tumor resection was primarily transthoracic esophagectomy for type I and transhiatal extended total gastrectomy with distal esophageal resection for type II and III cancers [5]. In all 3 types most lymph node metastases were localized at the paracardial region (station 1 and 2), at the lesser gastric curvature (station 3), at the left gastric artery (station 7), and in the lower mediastinum (station 110 and 111). The rate of lymphatic metastasis in the lower mediastinum was only high for AEG type I tumors at 32% and lower for AEG type II at 16% and 12% for type III cancers. The lymph nodes of the middle and upper mediastinum were only routinely removed in type I tumors with a 10% or 5% infiltration rate, respectively. For type II and III tumors therefore no data on these regions were available. The rate of lymph node metastasis at the distal stomach, station 5 at the supra-pyloric area and station 4 and 6 at the greater curvature and infra-pyloric region was only 2% for type II and 15% for type III tumors. However this was a series of mostly advanced AC (pT3/pT4).

A large nation-wide retrospective study in Japan of 2807 patients analyzed in detail the nodal spread of junctional tumors according to Nishi's classification. Inclusion criteria were patients without neoadjuvant therapy, tumors of less than 4 cm diameter, and all underwent R0 resection. The results supported the findings of Siewert et al. The lymphatic metastases were found also mainly in the abdominal nodes, especially at the right and left paracardial, lesser curvature

and the left gastric artery stations [6]. The lymph nodes at the distal stomach were rarely infiltrated: station 4sa 0.1% (pT1), 0.8% (pT2), station 4sb 0% (pT1), 0.5% (pT2), station 4d 0.2% (pT1), 0.4% (pT2), station 5 0% (pT1), 0.5% (pT2) and station 6 0.1% (pT1), 0.9% (pT2). In pT3/pT4 carcinomas, lymph node infiltration in these stations was only about 1% higher and the removal of these lymph nodes had no prognostic benefit.

These lymph node metastasis rates were confirmed by a recent prospective study jointly organized by the Japan Esophageal Society and Japanese Gastric Cancer Association, including 363 patients with the same definition of EGJ tumors (91% adenocarcinomas, 240 transhiatal and 120 transthoracic approach) as in the study of Yamashita (pT1 17%, pT2 17%, pT3 48%, pT4 17%: Lymph node station 4sa 4.3%, station 4sb 0.8%, station 4d 2.2%, station 5 1.1% and station 6 1.7% [7]. Based on these data the Japanese Gastric Cancer Association recommended that routine dissection of the lymph node stages 4, 5 and 6 was not necessary in tumors of the EGJ [6]. Further they concluded that the length of esophageal infiltration was a better indicator for mediastinal lymph node metastasis than the location of the tumor epicenter. This correlation was also reported from Koyanagi from a series of 168 patients with AEG II tumors [8].

A very exact pattern of lymph node metastasis in AEG II Nishi tumors could only be detected if in a series of patients total esophagogastrectomy with radical mediastinal and abdominal lymphadenectomy is performed. As this is not possible the mediastinal lymph nodes can only be evaluated by preoperative CT-scan and endosonography. The abdominal nodes will be completely removed anyhow by D2 lymphadenectomy except in cases with limited gastric resection.

Another question is the existence of lymph node metastasis in the greater omentum and the value of its removal in patients with EGJ tumors. The rate of lymph node metastasis in the omentum is very low and therefore total omentectomy is avoided especially in the T1 or T2 category [6, 9, 10].

Early adenocarcinoma

Because of these data a limited resection of the distal esophagus and the proximal stomach is adequate in patients with cT1, perhaps cT2 category without clinical suspicion of lymph node metastasis in the mediastinum or at the distal stomach. This is especially so if no other risk factors such as Grading G3, G4, diffuse type of Lauren subtype or poorly cohesive carcinoma are present [11]. The lymph nodes of compartment 1 (perigastric nodes number 1–6) are partially removed with the proximal stomach, whereas lymphadenectomy in compartment 2 (suprapancreatic nodes number 7–12) can be completely performed.

For reconstruction after distal esophagectomy and proximal gastrectomy, four options are available (Fig. 1):

- Direct esophagogastrostomy
- Merendino procedure with jejunal interposition between esophagus and stomach
- Double tract reconstruction with Roux-en-Y esophagojejunostomy, gastro-jejunostomy and jejunojejunostomy
- Esophagogastrostomy but with anti-reflux anastomosis such as the double-flap technique.

The characteristics of these four procedures are compared in Table 1. Direct esophagogastrostomy in the lower mediastinum is the easiest method, but it has a high rate of severe reflux esophagitis which is very difficult to treat. Therefore we avoid this option.

The Merendino procedure is the most difficult, because a pedicled jejunal loop has to be isolated and interposed between esophagus and stomach. This procedure is complicated by quite a high rate of kinking of the jejunal loop with swallowing problems and delayed gastric emptying especially if the vagus nerves could not be preserved. Further reflux esophagitis is a frequent problem [12, 13].

cT1/cT2 cN0

low risk:

- no poorly cohesive carcinoma
- intestinal type of Lauren
- Grading 1 or 2
- no lymph node metastasis at the distal stomach

limited abdomino-transhiatal esophagogastric resection

Reconstruction

- Double tract
- Merendino
- Esophagogastrostomy
- Esophagogastrostomy with anti-reflux anastomosis

cT3/resectable cT4 or

cT1/cT2 with high risk

(poorly cohesive carcinoma, diffuse type, G3 or G4, cN+)

- abdomino-transhiatal total gastrectomy with distal esophageal resection and esophagojejunostomy

- abdomino-thoracic subtotal esophagectomy with proximal gastric resection and high intrathoracic or cervical esophagogastrostomy

- abdominothoracic subtotal esophagectomy and total gastrectomy with colon interposition and high intrathoracic or cervical anastomosis

Fig. 1 Algorithm for the surgical treatment of AEG II or EG, E=G, GE Nishi adenocarcinomas M0

Table 1 Comparison of the characteristics of four options of reconstruction after limited resection of the esophagogastric junction

	Esophago-gastrectomy	Double tract	Merendino	Esophago-gastrectomy with anti-reflux flap
Anastomosis	1	3	3	1
Vascular pedicle	Stomach	Large stalk of mesentery	Small stalk of mesentery	Stomach
Length of organ for reconstruction	Long	Limited	Limited	Long
Kinking	Rare	Rare	Frequent	Rare
Vagus preservation	No	Possible but not necessary	Possible and important	No
Emptying channels	1	2	1	1
Innervation and peristalsis of jejunal loop	–	Good	Impaired (jejunal isolation)	–
Reflux	Very severe	Rare	Increased	Rare
Difficulty	Simple	Simple	Difficult	Difficult

We favor the double tract reconstruction, because it has the lowest rate of reflux esophagitis and because of 2 channels, problems of delayed emptying are very rare [14–19]. Compared to total gastrectomy with Roux-en-Y esophagojejunostomy the preservation of the distal stomach and double tract reconstruction has some advantages according to the retrospective studies [16–19]

- a shorter operating time
- lower blood loss
- lesser postoperative vitamin B12 supplementation
- lower hemoglobin change [17, 18].
- the incidence of reflux symptoms $\geq$ Visick II is low (1–2%) and not different to total gastrectomy
- overall survival is similar compared to total gastrectomy in clinical stage I proximal gastric cancer.

A multicenter randomized trial comparing laparoscopic proximal gastrectomy with double-tract reconstruction versus laparoscopic total gastrectomy for proximal gastric cancer cT1N0M0 is being conducted in Korea [20]. The primary end-points are haemoglobin change and vitamin B12 cumulative supplement quantity at post-gastrectomy 2 year.

Esophagogastrostomy with anti-reflux anastomosis is being investigated [21]. Only one anastomosis is needed. Preliminary data suggest low incidence of reflux esophagitis. However the technique is technically demanding. Hosoda et al. described none of 20 patients with heartburn without antacid drugs and in 19 of 20 patients a reflux percent time of $< 1.4\%$ [21].

Advanced adenocarcinoma

For advanced AEG II/Nishi tumors or early AC which do not qualify for limited resection, two main types of resection and one exceptional type can be applied (Fig. 1):

- transthoracic subtotal esophagectomy and proximal gastric resection with reconstruction by gastric pull-up with either intrathoracic or cervical esophagogastrostomy.
- abdomino-transhiatal total gastrectomy with distal esophageal resection and reconstruction by Roux-en-Y esophagojejunostomy. If by transhiatal approach the anastomosis is difficult it can also be performed through an additional lower thoracotomy.
- subtotal esophagectomy and total gastrectomy with reconstruction by colon interposition. This is only indicated in very large tumors or patients with previous gastric resection.

The pros and cons of these three procedures are compared in Table 2.

In advanced AEG II/Nishi tumors the length of esophageal infiltration is the most important issue for decision making about the type of resection and reconstruction. The oral safety margin at the esophagus should be at least 2 cm on the extended fresh specimen. Otherwise the prognosis is significantly inferior according to the analysis of Mine et al. [22].

The R0-resectability in oral direction via an abdomino-transhiatal exposure is also dependent on individual anatomy; for example the presence of a large hiatal hernia, a

Table 2 Advantages (+) and disadvantages (–) of subtotal esophagectomy with gastric pull-up versus transhiatal extended gastrectomy with distal esophageal resection and Roux-en-Y esophagojejunostomy versus subtotal esophagectomy and total gastrectomy and colon interposition

Esophagectomy with gastric pull up	Extended Gastrectomy with Roux-en-Y esophagojejunostomy	Esophagogastrrectomy with colonic interposition
– 2 Cavity operation (thorax/abdomen)	+ 1 ½ cavity operation (abdomen/transhiatal)	– 2 or 3 cavity operation (thorax/abdomen/neck)
– Safety margin distal (stomach)	– Safety margin proximal (esophagus)	+ Wide safety margins (esophagus/stomach)
+ Preservation of ¾, 2/3 of stomach	– Loss of stomach	– Loss of stomach
– Loss of ¾ of esophagus	+ Preservation of ¾ of esophagus	– Loss of ¾ of esophagus
+ Big reservoir	– Small reservoir	– Small reservoir
+ Pancreatocibal synchrony	– Pancreatocibal asynchrony	– Pancreatocibal asynchrony
– Incomplete D1 complete D2 lymphadenectomy	+ Complete D2 lymphadenectomy	+ Complete D2 lymphadenectomy
+ Radical mediastinal lymphadenectomy	– Only lower mediastinal lymphadenectomy	+ Radical mediastinal lymphadenectomy
+ Length of stomach	– Length of jejunum	+ Length of colon
– Danger of hiatal herniation of bowel	+ Low danger of hiatal herniation of bowel	– Danger of hiatal herniation of bowel
– Delayed gastric emptying	– Delayed jejunal emptying	– Delayed colonic emptying
– Pylorospasm	+ Not relevant	+ Not relevant
– Gastroesophageal reflux	+ Rare alkaline reflux	+ Rare alkaline reflux
– Necessity of PPI	– Necessity of B12	– Necessity of B12
+ Less dumping	– More Dumping	– More Dumping

short esophagus, large body size and obesity will make an anastomosis at the hiatus or lower mediastinum difficult. In this context the questions are:

- can the esophageal part of the tumor be completely resected?
- which extent of mediastinal lymphadenectomy should be chosen based on preoperative CT/endosonography and intraoperative findings?
- can a jejunal loop with sufficient length and good vascularization be prepared and used for a transhiatal anastomosis without tension?

In case of planned abdomino-transhiatal extended gastrectomy our recommended strategy is first to prepare the distal esophagus in the lower mediastinum by a transhiatal approach. If visually and by palpation an R0-resection at the esophagus is possible, it is severed and an intraoperative frozen section is performed. If this is tumor free and the jejunum has enough length for reconstruction, the dissection for total gastrectomy can be started. This strategy keeps the option for conversion to esophagectomy and proximal gastric resection and reconstruction by gastric conduit in case of a positive esophageal resection margin on frozen section. Intraoperative endoscopy can also help determine the site of proximal esophageal transection for earlier tumors which are difficult to palpate or in case of dysplasia or Barrett's segment extending above the palpable tumor.

Apart from the extent of esophageal and gastric tumor infiltration, there are other criteria which are important for decision making about the best surgical procedure [23]:

- availability of intraoperative frozen section
- localization of suspicious lymph nodes in the mediastinum or upper abdomen
- mobility of the mesenteric root of the jejunum
- adiposity with fatty mesentery
- architecture of the vascularization of the upper jejunum
- abnormal stomach or previous gastric resections
- vascularization of the gastric conduit after gastrolisis
- previous operations of the colon, important for reconstruction in case of an inadequate gastric conduit
- previous thoracic surgery especially lung resection at the right side or left (one lung ventilation)
- lung function and functional reserves during thoracotomy and one-lung- ventilation
- experience of the surgeons in thoracic surgery.

The literature concerning surgical results of AEG II/ Nishi tumors is not very conclusive on the ideal type of surgery. In a series of transthoracic esophagectomy with 3-field lymphadenectomy Lerut et al. found high intrathoracic or cervical lymph node metastasis in 25% for AEG

I and 17% for AEG II [24]. Similar results were demonstrated in another study [25]. However these results have not been reproduced and three-field lymphadenectomy remains an uncommon procedure for adenocarcinoma of the esophagus or cardia.

The Dutch randomized trial compared 106 patients who underwent transhiatal and 114 with transthoracic resection for mid-lower third/cardia adenocarcinoma. Pulmonary complication rates were 27% for transhiatal vs. 57% for transthoracic group. The transhiatal group had shorter ventilation time, intensive care unit and hospital stay. In-hospital mortality and overall 5-year survival rates were similar in both groups. Patients who underwent transthoracic resection had more lymph nodes harvested (31 vs. 16). In those with 1–8 positive lymph nodes, transthoracic approach had a significant survival advantage (64% vs. 23%, in 5 years). However, survival rates were similar in those patients without nodal metastases or with more than eight nodal metastases. In patients with type I cancers, 5-year survival was 51% in those with transthoracic resection vs. 37% for transhiatal resection, although statistically the comparison was not significant [26, 27]. It was concluded that transthoracic resection could have survival advantage in type I cancers, especially in those with limited nodal metastases in the expense of increased morbidity. For type II cancers, no significant survival differences were found.

The Japanese Oncology Group trial 9502 was a randomized trial comparing a transabdominal versus a left thoraco-abdominal approach for Siewert II or III adenocarcinomas [28, 29]. It was hypothesized that up to 30% of patients with such tumors would have lower mediastinal nodal metastases and that a left thoraco-abdominal approach could result in better mediastinal clearance and therefore better prognosis. Adenocarcinomas of the esophagogastric junction that had infiltrated to the esophagus for 3 cm or less, clinically T2-4, N0-2, M0 were randomly assigned to a transabdominal ($n = 82$) or left thoracoabdominal approach ($n = 85$). Both groups underwent total radical gastrectomy with left upper paraaortic dissection. The left thoracoabdominal group also had formal lower mediastinal dissection. The trial was closed prematurely after the first interim analysis, when the predicted probability of left thoracoabdominal approach having a significantly better overall survival than transabdominal route at the final analysis was only 3.7%. The morbidity rate was worse after the left thoracoabdominal approach (especially pulmonary complication rates). A 10-year follow-up of the trial yielded similar results [29]. Thus a transabdominal approach seems adequate, though the surgeon must be prepared to add a thoracotomy when frozen section indicates a positive proximal resection margin. Although JCOG 9502 is very influential, the trial is somewhat limited by the slight imbalance of factors between the two groups, the finding of lower mediastinal nodal

involvement being lower than originally projected when the trial was planned, and the premature closure of the study.

In a series from Hongkong with 380 AEG tumors (59% esophagectomy, 28% proximal gastric and distal esophageal resection, 12% extended total gastrectomy), the surgical approach was not found to be a significant prognostic factor in multivariate analysis. Only the pT-, pN- and the R-category were prognostic (unpublished data). In an international survey with questionnaires from 49 countries and 6 continents, Haverkamp et al. have found quite some differences in the surgical technique for AEG tumors [30]. The preferred technique for type I was esophagectomy in 93% and for type II and III extended total gastrectomy in 66% and 90%, respectively. However, the preference seemed to be strongly influenced by surgeons' expertise (gastric versus esophago-gastric surgeons), and location of centers (by continents).

Decision making

A pragmatic solution for AEG II/Nishi EG, E=G, GE type tumors recommended by the authors could be as follows:

Factors that are in favor of abdomino-transhiatal approach and extended total gastrectomy:

- small superficial tumor cT1 (cT2) but diffuse type of Laurén, Grading G3, G4, L1, V1 or poorly cohesive carcinoma.
- normal esophagus (safer anastomosis, especially in those without high grade obstruction or preoperative chemoradiotherapy)
- elderly patients with increased risk
- good exposure at the esophageal hiatus
- no suspicion of mediastinal lymph node metastasis
- good circumstances for reconstruction by jejunal Roux-en-Y loop.

Factors in favor of transthoracic approach and esophagectomy:

- large tumor with substantial esophageal infiltration
- edematous and unhealthy esophagus (such as proximal to advanced cancer with high grade stenosis, or post neoadjuvant chemoradiotherapy)
- bad exposure at the esophageal hiatus
- suspicion of mediastinal lymph node metastasis
- normal stomach with good prerequisites for reconstruction.

Factors in favor of a limited esophagogastric resection:

- small tumor cT1 (cT2)

- intestinal type of Lauren
- Grading G1, G2, L0, V0
- no poorly cohesive carcinoma
- no suspicion of mediastinal lymph node metastasis
- no suspicion of lymph node metastasis at the distal stomach
- good exposition at the esophageal hiatus
- normal distal stomach
- good circumstances for reconstruction by jejunal Roux-en-Y loop.

The decision making on the optimal resection and reconstruction methods should take into account the global view of all clinical and intraoperative factors. Finally some patients can be completely resected and adequately reconstructed in different ways. However the number of such patients will be few after considering the criteria mentioned in this review.

Compliance with ethical standards

Conflicts of interest The author declares that they have no competing interests.

Human and animal rights statement This review article does not contain any studies with human participants performed by any of the authors.

Informed consent Informed consent is not necessary.

References

1. Siewert JR, Hölscher AH, Becker K, Gossner W. Cardia cancer: attempt at a therapeutically relevant classification. *Chirurg.* 1987;58(1):25–32.
2. Hölscher AH, Schüller M, Siewert JR. Surgical treatment of adenocarcinomas of the gastroesophageal junction. *Dis Esophagus.* 1988;1:35–49.
3. Nishi MKT, Akune T, et al. Cardia cancer-proposal of cancer in the esophagogastric junction (in Japanese). *Geka Shinryo (Surg Diagn Treat).* 1973;15:1328–38.
4. Kitagawa Y, Uno T, Oyama T, Kato K, Kato H, Kawakubo H, et al. Esophageal cancer practice guidelines 2017 edited by the Japan Esophageal Society: part 1. *Esophagus.* 2019;16(1):1–24. <https://doi.org/10.1007/s10388-018-0641-9>.
5. Siewert JR, Feith JM, Werner JM, Stein JH. Adenocarcinoma of the esophagogastric junction: results of surgical therapy based on anatomical/topographic classification in 1002 consecutive patients. *Ann Surg.* 2000;232(3):353–61. <https://doi.org/10.1097/0000658-200009000-00007>.
6. Yamashita H, Seto Y, Sano T, Makuuchi H, Ando N, Sasako M. Results of a nation-wide retrospective study of lymphadenectomy for esophagogastric junction carcinoma. *Gastric Cancer.* 2017;20(Supplement 1):69–83. <https://doi.org/10.1007/s10120-016-0663-8>.
7. Kurokawa Y, Takeuchi H, Doki Y, Mine S, Terashima M, Yasuda T, et al. Mapping of lymph node metastasis from esophagogastric

- junction tumors: a prospective nationwide multicenter study. *Ann Surg.* 2019. <https://doi.org/10.1097/SLA.0000000000003499> **PubMed PMID: 31404008.**
8. Koyanagi K, Kato F, Kanamori J, Daiko H, Ozawa S, Tachimori Y. Clinical significance of esophageal invasion length for the prediction of mediastinal lymph node metastasis in Siewert type II adenocarcinoma: a retrospective single-institution study. *Ann Gastroenterol Surg.* 2018;2(3):187–96. <https://doi.org/10.1002/ags3.12069>.
9. Jongerius EJ, Boerma D, Seldenrijk KA, Meijer SL, Scheepers JJ, Smedts F, et al. Role of omentectomy as part of radical surgery for gastric cancer. *Br J Surg.* 2016;103(11):1497–503. <https://doi.org/10.1002/bjs.10149> (**PubMed PMID: 27550526. Epub 2016/08/24**).
10. Kim MC, Kim KH, Jung GJ, Rattner DW. Comparative study of complete and partial omentectomy in radical subtotal gastrectomy for early gastric cancer. *Yonsei Med J.* 2011;52(6):961–6. <https://doi.org/10.3349/ymj.2011.52.6.961> (**PubMed PMID: 22028160; PubMed Central PMCID: PMC3220242. Epub 2011/10/27**).
11. Mariette C, Carneiro F, Grabsch HI, van der Post RS, Allum W, de Manzoni G, et al. Consensus on the pathological definition and classification of poorly cohesive gastric carcinoma. *Gastric Cancer.* 2019;22(1):1–9. <https://doi.org/10.1007/s10120-018-0868-0> (**Epub 2018/09/01. PubMed PMID: 30167905**).
12. Gutschow CA, Schröder W, Wolfgarten E, Hölscher AH. Merendino procedure with preservation of the vagus for early carcinoma of the gastroesophageal junction. *Zentralbl Chir.* 2004;129(4):276–81. <https://doi.org/10.1055/s-2004-820307> (**PubMed PMID: 15354248. Epub 2004/09/09**).
13. Zapletal C, Heesen C, Origer J, Pauthner M, Pech O, Ell C, et al. Quality of life after surgical treatment of early Barrett's cancer: a prospective comparison of the Ivor-Lewis resection versus the modified Merendino resection. *World J Surg.* 2014;38(6):1444–52. <https://doi.org/10.1007/s00268-013-2410-1>.
14. Hölscher AHBF, Hemmerich M, St Minot, Schmidt H. Double tract reconstruction following limited esophagogastric resection of AEG Types II and II adenocarcinomas. *Zentralbl Chir.* 2019;144:1–6.
15. Aikou TNS, Shimazu H, et al. Antrum preserving double tract method for reconstruction following proximal gastrectomy. *Jpn J Surg.* 1988;18:114–5.
16. Jung DH, Ahn S-H, Park DJ, Kim H-H. Proximal gastrectomy for gastric cancer. *J Gastric Cancer.* 2015;15(2):77–86. <https://doi.org/10.5230/jgc.2015.15.2.77>.
17. Ahn SH, Jung DH, Son SY, Lee CM, Park DJ, Kim HH. Laparoscopic double-tract proximal gastrectomy for proximal early gastric cancer. *Gastric Cancer.* 2014;17(3):562–70. <https://doi.org/10.1007/s10120-013-0303-5> (**PubMed PMID: 24052482. Epub 2013/09/21**).
18. Jung D, Lee Y, Kim D, Park Y, Ahn S-H, Park D, et al. Laparoscopic proximal gastrectomy with double tract reconstruction is superior to laparoscopic total gastrectomy for proximal early gastric cancer. *Surg Endosc.* 2017;31(10):3961–9. <https://doi.org/10.1007/s00464-017-5429-9>.
19. Park JY, Park KB, Kwon OK, Yu W. Comparison of laparoscopic proximal gastrectomy with double-tract reconstruction and laparoscopic total gastrectomy in terms of nutritional status or quality of life in early gastric cancer patients. *Eur J Surg Oncol.* 2018;44(12):1963–70. <https://doi.org/10.1016/j.ejso.2018.08.014> **PubMed PMID: 30197164.**
20. KCLASS-05 Multicenter prospective randomized controlled trial of laparoscopic proximal gastrectomy and laparoscopic total gastrectomy for upper third early gastric cancer KCLASS-05 <http://klass.or.kr/trial/sub05.html>, <https://clinicaltrials.gov/ct2/show/NCT02892643>.
21. Hosoda K, Yamashita K, Moriya H, Mieno H, Ema A, Washio M, et al. Laparoscopically assisted proximal gastrectomy with esophagogastrostomy using a novel “Open-Door” technique: LAPG with Novel Reconstruction. *J Gastrointest Surg.* 2017;21(7):1174–80. <https://doi.org/10.1007/s11605-016-3341-6> (**PubMed PMID: 28025772. Epub 2016/12/28**).
22. Mine S, Sano T, Hiki N, Yamada K, Kosuga T, Nunobe S, et al. Proximal margin length with transhiatal gastrectomy for Siewert type II and III adenocarcinomas of the oesophagogastric junction. *Br J Surg.* 2013;100(8):1050–4. <https://doi.org/10.1002/bjs.9170>.
23. Wong C, Law S. Extent of lymphadenectomy for Barrett's cancer. *Transl Gastroenterol Hepatol.* 2019;4(36):1–7. <https://doi.org/10.21037/tgh.2019.05.07> (**Epub 24/5/2019**).
24. Lerut T, Naftoux P, Moons J, Coosemans W, Decker G, De Leyn P, et al. Three-field lymphadenectomy for carcinoma of the esophagus and gastroesophageal junction in 174 R0 resections: impact on staging, disease-free survival, and outcome: a plea for adaptation of TNM classification in upper-half esophageal carcinoma. *Ann Surg.* 2004;240(6):962–72.
25. Altorki N, Kent M, Ferrara C, Port J. Three-field lymph node dissection for squamous cell and adenocarcinoma of the esophagus. *Ann Surg.* 2002;236(2):177–83.
26. Omluo JM, Lagarde SM, Hulscher JB, Reitsma JB, Fockens P, van Dekken H, et al. Extended transthoracic resection compared with limited transhiatal resection for adenocarcinoma of the mid/distal esophagus: five-year survival of a randomized clinical trial. *Ann Surg.* 2007;246(6):992–1000. <https://doi.org/10.1097/sla.0b013e31815c4037> (**Discussion-1. PubMed PMID: 18043101. Epub 2007/11/29**).
27. Hulscher JB, van Sandick JW, de Boer AG, Wijnhoven BP, Tijssen JG, Fockens P, et al. Extended transthoracic resection compared with limited transhiatal resection for adenocarcinoma of the esophagus. *N Engl J Med.* 2002;347(21):1662–9.
28. Sasako M, Sano T, Yamamoto S, Sairenji M, Arai K, Kinoshita T, et al. Left thoracoabdominal approach versus abdominal-transhiatal approach for gastric cancer of the cardia or subcardia: a randomised controlled trial. *Lancet Oncol.* 2006;7(8):644–51.
29. Kurokawa Y, Sasako M, Sano T, Yoshikawa T, Iwasaki Y, Nashimoto A, et al. Ten-year follow-up results of a randomized clinical trial comparing left thoracoabdominal and abdominal transhiatal approaches to total gastrectomy for adenocarcinoma of the oesophagogastric junction or gastric cardia. *Br J Surg.* 2015;102(4):341–8. <https://doi.org/10.1002/bjs.9764> (**PubMed PMID: 25605628; PubMed Central PMCID: PMC3502402. Epub 2015/01/22**).
30. Haverkamp L, Seesing MFJ, Ruurda JP, Boone J, Hillegersberg RV. Worldwide trends in surgical techniques in the treatment of esophageal and gastroesophageal junction cancer. *Dis Esophagus.* 2017;30(1):1–7. <https://doi.org/10.1111/dote.12480>.

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