Improved Functional Results After Minimally Invasive Esophagectomy: Intrathoracic Versus Cervical Anastomosis

Frans van Workum, MD, Jolijn van der Maas, MD, Frits J. H. van den Wildenberg, MD, Fatih Polat, MD, Ewout A. Kouwenhoven, MD, PhD, Marc J. van Det, MD, PhD, Grard A. P. Nieuwenhuijzen, MD, PhD, Misha D. Luyer, MD, PhD, and Camiel Rosman, MD, PhD

Department of Surgery, Radboudumc, Nijmegen; Department of Surgery, Canisius-Wilhelmina Hospital, Nijmegen; Department of Surgery, ZGT Hospital, Almelo; and Department of Surgery, Catharina Hospital, Eindhoven, the Netherlands

Background. **Both cervical esophagogastric anastomosis (CEA) and intrathoracic esophagogastric anastomosis (IEA) are used to restore gastrointestinal integrity following minimally invasive esophagectomy (MIE). No prospective randomized data on functional outcome, postoperative morbidity, and mortality between these techniques are currently available.**

Methods. **A comparison was conducted including all consecutive patients with esophageal carcinoma of the distal esophagus or gastroesophageal junction undergoing MIE with CEA or MIE with IEA from October 2009 to July 2014 in 3 high-volume esophageal cancer centers. Functional outcome, postoperative morbidity, and mortality were analyzed.**

Results. **MIE with CEA was performed in 146 patients and MIE with IEA in 210 patients. The incidence of recurrent laryngeal nerve palsy was 14.4% after CEA and 0% after IEA ($p < 0.001$). Dysphagia, dumping, and regurgitation were reported less frequently after IEA compared with CEA ($p < 0.05$). Dilatation of benign strictures occurred in 43.8% after CEA and this was 6.2% after IEA ($p < 0.001$). If a benign stricture was identified, it was dilated a median of 4 times in the CEA group and only once in the IEA group ($p < 0.001$). Anastomotic leakage for which reoperation was required occurred in 8.2% after CEA and in 11.4% after IEA (not significant). Median ICU stay, hospital stay, in-hospital mortality, 30-day mortality, and 90-day mortality were similar between the groups (not significant).**

Conclusions. **MIE with IEA was associated with better functional results than MIE with CEA with less dysphagia, less benign anastomotic strictures requiring fewer dilatations, and a lower incidence of recurrent laryngeal nerve palsy. Other postoperative morbidity and mortality did not differ between the groups.**

(Ann Thorac Surg 2016;■:■–■)

Esophagectomy remains the cornerstone for curative treatment of patients with esophageal carcinoma. This procedure is historically associated with considerable morbidity and mortality. The last decade, significant improvements in morbidity, mortality, and survival after esophagectomy have been made due to centralization of treatment [1], minimally invasive esophagectomy (MIE) surgery [2, 3], and neoadjuvant treatment strategies [4]. Therefore, the survival of patients has increased and functional morbidity and quality-of-life issues have become more apparent and important.

Both cervical esophagogastric anastomoses (CEA) and intrathoracic esophagogastric anastomoses (IEA) are used worldwide to restore gastrointestinal continuity after esophagectomy with gastric tube reconstruction. Esophagectomy was first described with IEA, but was associated with considerable mortality in case of anastomotic leakage [5]. In an attempt to reduce postoperative mortality, a cervical anastomosis was introduced because cervical anastomotic leakage could be managed by opening the cervical wound and thus avoiding mediastinal contamination in a group of patients [6].

Although each technique has its own complications, stricture formation (30% to 42%) [7, 8], recurrent laryngeal nerve palsy (22%) [9], and hematoma in the neck leading to swallow disturbances, hoarseness, and impaired quality of life are mainly associated with a CEA due to the nature of its location. Usually, multiple gastroenterologist consultations, functional imaging investigations, and dilatations are required to treat a stricture to an acceptable level [7]. Moreover, recurrent laryngeal nerve palsy increases postoperative ventilation time as well as intensive care unit and hospital length of stay [9].

With improvements in surgical technique, radiologic interventions, endoscopic interventions, and intensive

Accepted for publication July 5, 2016.

Address correspondence to Dr van Workum, Radboudumc, Geert Grooteplein Zuid 10, 6525 GA, Nijmegen, the Netherlands; email: frans.vanworkum@radboudumc.nl.

Published by Elsevier

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2016.07.010

care medicine, intrathoracic anastomotic leakage is now a manageable complication [10, 11] and this has stirred renewed interest in IEA. An intrathoracic level provides better healing of the anastomosis because the relatively more ischemic tip of the gastric tube in CEA can be avoided and an anastomosis can be created using a better vascularized, lower level of the gastric tube. Moreover, hematoma in the neck is avoided and recurrent laryngeal nerve palsy is prevented because this nerve is mainly outside the operative field. Currently, no compelling differences in functional outcome between CEA and IEA after MIE have been shown and comparisons of postoperative morbidity are limited. Therefore, the aim of this study was to compare functional outcome and other postoperative morbidity in patients undergoing MIE with CEA or IEA.

Patients and Methods

Patients

This study was performed in 3 regional referral centers for esophageal cancer surgery in the Netherlands (Catharina Hospital, Eindhoven; ZGT Hospital, Almelo; and Canisius-Wilhelmina Hospital, Nijmegen). All patients were discussed preoperatively and postoperatively in a weekly multidisciplinary team meeting. All centers are high-volume centers with each center performing at least 40 esophageal resections per year. All hospitals were experienced in MIE and made a transition from a MIE with CEA to MIE with IEA during the study period. The surgical team in each hospital consisted of 2 or 3 esophageal surgeons, who were all trained in advanced surgical MIE techniques.

All patients with esophageal cancer of the distal esophagus or gastroesophageal junction undergoing elective MIE with a curative intent for esophageal carcinoma with CEA (from October 2009 to July 2014) and with IEA (from December 2010 to July 2014) were included. Patients received neoadjuvant chemoradiotherapy consisting of 41.4 Gy in 23 fractions, 5 days/week, and weekly administration of carboplatin and paclitaxel [4], unless this was contraindicated.

Relevant data on patient and operation characteristics, functional results, and postoperative morbidity and mortality were registered prospectively in a database. A retrospective cohort analysis was subsequently performed.

Operative Techniques

For MIE with IEA, the surgical technique was a totally minimally invasive laparothoracoscopic esophagectomy with intrathoracic anastomosis (Ivor Lewis procedure [5]). In the IEA group, a side-to-side (S-S) anastomosis was constructed using a linear stapling device or an end-to-side (E-S) anastomosis was constructed using a 28 mm circular stapling device. For MIE with CEA, a totally minimally invasive thoracolaparoscopic esophagectomy with CEA was performed (McKeown procedure [6]) or a laparoscopic esophagectomy with blunt esophageal dissection and CEA (Orringer procedure [12]) was performed. The thoracoscopic part of the Ivor Lewis or the McKeown procedure was performed with the patient in prone position. The anastomotic technique in the CEA group was hand-sewn end-to-end (E-E) or E-S, hand-sewn S-S, semimechanical S-S [13], or stapled S-S [14]. For both MIE with IEA and MIE with CEA, no standard pyloric drainage procedure was performed.

Definitions

For assessing functional outcome, the percentage of patients receiving jejunostomy feeding, the rate of discontinuation of jejunostomy feeding and duration of jejunostomy feeding were scored. Dysphagia, dumping, and regurgitation were scored based on clinical assessment at the regular postoperative outpatient clinic visits. Recurrent laryngeal nerve palsy was defined as (partial) absence of vocal cord movement on laryngoscopy. Anastomotic leakage was defined as leakage of the anastomosis on a computed tomography scan with intravenous and oral contrast (swallow computed tomography scan), leakage confirmed by endoscopy, reoperation, or clinical leakage (ie, drainage of ingested materials into the chest tube or the cervical wound). Anastomotic leakage is graded according to the Esophagectomy Complications Consensus Group [15], into type I (no reintervention or reoperation required), type II (reintervention but no reoperation), and type III (reoperation). The reoperation rate was defined as the incidence of reoperations during admission or within the first 30 days after surgery. Pneumonia was defined as clinically diagnosed pneumonia for which treatment was started. Pleural empyema was defined as a pleural collection in which pathogens were found on culture investigations. Cardiac complications were defined as the combined incidence of clinically diagnosed arrhythmias, cardiac ischemic events, and cardiac failure. Other complications were defined as other unintentional events harmful to the patient during the postoperative period. The total complication rate was defined as the combined incidence of the complications listed previously. The in-hospital mortality rate was defined as mortality from any cause during the admission for esophageal surgery and the 30-day and 90-day mortality as mortality from any cause within 30 or 90 days after surgery including in-hospital mortality.

Statistical Analysis

Data on patient characteristics and outcome were analyzed using SPSS 18.0 software (IBM, Armonk, NY). To evaluate differences between the groups, the chi-square or Fisher exact test was used for binomial variables. For continuous variables that did not fit a normal distribution, the Mann-Whitney *U* test was used. For the 1-year survival curve the Kaplan-Meijer method with log-rank test was used. Differences were considered statistically significant when p was less than 0.05.

Results

Patient, tumor, operation, and pathology characteristics

One hundred forty-six patients underwent MIE with CEA and 210 underwent MIE with IEA. Patient characteristics were comparable between both groups, but there were more junction tumors in the CEA group (Table 1). Surgery details are shown in Table 2. The abdominal conversion rate was 5.5% in the MIE with CEA group, compared with 2.9% in the MIE with IEA group ($p = 0.02$). Thoracic conversion rate, median operative time, and blood loss were similar. R0-resection rate was similar between the groups. In the MIE with CEA group, median 13 (range, 0 to 54) lymph nodes were resected, compared with 21 (range, 5 to 51) lymph nodes in the MIE with IEA group ($p < 0.001$) (Table 2).

Functional Morbidity

Functional results are shown in Table 3. Recurrent laryngeal nerve palsy was diagnosed in 14.4% after CEA and 0% after IEA ($p < 0.001$). Postoperative jejunostomy feeding was started in 99.3% after CEA compared with 78.6% after IEA ($p < 0.001$), could be discontinued in a similar proportion in both groups (not significant) but could be discontinued earlier in the IEA group: after a median of 1.1 months compared with after 1.6 months after CEA ($p = 0.001$). In addition, complaints of dysphagia ($p < 0.001$), dumping ($p = 0.001$), and regurgitation ($p = 0.04$) were reported less frequently after IEA.

In 56.2% of patients in the MIE with CEA group an endoscopy was performed for a suspected benign anastomotic stricture, compared with 16.7% in the MIE with IEA group ($p < 0.001$). Dilatation of benign strictures occurred in 43.8% after CEA and in 6.2% after IEA ($p < 0.001$). In a binary logistic regression analysis, this difference persisted after correcting for anastomotic technique and anastomotic configuration ($p = 0.001$). In addition, anastomotic technique (hand-sewn or stapled or semistapled) and anastomotic configuration (E-E, E-S, or S-S) were not significantly correlated to anastomotic dilatation incidence in the group with cervical anastomosis. If a benign stricture was found, it was dilated a median of 4 times in the CEA group and only once in the IEA group ($p < 0.001$). The duration of the dilation period was longer after CEA: a median of 4 months compared with a median of less than 1 month after IEA ($p = 0.001$).

Postoperative morbidity, mortality, and survival

Postoperative morbidity and mortality results are shown in Table 4. Anastomotic leakage was 29.5% after CEA and 20.5% after IEA ($p = 0.052$). The incidence of type II anastomotic leakage was 18.5% after CEA and 7.1% after IEA ($p = 0.001$). Type I and type III anastomotic leakage was similar between the groups. Empyema occurred in 4.8% after CEA and in 13.5% after IEA ($p = 0.008$). If empyema occurred, this was related to anastomotic leakage in 71.4% after IEA, compared with 85.7% after CEA (not significant). Asystole occurred in 3.4% after CEA and in 0.5% after IEA ($p = 0.04$). The incidence of pneumonia, other cardiac complications, and other

Table 1. Patient and Tumor Characteristics

Characteristics	Cervical Anastomosis (n = 146)	Intrathoracic Anastomosis (n = 210)	*p* Value
Mean age, years	64.3	64.4	0.67
Mean BMI, kg/m^2	25.9	26.5	0.65
Sex, %			0.39
Male	80.8	84.3	
Female	19.2	15.7	
ASA classification, %			0.05
1	14.4	8.6	
2	70.5	66.2	
3	15.1	24.3	
4	0.0	1.0	
Tumor location, %			0.04
Distal esophagus	72.6	81.9	
Junction	27.4	19.1	
Tumor type, %			0.19
SCC	15.8	9.0	
Adenocarcinoma	82.2	90.0	
Other	1.4	0.5	
Unable to specify	0.7	0.5	
Tumor stage, %			0.69
Stage I	13.2	13.6	
Stage II	29.9	29.1	
Stage III	56.2	57.3	
Stage IV	0.7	0	
Neoadjuvant therapy, %			0.55
Chemoradiotherapy	87.7	90.0	
Chemotherapy	5.5	5.7	
Radiotherapy	0.7	0.0	
None	6.2	4.3	

ASA = American Society of Anesthesiologists; BMI = body mass index; SCC = squamous cell carcinoma.

complications was similar between the groups. The reintubation and reoperation rate were comparable between the groups. The reintervention rate was significantly higher in the IEA group (29.0%) than in the CEA group (17.8%, $p = 0.02$) and this was caused by a higher radiologic reintervention rate in the IEA group. Hospital and intensive care unit length of stay did not differ between the groups. Thirty-day, 90-day, and in-hospital mortality rates were comparable between the groups. The 1-year overall survival curve is shown in Figure 1. No significant difference in survival was observed between the groups ($p = 0.85$).

Comment

Our study showed remarkably lower functional morbidity after intrathoracic anastomosis compared with cervical anastomosis including less dysphagia, less benign anastomotic strictures requiring fewer dilatations, and a lower incidence of recurrent laryngeal nerve palsy. The significantly lower incidence of benign anastomotic strictures

Table 2. Operation and Pathology Characteristics

Characteristics	Cervical Anastomosis (n = 146)	Intrathoracic Anastomosis (n = 210)	*p* Value
Procedure, %			
Orringer	47.9	0.0	
McKeown	52.1	0.0	
Ivor Lewis	0.0	100.0	
Anastomotic configuration, %			
End to end	77.9	0.5	
End to side	6.2	55.2	
Side to side	15.9	44.3	
Anastomotic technique, %			
Hand-sewn	84.2	2.9	
Stapled	3.4	97.1	
Semimechanical	12.3	0.0	
Abdominal conversion rate, %	5.5	2.9	0.02
Thoracic conversion rate, %	0	1.9	0.15
Median operation time (range), min	314 (140–529)	300 (162–648)	0.92
Median blood loss (range), mL	175 (0–2800)	150 (0–2200)	0.17
R0-resection rate, %	96.6	93.8	0.24
Complete pathological response, %	23.3	22.9	0.92
Median lymph nodes (range)	13 (0–54)	21 (5–51)	<0.001
Mean positive lymph nodes (range)	1 (0–10)	2 (0–27)	0.09

requiring dilatation after IEA is not in line with results from earlier randomized studies [16]. Potential explanations are that these previous studies were not designed or powered to detect a difference in benign anastomotic strictures or that this difference resulted from improvements in anastomotic technique (ie, modern-day staplers). The higher incidence of benign anastomotic strictures after CEA might be caused by relatively more ischemia of the tip of the gastric tube in CEA. This may lead to an increased incidence of anastomotic leakage [17] and anastomotic strictures [8]. In our series, benign strictures were a major contributor to the higher dysphagia incidence in the cervical anastomosis group. Unfortunately, comparisons of quality of life after MIE with IEA and MIE with CEA are currently not available [18].

Although the incidence of type II anastomotic leakage was higher after CEA, this did not lead to higher morbidity or mortality. The incidence of empyema was higher after IEA and although this did not lead to more reoperations, it contributed to a higher radiologic reintervention rate. In addition, length of stay and mortality did not differ between the groups. We experienced a relatively high incidence of anastomotic leakage in both the CEA and the IEA groups. Especially after IEA, the incidence is reported to be significantly lower in the literature [19]. The most important explanation for the high incidence of anastomotic leakage is the learning curve of introducing an IEA instead of CEA after MIE [20, 21]. The presence of a learning curve is corroborated by the lower incidence of abdominal conversions in the

Table 3. Functional Results

Functional Results	Cervical Anastomosis (n = 184)	Intrathoracic Anastomosis (n = 223)	*p* Value
Postoperative jejunostomy feeding, %	99.3	78.6	<0.001
Discontinuation of jejunostomy feeding, %	87.7	87.8	0.97
Median jejunostomy feeding duration (range), months	1.6 (0–17.5)	1.1 (0–12.4)	0.001
Recurrent laryngeal nerve palsy, %	14.4	0	<0.001
Dysphagia, %	55.9	12.4	<0.001
Dumping, %	21.4	9.0	0.001
Regurgitation, %	13.8	7.1	0.04
Endoscopy for suspected benign anastomotic stricture, %	56.2	16.7	<0.001
Benign anastomotic stricture requiring dilatation, %	43.8	6.2	<0.001
Median number of dilatations (range)	4 (1–21)	1 (1–12)	<0.001
Median duration of dilatations (range), months	4 (0–43)	0 (0–13)	0.001

Table 4. Postoperative Morbidity and Mortality

Morbidity and Mortality	Cervical Anastomosis (n = 146)	Intrathoracic Anastomosis (n = 210)	*p* Value
Anastomotic leakage, %	29.5	20.5	0.052
Grade 1	2.7	1.9	0.72
Grade 2	18.5	7.1	0.001
Grade 3	8.2	11.4	0.32
Pneumonia, %	47.9	43.8	0.44
Pleural empyema, %	4.8	13.3	0.008
Pneumothorax, %	6.8	7.1	0.92
Mediastinitis, %	4.1	3.3	0.70
Cardiac complications, %	31.5	24.8	0.16
Atrial fibrillation	26.7	21.9	0.30
Myocardial infarction	2.7	1.0	0.23
Asystole	3.4	0.5	0.04
Pericarditis	0.7	0.5	1.0
Other	3.4	3.3	0.96
Other complications, %	39.0	38.1	0.86
Delirium	10.3	13.8	0.319
Jejunostomy related	13.0	8.1	0.13
UTI/urinary retention	4.1	3.8	0.89
Thromboembolic	1.4	1.9	1.0
Need for CVVH	2.7	2.9	1.0
CVA	1.4	1.9	1.0
CIPN	2.1	1.9	1.0
Chyle leakage, %	6.2	7.6	0.60
Reintubation rate, %	16.4	15.7	0.86
Reintervention rate, %	17.8	29.0	0.02
Chest tube (bedside)	4.8	5.2	0.85
Radiologic	5.5	16.2	0.002
Endoscopic	11.6	14.3	0.47
Median length of stay (range),			
ICU (days)	3 (1–175)	3 (1–134)	0.14
Hospital (days)	13 (3–232)	13 (5–148)	0.77
Readmission rate, %			
ICU	16.4	19.0	0.53
Hospital	13.7	14.3	0.88
Mortality, %			
30-day	4.8	4.8	0.99
90-day	4.8	7.1	0.37
In-hospital	4.8	4.3	0.82

CIPN = critical illness polyneuropathy; CVA = cerebrovascular accident; CVVH = continuous venovenous hemodiafiltration; ICU = intensive care unit; UTI = urinary tract infection.

IEA group compared with the CEA group. Another explanation is the variety of definitions for anastomotic leakage used in the literature. Recently, the Esophagectomy Complications Consensus Group defined and graded postoperative complications including anastomotic leakage and this definition was used in the present study [15]. In addition, the high percentage of patients receiving neoadjuvant chemoradiotherapy might have contributed to the high incidence of anastomotic leakage because this has been associated with an increase in anastomotic leakage after esophagectomy. However, studies report inconsistent results [22, 23]. An aggressive attitude toward treatment of intrathoracic anastomotic leakage with early reinterventions contributed to a high reintervention rate. Thirty-day mortality was low (4.8%) and is comparable to the literature [2, 19, 24].

At baseline, a higher percentage of patients undergoing MIE with CEA were diagnosed with gastroesophageal junction tumor than in the MIE with IEA group and this is explained by the fact that for a junction tumor surgeons might have favored a minimally invasive transhiatal approach. More patients in the CEA group received a feeding jejunostomy tube which can be explained by some patients in the IEA group participating in a trial in which no feeding jejunostomy was created but patients were allowed early enteral feeding [25]. In the IEA group

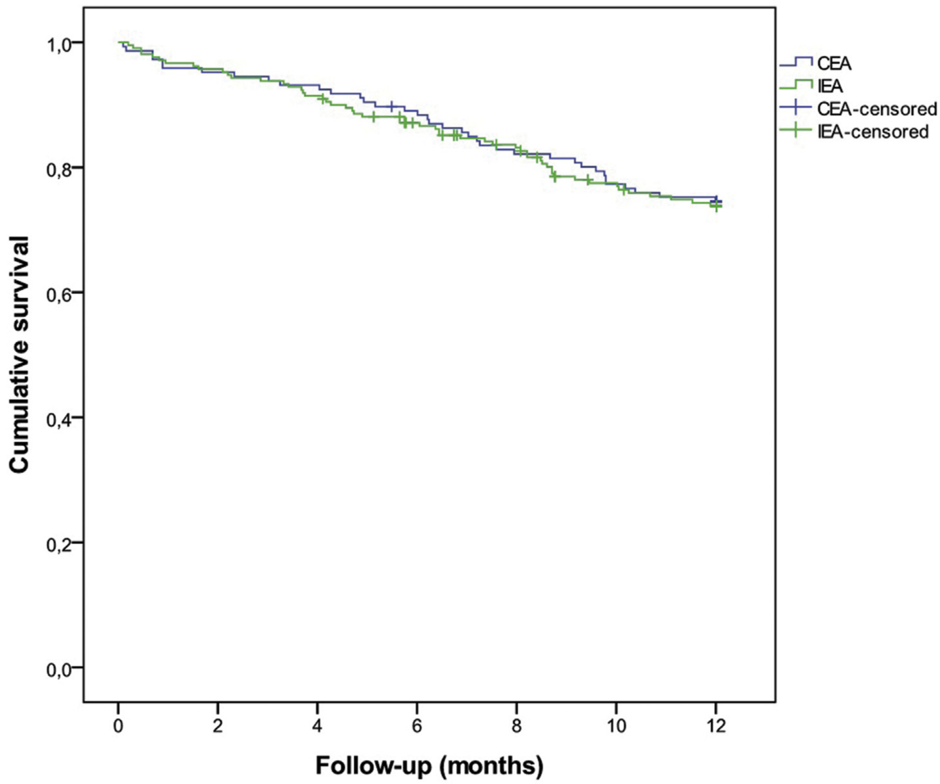

Fig 1. One-year survival. (CEA = cervical esophagogastric anastomosis; IEA = intrathoracic esophagogastric anastomosis.)

significantly more lymph nodes were retrieved than in the CEA group, which can be explained by a 2-field lymph node dissection in all patients in the IEA group and in only 52.1% of patients in the CEA group.

The strength of this study is the focus on functional morbidity, the consecutive design, and the comparison of a large cohort of patients treated by MIE with CEA or MIE with IEA. Limitations of this study are its retrospective character and the different surgical techniques used to create a cervical or intrathoracic anastomosis. The use of different anastomotic techniques may cloud interpretation of the data. Selection bias might also be a confounding factor because MIE with CEA was the preferred operation before introduction of MIE with IEA in the last few years. This might have led to improved perioperative care in the MIE with IEA group. Unfortunately, we were unable to match patients for this improvement of care because data on perioperative care were not measured. In addition, the fact that a learning curve of IEA after MIE could have increased postoperative morbidity has to be taken into account when interpreting the results of this study. Because of these limitations, a high-quality randomized controlled trial is warranted to prospectively confirm these findings, before results can be implemented into general practice.

MIE with IEA was associated with significantly decreased functional morbidity compared with MIE with CEA in this study. The remaining postoperative morbidity was comparable between the techniques. A randomized controlled trial is warranted to investigate whether these findings can be confirmed prospectively.

References

1. Wouters MW, Karim-Kos HE, le Cessie S, et al. Centralization of esophageal cancer surgery: does it improve clinical outcome? Ann Surg Oncol 2009;16:1789–98.
2. Biere SS, van Berge Henegouwen MI, Maas KW, et al. Minimally invasive versus open oesophagectomy for patients with oesophageal cancer: a multicentre, open-label, randomised controlled trial. Lancet 2012;379:1887–92.
3. Marriette M, Meunier B, Pezet D, et al. Hybrid minimally invasive versus open oesophagectomy for patients with oesophageal cancer: A multicenter, open-label, randomized phase III controlled trial, the MIRO trial. J Clin Oncol 2015;33 suppl 3:5; (abstr).
4. Van Hagen P, Hulshof MC, van Lanschot JJ, et al. Preoperative chemoradiotherapy for esophageal or junctional cancer. N Engl J Med 2012;366:2074–84.
5. Lewis I. The surgical treatment of carcinoma of the esophagus: with special reference to a new operation for growths of the midde third. Br J Surg 1946;34:18–31.
6. McKeown KC. Total three-stage esophagectomy for cancer of the esophagus. Br J Surg 1976;63:259–62.
7. Van Heijl M, Gooszen JA, Fockens P, Busch OR, van Lanschot JJ, van Berge Henegouwen MI. Factors for development of benign cervical strictures after esophagectomy. Ann Surg 2010;251:1064–9.
8. Pierie JP, de Graaf PW, Poen H, van der Tweel I, Obertop H. Incidence and management of benign stricture after cervical oesophagogastrostomy. Br J Surg 1993;80:471–4.

9. Hulscher JB, van Sandick JW, Devriese PP, van Lanschot JJ, Obertop H. Vocal cord paralysis after subtotal esophagectomy. Br J Surg 1999;86:1583–7.
10. Whooley BP, Law S, Alexandrou A, Murthy SC, Wong J. Critical appraisal of the significance of intrathoracic anastomotic leakage after esophagectomy for cancer. Am J Surg 2001;181:198–203.
11. Rutegård M, Lagergren P, Rouvelas I, Lagergren J. Intrathoracic anastomotic leakage and mortality after esophageal cancer resection: a population-based study. Ann Surg Oncol 2012;19:99–103.
12. Orringer MB, Sloan H. Esophagectomy without thoracotomy. J Thorac Cardiovasc Surg 1978;76:643–54.
13. Collard JM, Romagnoli R, Goncette L, Otte JB, Kestens PJ. Terminalized semimechanical side-to-side suture technique for cervical esophagogastrostomy. Ann Thorac Surg 1998;65:814–7.
14. Orringer MB, Marshall B, Iannettoni MD. Eliminating the cervical esophagogastric anastomotic leak with a side-to-side stapled anastomosis. J Thorac Cardiovasc Surg 2000;119:277–88.
15. Low DE, Alderson D, Cecconello I, et al. International Consensus on Standardization of Data Collection for Complications Associated With Esophagectomy: Esophagectomy Complications Consensus Group (ECCG). Ann Surg 2015;262:286–94.
16. Biere SS, Maas KW, Cuesta MA, van der Peet DL. Cervical or thoracic anastomosis after esophagectomy for cancer: A systematic review and meta-analysis. Dig Surg 2011;28:29–35.
17. Urschel JD. Esophagogastrostomy anastomotic leaks complicating esophagectomy: a review. Am J Surg 1995;169:634–40.
18. Scarpa M, Valente S, Alfieri R, et al. Systematic review of health-related quality of life after esophagectomy for esophageal cancer. World J Gastroenterol 2011;17:4660–74.
19. Luketich JD, Pennathur A, Awais O, et al. Outcomes after minimally invasive esophagectomy: review of over 1000 patients. Ann Surg 2012;256:95–103.
20. Tapias LF, Morse CR. Minimally invasive Ivor Lewis esophagectomy: Description of a learning curve. J Am Coll Surg 2014;218:1130–40.
21. van Workum F, van den Wildenberg FJ, Polat F, de Wilt JH, Rosman C. Minimally invasive oesophagectomy: preliminary results after introduction of an intrathoracic anastomosis. Dig Surg 2014;31:95–103.
22. Vande Walle C, Ceelen WP, Boterberg T, et al. Anastomotic complications after Ivor Lewis esophagectomy in patients treated with neoadjuvant chemoradiation are related to radiation dose to the gastric fundus. Int J Radiat Oncol Biol Phys 2012;82:e513–9.
23. Koëter M, van der Sangen MJC, Hurkmans CW, Luyer MDP, Rutten HJT, Nieuwenhuijzen GAP. Radiation dose does not influence anastomotic complications in patients with esophageal cancer treated with neoadjuvant chemoradiation and transhiatal esophagectomy. Radiat Oncol 2015;10:59.
24. Nguyen NT, Hinojosa MW, Smith BR, Chang KJ, Gray J, Hoyt D. Minimally invasive esophagectomy lessons learned from 104 operations. Ann Surg 2008;248:1081–91.
25. Weijs TJ, Nieuwenhuijzen GA, Ruurda JP, et al. Study protocol for the nutritional route in oesophageal resection trial: a single-arm feasibility trial (NUTRIENT trial). BMJ Open 2014;4:e004557.