World J Surg (2019) 43:580–589
https://doi.org/10.1007/s00268-018-4825-1

ORIGINAL SCIENTIFIC REPORT (INCLUDING PAPERS PRESENTED AT SURGICAL CONFERENCES)

Analysis of the Effect of Early Versus Conventional Nasogastric Tube Removal on Postoperative Complications After Transthoracic Esophagectomy: A Single-Center, Randomized Controlled Trial

Masato Hayashi[1] · Hirofumi Kawakubo[1] · Yoshiaki Shoji[2] · Syuhei Mayanagi[1] · Rieko Nakamura[1] · Koichi Suda[1] · Norihito Wada[1] · Hiroya Takeuchi[3] · Yuko Kitagawa[1]

Published online: 23 October 2018

Abstract

Background Although esophagectomy is the only curative option for esophageal cancer, the associated invasiveness is high. Nasogastric (NG) tube use may prevent complications; however, its utility remains unclear, and the decompression period depends on the doctor. This study aimed to reveal the effect of conventional versus early NG tube removal on postoperative complications after esophagectomy.

Methods This single-center prospective randomized controlled clinical trial enrolled patients aged 20–80 years with histologically proven primary esophageal squamous cell carcinoma. Eighty patients admitted for transthoracic first-stage esophagectomy reconstructed with gastric conduit were randomly assigned (1:1) to the conventional and early NG tube removal groups. In the conventional NG tube removal group, the tube was removed on postoperative day (POD) 7; in the other, it was removed on POD 1. The occurrence rate of major complications, length of postoperative hospital stay, and NG tube reinsertion rate were compared between the groups.

Results The incidence of postoperative major complications such as pneumonia, anastomotic leakage, recurrent nerve palsy and gastrointestinal bleeding, and the NG tube reinsertion rate was not different between the groups. However, recurrent nerve palsy was more commonly observed in the conventional removal group; this difference was not significant. In terms of postoperative pneumonia, tumor location and field of lymph node dissection were significant risk factors.

Conclusion Although early NG tube removal did not reduce the rate of postoperative pneumonia, it could be performed safely. Hence, the NG tube can be removed earlier than conventional methods.

Background

Esophageal cancer is the sixth leading cause of cancer-related mortality worldwide due to its high malignant potential and poor prognosis [1]. Transthoracic esophagectomy is a core strategy to treat esophageal cancer. Although esophagectomy is regarded as the only curative option for esophageal cancer, the invasiveness of the procedure is still relatively higher than that of other gastrointestinal surgeries. In general, the occurrence of perioperative complications associated with esophagectomy has reached 45% [2], and respiratory complications are dominant [3]. As the occurrence of complications after

✉ Hirofumi Kawakubo
hkawakubo@z3.keio.jp

[1] Department of Surgery, School of Medicine, Keio University, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan

[2] Department of Surgery, Cancer Institute Hospital, 3-8-31 Ariake, Koto-ku, Tokyo 135-8550, Japan

[3] Department of Surgery, School of Medicine, Hamamatsu University, 1-20-1 Handayama, Higashi-ku, Hamamatsu-shi, Shizuoka Prefecture 431-3192, Japan

esophagectomy is inevitable, several prophylaxes such as smoking cessation, respiratory rehabilitation, and perioperative blood glucose control have been used [4]. Nasogastric (NG) tubes are used to prevent anastomotic leakage, detect postoperative bleeding, and prevent aspiration pneumonia. NG tubes are conventionally used for 7 days after esophagectomy at our institution to prevent postoperative complications. However, the utility of NG tubes is still unclear, and the decompression period depends on the doctor. Sato et al. [5] reported that in the postoperative management of esophagectomy, the decompression of the NG tube impedes expectoration, causing the exacerbation of postoperative respiratory infection risk. Nguyen et al. [6] reported that NG tube decompression during minimally invasive esophagectomy can be safely omitted because there was no difference in the complication rate between the group with NG tubes and the group without them. Three randomized controlled trials analyzed the NG tube decompression period, but the conclusions were inconsistent and the sample size, small [7–9]. We hypothesized that NG tubes can be safely removed on postoperative day (POD) 1 of transthoracic esophagectomy with a reduction in the postoperative pneumonia incidence rate.

This study aimed to reveal the effect of NG tube decompression on postoperative complications after esophagectomy.

Materials and methods

Study design and participants

This single-center prospective randomized controlled clinical trial was performed at Keio University Hospital in Japan. Patients aged 20–80 years with histologically proven primary esophageal squamous cell carcinoma that was determined as resectable were eligible. Local ethics committee approval was obtained and informed consent provided by 80 consecutive patients admitted for transthoracic first-stage esophagectomy with gastric conduit reconstruction.

Patients were excluded if they met any of the following criteria: the presence of active bacterial infection; severe comorbidities, severe obesity [body mass index (BMI) $\geq$ 35], and severe emaciation (BMI $\leq$ 17.5); plans for second-stage surgery; plans for intrathoracic anastomosis; reconstruction organ other than gastric conduit being chosen; and hoping to be pregnant.

Although tumor staging was evaluated according to the seventh edition of the International Union Against Cancer tumor, node, metastasis (TNM) classification system, treatment strategy was decided according to the recommendations of the Japanese Research Society for Esophageal Cancer [10, 11] which recognizes #104 and #102 lymph nodes as regional lymph nodes.

Randomization

Eligible patients were registered at Keio University Hospital. Patients were randomly assigned (1:1) to the conventional NG tube removal group and early NG tube removal group by a minimization method with biased-coin assignment to balance the groups on the basis of age, sex, preoperative treatment, and surgical procedures. The NG tube of patients assigned to the conventional removal group was removed on POD 7, while that of those in the early removal group was removed on POD 1. However, the final decision on whether or not to remove the tube depended on the doctor, after a comprehensive consideration of the patient's condition.

Surgical procedures

Prior to general anesthesia, epidural anesthesia was administered for intraoperative and postoperative analgesia. Selective intubation to block the right lung was performed in all the surgeries.

Three-field lymph node dissection (3FLND) with anastomosis in the neck was predominantly performed (93.0%), including right transthoracic subtotal esophagectomy and the dissection of cervical, mediastinal, and abdominal lymph nodes. In some cases, however, only two-field lymph node dissection (2FLND) was required, because of the tumor characteristics.

The thoracic procedures were predominantly performed using video-assisted thoracic surgery (VATS) with the patients in the hybrid position (87.3%). The upper mediastinal procedure was performed by initially placing the patients in the left lateral decubitus position and the middle and lower mediastinal procedures by rotating the operating table toward the prone position. The VATS procedures were performed via minithoracotomy (4–5 cm) with four or five trocars [12].

The abdominal procedures were carried out through an upper midline abdominal incision (22.5%) or by hand-assisted laparoscopic surgery (HALS) (77.5%). HALS was performed through a transverse minilaparotomy (7 cm) in the right upper quadrant, with one port below the navel and two ports in the left abdomen [12].

In all cases, anastomosis was performed in the neck, and all cervical anastomoses were completed with hand-sewing. Before finishing surgery, enterostomy was made in all cases.

After surgery, the patients were admitted to the intensive care unit (ICU), and mechanical ventilation was continued overnight. If a patient's condition was stable, he/she was

extubated on POD 1. The NG tube was also removed if the patient was assigned to the early NG tube removal group. On POD 3, the patients were admitted to the hypercare unit. On POD 6, the patients were admitted to the general surgical ward. All patients were administered proton pimp inhibiter via intravenous infusion or enterostomy. After evaluating the anastomosis using a contrast agent on POD 7, the NG tube was removed if the patient was assigned to the conventional NG tube removal group. In both groups, oral intake was initiated on POD 7. The kind of food that the patients consumed depended on the results of a swallowing function evaluation. Generally, thick liquids were initially provided, which were gradually switched to jelly-like food and then solid food. The patients were discharged when they were successfully able to consume solid food.

Outcomes

The primary outcome was the incidence of postoperative pneumonia. Postoperative pneumonia diagnosis required the following two criteria: body temperature $\geq$ 38 °C, or higher-than-normal levels of C-reactive protein or white blood cells. The new appearance of an infiltrative shadow in the chest radiograph/computed tomography (CT) image. The severity of all complications was assessed using the extended Clavien-Dindo classification [13].

Secondary outcomes were the incidence of anastomotic leakage and postoperative gastrointestinal bleeding, NG tube reinsertion rate, recurrent nerve palsy, length of postoperative hospital stay, and other postoperative complications.

Statistical analysis

This study was designed to assess the superiority of early NG tube removal in terms of a reduction in the incidence of postoperative pneumonia after esophagectomy. Our institution performs about 60 esophagectomies a year. We planned this study such that conclusions could be obtained in 2 years. Therefore, we enrolled 40 patients per group.

Statistical analyses were performed with SPSS Statistics software version 23.0 for Windows (IBM Corp., Armonk, NY, USA). Regarding patient characteristics, continuous values were analyzed using a nonparametric test (Mann–Whitney *U* test), and categorical values were compared using either a Pearson's Chi-squared test or Fisher's exact test. Multivariate logistic regression analysis using binary logistic regression was performed to analyze the risk factors for the primary outcome. Multivariate analysis was performed by using factors which showed *p* value less than 0.1 in univariate analysis. A *p* value <0.05 was considered significant. This study was registered with UMIN-CTR, No. UMIN000017553.

Results

Figure 1 shows the trial profile. Eighty eligible patients were enrolled and randomly assigned to the conventional NG tube removal group (40 patients) and early NG tube removal group (40 patients).

In the conventional removal group, three patients' NG tubes were removed before POD 7. In first case, NG tube was removed on POD 1 due to NG tube bending in gastric conduit. In second case, NG tube was removed after tracheostomy because the doctor decided to remove the tube on POD 4. In third case, patient's discomfort was so severe that doctors decided to remove the tube on POD 3. And other three patients' NG tubes were removed after POD 7. The reason why their NG tubes were removed after POD 7 was all cases needed long-period intubation due to severe recurrent nerve palsy. These three cases whose NG tubes were removed after POD 7 were not excluded from the analysis.

In the early removal group, six patients' NG tubes were not removed on POD 1. Five patients needed tracheostomy or reintubation due to recurrent nerve palsy or pneumonia so that NG tube was not removed on POD 1. And there was the other case in which the doctor decided not to remove the tube on POD 1 because the case was thought as high risk of recurrent nerve palsy due to surgical procedure. The details of protocol failures are described in Table 1. These protocol failures were excluded from the analysis.

Table 2 shows the baseline demographics and perioperative characteristics of the randomized patients. Both groups were well balanced except in the case of the preoperative FEV1.0% and length of ICU stay. The incidence of FEV1.0% was significantly higher [93.24 (±133.2)], and the length of ICU stay [3.49 (±2.2)] was also higher in the conventional removal group. Table 3 shows the primary and secondary outcomes. In this study, there were no significant differences in the primary or secondary outcomes between the conventional and early NG tube removal groups. However, recurrent nerve palsy was more commonly observed in the conventional removal group; this difference was not significant. In terms of the risk factors for postoperative pneumonia, univariate and multivariate analyses were conducted (Table 4). Factors with $p < 0.10$ in the univariate analysis, Brinkman index, preoperative treatment, tumor location, estimated blood loss, lymph node dissection field, and minitracheostomy were used in the multivariate analysis. The tumor location and the field of LN dissection showed significant difference between the group with postoperative pneumonia and that without postoperative pneumonia.

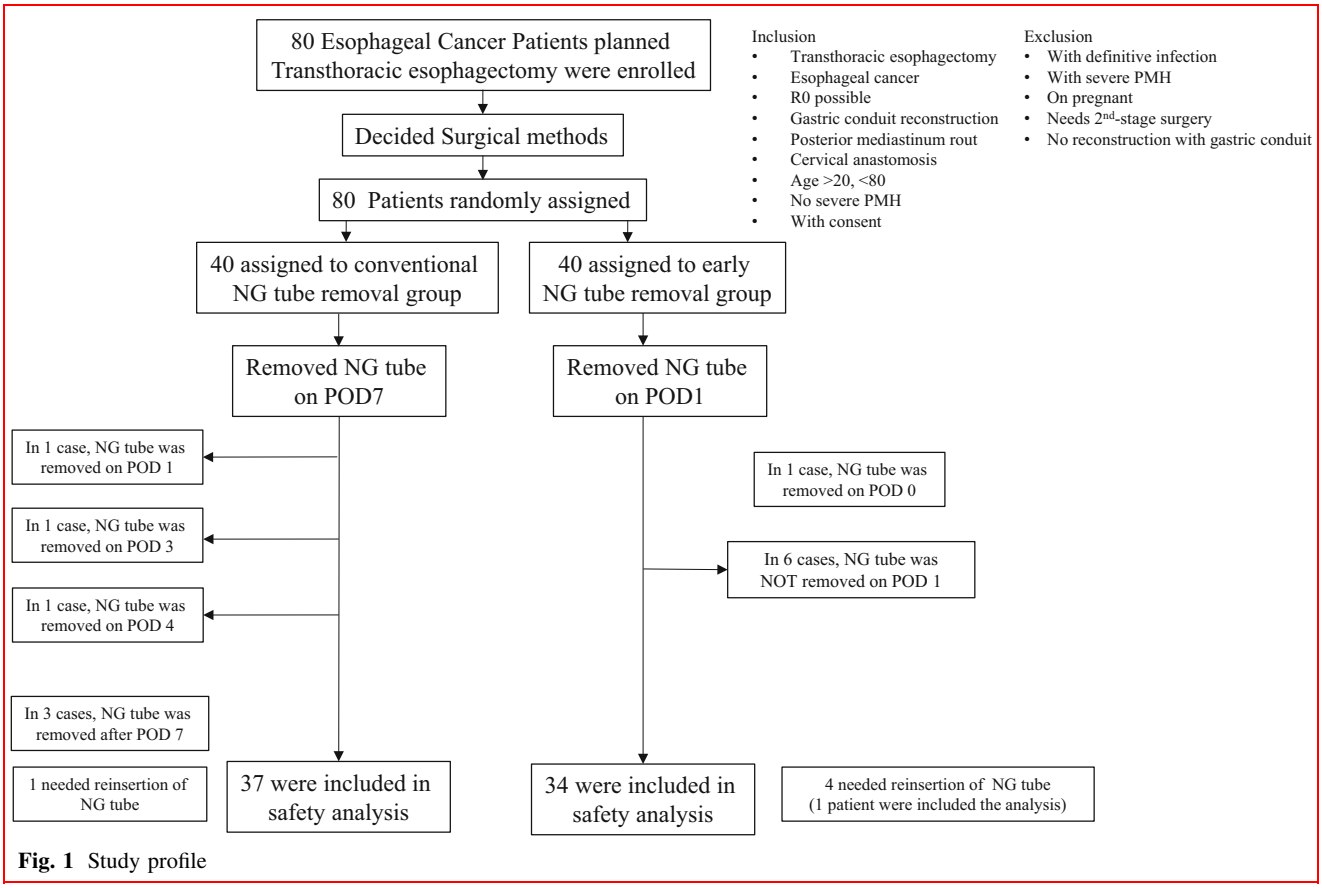

Fig. 1 Study profile

Table 5 shows the reasons for the reinsertion of the NG tube. Three patients in the early removal group required reinsertion of the NG tube due to the expansion of the gastric conduit. One patient in the early removal group required reinsertion due to reintubation, and one patient in the conventional removal group required reinsertion due to small intestinal obstruction.

Discussion

In this study, early NG tube removal did not reduce the incidence of postoperative pneumonia compared to conventional removal. While recurrent nerve palsy tended to be more frequently observed in the conventional removal group, no statistical difference was noted in terms of the other complications. However, from this fact, we can consider that the reason why the conventional group ICU stay was significantly longer than early removal group was that severe recurrent nerve palsy might lead tracheostomy which needed to stay in ICU long.

NG tube decompression is used to reduce the rate of postoperative complications and for their detection. Some surgeons have concerns pertaining to whether, in the absence of NG tube decompression, the degree of aspiration pneumonia, anastomotic leakage, or the delayed detection of postoperative gastrointestinal bleeding may be exacerbated. However, recent studies have suggested that NG tube decompression is not necessary in some gastrointestinal surgeries, as well as that NG tube intubation may increase the morbidity of postoperative complications [14–18]. Although we could not detect a reduction in the rate of postoperative complications, we also did not observe the exacerbation of complications with early NG tube removal.

In five cases, reinsertion of the NG tube was required. However, this study was safely performed without severe adverse events, and we observed no complications directly related to early NG tube removal and reinsertion.

No statistical difference was observed in the postoperative pneumonia incidence rate between the conventional and early removal groups. The risk factors for postoperative pneumonia, detected through univariate and multivariate analyses, were tumor location and the field of lymph node dissection. Some studies focusing on the risk factors for postoperative pneumonia after esophagectomy claimed that smoking history, preoperative FEV1.0%, or surgical procedures may be correlated with postoperative

Table 1 Details of protocol failures

Number	NG removal	Age	Sex	Surgical procedure	Any complication ≥ Grade III	Reasons of protocol failure
1	Early	63	Male	VATS/HALS	Pneumonia, recurrent nerve palsy	NG tube was not removed on POD 1 due to tracheostomy from recurrent nerve palsy
2	Early	64	Female	Thoracotomy/ laparotomy	Pneumonia, recurrent nerve palsy, chylothorax	NG tube was not removed on POD 1 due to tracheostomy from recurrent nerve palsy
3	Early	78	Male	Thoracotomy/ laparotomy	Pneumonia	NG tube was not removed on POD 1 due to tracheostomy from pneumonia
4	Early	77	Male	VATS/ laparotomy	Pneumonia	NG tube was not removed on POD 1 due to reintubation from pneumonia
5	Conventional	80	Male	Thoracotomy/ laparotomy	Pneumonia, intraabdominal abscess	NG tube was removed on POD 4 after tracheostomy
6	Early	55	Male	Thoracotomy/ HALS	Recurrent nerve palsy	NG tube was not removed on POD 1 due to tracheostomy from recurrent nerve palsy
7	Conventional	75	Male	VATS/HALS	No	NG tube was removed on POD 1 due to NG tube bending in gastric conduit
8	Early	54	Female	VATS/HALS	No	NG tube was not removed on POD 1 due to doctor's apprehension of reintubation
9	Conventional	50	Male	VATS/HALS	No	NG was removed on POD 3 due to severe discomfort of the patient

Table 2 Baseline demographics and perioperative characteristics of the randomized patients

	All patients $N = 71$	Conventional nasogastric tube removal group $N = 37$	Early nasogastric tube removal group $N = 34$	p value
Age (years)	63.04 (±7.8)	63.57 (±8.4)	62.47 (±7.2)	0.354
Sex: male/female	62 (87.3%)/9 (12.7%)	30 (81.1%)/7 (18.9%)	32 (94.1%)/2 (5.9%)	0.155
Body mass index	21.42 (±2.8)	21.05 (±2.5)	21.82 (±3.0)	0.284
Alcohol intake	46.31 (±41.1)	43.32 (±30.6)	49.6 (±50.33)	0.908
Flasher	47 (66.2%)	24 (64.9%)	23 (67.6%)	0.625
Brinkman Index	545.14 (±487.1)	583.11 (±464.3)	503.82 (±514.42)	0.380
Tumor location				
Upper thoracic	11 (15.5%)	8 (21.6%)	3 (8.8%)	0.492
Middle thoracic	35 (49.3%)	16 (43.2%)	19 (55.9%)	
Lower thoracic	22 (31.0%)	11 (29.7%)	11 (32.4%)	
Gastricesophagus	1 (1.4%)	1 (2.7%)	0	
Abdominoesophagus	2 (2.8%)	1 (2.7%)	1 (2.9%)	
Clinical stage				
cT1	34 (47.9%)	22 (59.5%)	12 (35.3%)	0.091
cT2	11 (15.5%)	2 (5.4%)	9 (26.5%)	
cT3	22 (31.0%)	10 (27.0%)	12 (35.3%)	
cT4a	2 (2.8%)	2 (5.4%)	0	
cT4b	2 (2.8%)	1 (2.7%)	1 (2.9%)	
cN0	36 (50.7%)	20 (54.1%)	16 (47.1%)	0.764
cN1	24 (33.8%)	12 (32.4%)	12 (35.3%)	
cN2	8 (11.3%)	3 (8.1%)	5 (14.7%)	
cN3	3 (4.2%)	2 (5.4%)	1 (2.9%)	
cM 0/1	66 (93.0%)/5 (7.0%)	35 (94.6%)/2 (5.4%)	31 (91.2%)/3 (8.8%)	0.275

Table 2 continued

	All patients $N = 71$	Conventional nasogastric tube removal group $N = 37$	Early nasogastric tube removal group $N = 34$	p value
cStage I	28 (39.4%)	16 (43.2%)	12 (35.3%)	0.618
cStage II	20 (28.2%)	8 (21.6%)	12 (35.3%)	
cStage III	18 (25.4%)	11 (29.7%)	7 (20.6%)	
cStage IV	5 (7.0%)	2 (5.4%)	3 (8.8%)	
Past medical history				
Hypertension	23 (32.4%)	14 (37.8%)	9 (26.5%)	0.325
Diabetes mellitus	8 (11.3%)	3 (8.1%)	5 (14.7%)	0.467
Respiratory disease	4 (5.6%)	3 (8.1%)	1 (2.9%)	0.615
Cardiovascular disease	3 (4.2%)	1 (2.7%)	2 (5.9%)	0.604
Cancer treatment	8 (11.3%)	4 (10.8%)	4 (11.8%)	1
Other	43 (60.6%)	24 (64.9%)	19 (55.9%)	0.475
Preoperative treatment	57 (71.3%)	27 (67.5%)	30 (75%)	0.790
ESD	6 (8.5%)	3 (8.1%)	3 (8.8%)	
CF	28 (39.4%)	13 (35.1%)	15 (44.1%)	
DCF	13 (18.3%)	6 (16.2%)	7 (20.6%)	
CF-Rt	4 (5.6%)	2 (5.4%)	2 (5.9%)	
Other	1 (1.4%)	1 (2.7%)	0	
FEV1.0 (L)	2.89 (±0.5)	2.76 (±0.5)	3.01 (±0.4)	0.019
FEV1.0% (%)	84.68 (±96.1)	93.24 (±133.2)	75.37 (±7.5)	0.032
%VC	108.90 (±13.3)	109.83 (±14.2)	107.89 (±12.3)	0.721
Surgical procedure				
VATS	62 (87.3%)	32 (86.5%)	30 (88.2%)	1
HALS	55 (77.5%)	29 (78.4%)	26 (76.5%)	1
Surgery time (min)	499.32 (±52.4)	511.05 (±57.7)	486.56 (±43.4)	0.073
Estimated blood loss (g)	178.18 (±189.0)	198.43 (±213.6)	156.15 (±158.1)	0.381
Field of LN dissection				
3 field	66 (93.0%)	35 (94.6%)	31 (91.2%)	0.665
Other	5 (7.0%)	2 (5.4%)	3 (8.8%)	
Thoracic duct resection	65 (91.5%)	35 (94.6%)	30 (88.2%)	0.417
R 0/1	69 (97.2%)/2 (2.8%)	2 (5.4%)	0	0.494
Pathological stage				
pT0	4 (5.6%)	1 (2.7%)	3 (8.8%)	0.220
pT1	40 (56.3%)	24 (64.9%)	16 (47.1%)	
pT2	7 (9.9%)	4 (10.8%)	3 (8.8%)	
pT3	20 (28.2%)	8 (21.6%)	12 (35.3%)	
pN0	35 (49.3%)	20 (54.1%)	15 (44.1%)	0.599
pN1	17 (23.9%)	9 (24.3%)	8 (23.5%)	
pN2	18 (25.4%)	8 (21.6%)	10 (29.4%)	
pN3	1 (1.4%)	0	1 (2.5%)	
M 0/1	66 (93.0%)/5 (7.0%)	3 (8.1%)	2 (5.9%)	0.518
pStage 0	3 (4.2%)	1 (2.7%)	2 (5.9%)	0.434
pStage I	27 (38.0%)	16 (43.2%)	11 (32.4%)	

Table 2 continued

	All patients $N = 71$	Conventional nasogastric tube removal group $N = 37$	Early nasogastric tube removal group $N = 34$	p value
pStage II	14 (19.7%)	9 (24.3%)	5 (14.7%)	
pStage III	22 (31.0%)	8 (21.6%)	14 (41.2%)	
pStage IV	5 (7.0%)	3 (4.2%)	2 (5.9%)	
ICU stay	2.96 (±1.7)	3.49 (±2.2)	2.38 (±0.6)	0.018
Postoperative stay	27.59 (±15.7)	29.38 (±18.1)	25.65 (±12.8)	0.174
NG tube removal day		6.98 (±1.6)	1.35 (±1.1)	<0.001
Tracheostomy	7 (9.9%)	7 (18.9%)	0	0.012
Minitracheostomy	53 (74.6%)	27 (73.0%)	26 (76.5%)	0.790

NG nasogastric, *ICU* intensive care unit, *FEV* forced expiratory volume, *VC* vital capacity, *LN* lymph node, *HALS* hand-assisted laparoscopic surgery, *VATS* video-assisted thoracic surgery, *ESD* endoscopic submucosal dissection, *DCF* docetaxel cisplatin and fluorouracil, *CF* cisplatin and fluorouracil, and *CF-Rt* cisplatin and fluorouracil with radiotherapy

Table 3 Primary and secondary outcomes for the intention to treat population

	Conventional nasogastric tube removal group $N = 37$	Early nasogastric tube removal group $N = 34$	p value
Primary outcome			
Postoperative pneumonia ≥ Grade II	8 (21.6%)	7 (20.6%)	1
Secondary outcomes			
Anastomotic leakage ≥ Grade III	1 (2.7%)	3 (8.8%)	0.344
Postoperative gastrointestinal bleeding	0	0	–
Reinsertion of nasogastric tube	1 (2.7%)	1 (2.9%)	1
Recurrent nerve palsy ≥ Grade III	5 (13.5%)	0	0.055
Postoperative hospital stay (days)	29.4 (±18.06)	25.7 (±12.76)	0.373
Other major complications ≥ Grade III	9 (24.3%)	3 (8.8%)	0.115

pneumonia [17, 18]. The results of previous studies differ from those of this study in terms of the risk factors for pneumonia. However, this study employed a single-center design to standardize the surgical procedures and well balanced between the groups. In this study, randomization was successfully performed, and our results are significant.

The present study has some limitations. Its protocol determined the timing of the NG tube removal for each group, but the decision to remove or reinsert the tube finally depended on the doctor, after careful consideration of the patient's condition. In this study, five patients required reinsertion of the NG tube, and the most common reason was the expansion of the gastric conduit. However, there is no definition for the expansion of gastric conduits. Accurate criteria for removal, non-removal, or reinsertion have to be defined so that doctors can take informed decisions on tube removal and reinsertion.

Conclusion

Although early NG tube removal in patients who underwent esophagectomy did not reduce the incidence rate of postoperative pneumonia, it was performed safely. Hence, the NG tube can be removed earlier than in conventional methods.

Table 4 Analysis of postoperative pneumonia ≥ Grade II

	Univariate analysis			Multivariate analysis		
	With postoperative pneumonia ≥ Grade II $N = 15$	Without postoperative pneumonia ≥ Grade II $N = 56$	p value	Exp	95% CI	p value
Conventional NG tube removal	8 (53.3%)	29 (51.8%)	1			
Early NG tube removal	7 (46.7%)	27 (48.2%)				
Age (years)	65.2 (±5.86)	62.5 (±8.23)	0.199			
Sex: male/female	14 (93.3%)/1 (6.7%)	48 (85.7%)/8 (14.3%)	0.673			
Body mass index	20.8 (±2.63)	21.6 (±2.79)	0.338			
Alcohol intake	30.4 (±20.81)	50.6 (±44.16)	0.161			
Brinkman Index	746.0 (±598.72)	491.3 (±443.53)	0.072	1	0.999–1.002	0.306
FEV1.0 (L)	2.87 (±0.46)	2.89 (±0.53)	0.719			
FEV1.0% (%)	74.1 (±8.53)	87.5 (±108.10)	0.554			
%VC	106.4 (±12.92)	109.6 (±13.40)	0.460			
Past medical history						
Hypertension	4 (26.7%)	19 (33.9%)	0.759			
Diabetes mellitus	0	8 (14.3%)	0.189			
Respiratory disease	1 (6.7%)	3 (5.4%)	1			
Cardiovascular disease	1 (6.7%)	2 (3.6%)	0.515			
Cancer treatment	2 (13.3%)	6 (10.7%)	0.673			
Other	9 (60.0%)	34 (60.7%)	1			
Preoperative treatment	12 (80.0%)	40 (71.4%)	0.086	0.834	0.171–4.054	0.822
Tumor location						
Upper thoracic	5 (33.3%)	6 (10.7%)	0.028	0.376	0.148–0.961	0.041
Middle thoracic	6 (40.0%)	29 (51.8%)				
Lower thoracic	2 (13.3%)	20 (35.7%)				
Gastricesophagus	1 (6.7%)	0				
Abdominoesophagus	1 (6.7%)	1 (1.8%)				
Pathological stage						
pT0	0	4 (7.1%)	0.300			
pT1	12 (80.0%)	28 (50.0%)				
pT2	1 (6.7%)	6 (10.7%)				
pT3	2 (13.3%)	2 (3.6%)				
pN0	8 (53.3%)	27 (48.2%)	0.926			
pN1	3 (20.0%)	14 (25.0%)				
pN2	4 (26.7%)	14 (25.0%)				
pN3	0	1 (1.8%)				
M 0/1	14 (93.3%)/1 (6.7%)	52 (92.9%)/4 (7.1%)	0.187			
pStage 0	0	3 (5.4%)	0.450			
pStage I	8 (53.3%)	19 (33.9%)				
pStage II	2 (13.3%)	12 (21.4%)				
pStage III	4 (26.7%)	18 (32.1%)				
pStage IV	1 (6.7%)	4 (7.1%)				
Surgical procedure						
Surgery time (min)	508.3 (±49.74)	496.9 (±53.30)	0.310			
Estimated blood loss (g)	230.0 (±169.76)	164.3 (±192.81)	0.099	1	0.998–1.004	0.410
VATS	13 (86.7%)	49 (87.5%)	1			

Table 4 continued

	Univariate analysis With postoperative pneumonia ≥ Grade II $N = 15$	Without postoperative pneumonia ≥ Grade II $N = 56$	p value	Multivariate analysis Exp	95% CI	p value
HALS	10 (66.7%)	45 (80.4%)	0.303			
Field of LN dissection						
3-field	12 (80.0%)	54 (96.4%)	0.060	36.48	1.647–808.12	0.023
Other	3 (20.0%)	2 (3.6%)				
Thoracic duct resection	14 (93.3%)	51 (91.1%)	1			
Minitracheostomy	14 (93.3%)	39 (69.6%)	0.094	0.272	0.030–2.434	0.244
Tracheostomy	0	7 (12.5%)	0.332			

NG nasogastric, *CI* confidence interval, *FEV* forced expiratory volume, *VC* vital capacity, *LN* lymph node, *HALS* hand-assisted laparoscopic surgery, and *VATS* video-assisted thoracic surgery

Table 5 Reasons for reinsertion

Number	NG removal	Age (years)	Sex	Surgical procedure	Any complication ≥ Grade III	Reasons for NG tube reinsertion
1	Conventional	58	Male	VATS/HALS	Anastomotic leakage, small intestinal obstruction	NG tube was reinserted due to small intestinal obstruction and anastomotic leakage
2	Early	63	Male	VATS/HALS	Pneumonia, recurrent nerve palsy	NG tube was reinserted due to expansion of gastric conduit
3	Early	64	Female	Thoracotomy/ Laparotomy	Pneumonia, recurrent nerve palsy, chylothorax	NG tube was reinserted due to expansion of gastric conduit
4	Early	60	Female	VATS/HALS	No	NG tube was reinserted due to expansion of gastric conduit
5	Early	78	Male	Thoracotomy/ Laparotomy	Pneumonia	NG tube was reinserted due to reintubation from severe pneumonia

NG nasogastric, *HALS* hand-assisted laparoscopic surgery, *VATS* video-assisted thoracic surgery

Acknowledgements The authors thank Kumiko Motooka, who belongs to the staff at the Department of Surgery in Keio University School of Medicine, for her help in the preparation of this report.

Funding This study was funded by Takeda Pharmaceutical Company Limited.

References

1. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D (2011) Global cancer statistics. CA Cancer J Clin 61:69–90
2. Griffin SM, Shaw IH, Dresner SM (2002) Early complications after Ivor Lewis subtotal esophagectomy with two-field lymphadenectomy: risk factors and management. J Am Coll Surg 194:285–297
3. Ando N, Ozawa S, Kitagawa Y, Shinozawa Y, Kitajima M (2000) Improvement in the results of surgical treatment of advanced squamous esophageal carcinoma during 15 consecutive years. Ann Surg 232:225–232
4. Whooley BP, Law S, Murthy SC, Alexandrou A, Wong J (2001) Analysis of reduced death and complication rates after esophageal resection. Ann Surg 233:338–344
5. Sato T, Takayama T, So K, Murayama I (2007) Is retention of a nasogastric tube after esophagectomy a risk factor for postoperative respiratory tract infection? J Infect Chemother 13:109–113
6. Nguyen NT, Slone J, Wooldridge J, Smith BR, Reavis KM, Hoyt D (2009) Minimally invasive esophagectomy without the use of postoperative nasogastric tube decompression. Am Surg 75:929–931
7. Daryaei P, Vaghef Davari F, Mir M, Harirchi I, Salmasian H (2009) Omission of nasogastric tube application in postoperative care of esophagectomy. World J Surg 33:773–777. https://doi.org/10.1007/s00268-009-9930-8
8. Shackcloth MJ, McCarron E, Kendall J, Russell GN, Pennefather SH, Tran J, Page RD (2006) Randomized clinical trial to determine the effect of nasogastric drainage on tracheal acid aspiration following oesophagectomy. Br J Surg 93:547–552
9. Mistry RC, Vijayabhaskar R, Karimundackal G, Jiwnani S, Pramesh CS (2012) Effect of short-term vs prolonged nasogastric decompression on major postesophagectomy complications: a parallel-group, randomized trial. Arch Surg 147:747–751
10. Kaburagi T, Takeuchi H, Kawakubo H, Omori T, Ozawa S, Kitagawa Y (2014) Clinical utility of a novel hybrid position combining the left lateral decubitus and prone positions during thoracoscopic esophagectomy. World J Surg 38:410–418. https://doi.org/10.1007/s00268-013-2258-4
11. Katayama H, Kurokawa Y, Nakamura K et al (2016) Extended Clavien-Dindo classification of surgical complications: Japan

clinical oncology group postoperative complications criteria. Surg Today 46:668–685
12. Lee JH, Hyung WJ, Noh SH (2002) Comparison of gastric cancer surgery with versus without nasogastric decompression. Yonsei Med J 43:451–456
13. Rao W, Zhang X, Zhang J, Yan R, Hu Z, Wang Q (2011) The role of nasogastric tube in decompression after elective colon and rectum surgery: a meta-analysis. Int J Colorectal Dis 26:423–429
14. Nelson R, Edwards S, Tse B (2007) Prophylactic nasogastric decompression after abdominal surgery. Cochrane Database Syst Rev 3:CD004929
15. Weijs TJ, Kumagai K, Berkelmans GH, Nieuwenhuijzen GA, Nilsson M, Luyer MD (2017) Nasogastric decompression following esophagectomy: a systematic literature review and meta-analysis. Dis Esophagus 30:1–8
16. Ichida H, Imamura H, Yoshimoto J, Sugo H, Ishizaki Y, Kawasaki S (2016) Randomized controlled trial for evaluation of the routine use of nasogastric tube decompression after elective liver surgery. J Gastrointest Surg 20:1324–1330
17. Shiozaki A, Fujiwara H, Okamura H et al (2012) Risk factors for postoperative respiratory complications following esophageal cancer resection. Oncol Lett 3:907–912
18. Takeuchi H, Miyata H, Ozawa S et al (2017) Comparison of short-term outcomes between open and minimally invasive esophagectomy for esophageal cancer using a nationwide database in Japan. Ann Surg Oncol 24:1821–1827