World J Surg (2018) 42:2902–2909
https://doi.org/10.1007/s00268-018-4572-3

ORIGINAL SCIENTIFIC REPORT

Preoperative Smoking Cessation is Integral to the Prevention of Postoperative Morbidities in Minimally Invasive Esophagectomy

Naoya Yoshida[1,2] · Kenichi Nakamura[1] · Daisuke Kuroda[1] · Yoshifumi Baba[1] · Yuji Miyamoto[1] · Masaaki Iwatsuki[1] · Yukiharu Hiyoshi[1] · Takatsugu Ishimoto[1,2] · Yu Imamura[3] · Masayuki Watanabe[3] · Hideo Baba[1]

Published online: 12 March 2018

Abstract

Background Preoperative smoking cessation is considered integral to decreasing postoperative morbidities after esophagectomy. To our knowledge, the association of the duration of smoking cessation with the occurrence of postoperative morbidity has never been investigated in minimally invasive esophagectomy (MIE).

Methods A total of 198 consecutive MIEs for esophageal cancer between June 2011 and December 2017 were eligible for the study. According to the length of smoking cessation, patients were separated into three groups: ≤ 30, 31–90, and ≥ 91 days. Incidence of postoperative morbidities was retrospectively analyzed among the groups.

Results In patients with smoking cessation ≤ 30 days, morbidities of Clavien–Dindo classification (CDc) ≥ II, severe morbidities of CDc ≥ IIIb, pneumonia, and any pulmonary morbidities were frequently observed. Morbidities of CDc ≥ II, pneumonia, and any pulmonary morbidities increased as the length of cessation became shorter. Smoking cessation ≤ 30 days was a significant risk factor for severe morbidity (hazard ratio [HR] 4.89, 95% confidence interval [CI] 1.993–12.011; $P < 0.001$). Smoking cessation ≤ 90 days (HR 3.98, 95% CI 1.442–10.971; $P = 0.008$), past smoking (per 100 increase in Brinkman index), and cardiovascular comorbidity were significant risk factors for pneumonia. Smoking cessation ≤ 30 days (HR 3.13, 95% CI 1.351–7.252; $P = 0.008$) and past smoking were significant risk factors for any pulmonary morbidity.

Conclusions Preoperative smoking cessation is considerably important to prevent postoperative morbidities, even in MIE. At least, preoperative cessation ≥ 31 days is preferable to decrease considerable morbidities after MIE.

Introduction

Esophagectomy for esophageal cancer is associated with high incidences of postoperative morbidities [1–4]. Notably, pulmonary and infectious complications are frequent and are the leading causes of operation-related mortality after esophagectomy [5–8]. Those morbidities may also correlate with poor long-term outcomes [9–11]. Thus, reducing postoperative morbidities is important to improve both short-term and long-term outcomes after esophagectomy.

Minimally invasive esophagectomy (MIE) is widely accepted as a less invasive surgery compared with open esophagectomy (OE). One prospective randomized

✉ Hideo Baba
hdobaba@kumamoto-u.ac.jp

[1] Department of Gastroenterological Surgery, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Chuoku, Kumamoto 860-8556, Japan

[2] Division of Translational Research and Advanced Treatment Against Gastrointestinal Cancer, Kumamoto University, 1-1-1 Honjo, Chuoku, Kumamoto 860-8556, Japan

[3] Department of Gastroenterological Surgery, Cancer Institute Hospital of Japanese Foundation for Cancer Research, 3-8-31 Ariake, Koto-ku, Tokyo 135-8550, Japan

controlled trial (RCT) and two meta-analyses demonstrated the superiority of MIE regarding the incidence of postoperative morbidities [12–14]. On the other hand, several retrospective studies based on large nationwide clinical databases could not prove the superiority [1, 15]. Thus, whether MIE truly correlates with the reduction of morbidity is debatable.

To date, many studies suggested that smoking is an independent risk factor for the occurrence of morbidities after esophagectomy [3, 6–8, 16]. In patients who continue to smoke, preoperative smoking cessation is important to decreasing morbidities after esophagectomy [17]. However, most of those studies were mainly designed for patients undergoing OE. It is unclear how preoperative smoking and cessation affect the postoperative course in MIE. Thus, this study aimed to investigate the association between duration of preoperative smoking cessation and the incidence of morbidities after MIE. In addition, we elucidated the adequate duration of cessation to prevent postoperative morbidities.

Materials and methods

Patients

Two hundred and thirty-three consecutive patients who underwent elective MIE for esophageal cancer at Kumamoto University Hospital between June 2011 and December 2017 were eligible. Five patient who underwent salvage esophagectomy after definitive chemoradiotherapy was excluded from this study. During their admission for surgery, we routinely asked patients about their past history of smoking and duration of cessation. According to the duration of cessation, 198 patients with past smoking were separated into three groups: $\leq$ 30, 31–90, and $\geq$ 91 days. An optimal length of cessation to prevent complications after esophagectomy has rarely been investigated. We referred to previous studies and attempted to identify an optimal duration of smoking cessation that was applicable to/utilized in thoracic surgery. We observed that cessation for 30 days was the most frequently adopted duration to investigate the usefulness of preoperative smoking cessation [18, 19]. A study performed by Ngaage et al. [20] reported smoking cessation over a 90-day duration to investigate the occurrence of pulmonary complications after cardiac surgery. Finally, the incidence of postoperative morbidity was retrospectively investigated among the groups in order to elucidate which duration of smoking cessation could significantly reduce postoperative morbidity. In addition, the incidence of postoperative morbidity was also investigated in 30 never-smokers. The study procedures were approved by our institutional review board (Registry Number 1459). Documented consent was obtained from each patient.

Treatment strategy and surgery

The pretreatment tumor stage was assessed in accordance with the Cancer Staging Manual, version 7 [21]. For tumors in clinical stage 0 and IA, we performed esophagectomy without neoadjuvant treatment. For tumors in clinical stage IB, II, and III, neoadjuvant chemotherapy (NAC) or neoadjuvant chemoradiotherapy (NACRT) were administered before esophagectomy. In this study, all patients underwent MIE. MIE was defined as an esophagectomy performed using only thoracoscopy, regardless of laparoscopy use. Manipulation in the chest was implemented from the right thorax in the left hemiprone position. The extent of lymphadenectomy was determined in accordance with the 2012 guidelines of the Japan Esophageal Society [22]. A three-field lymphadenectomy was principally conducted for tumors in the upper- and middle-thoracic esophagus. Cervical lymph node dissection was omitted for T1 tumors in the lower esophagus.

Perioperative managements

Methylprednisolone (bolus) and neutrophil elastase inhibitors (continuous intravenous administration for 24 h) were routinely administered at the onset of surgery. Antibiotics were also administered every 4 h intraoperatively. Extubation was principally performed immediately following surgery in the operating room. Patients were usually observed in the intensive care unit for only a day postoperatively. Postoperative rehabilitation was initiated by a physical therapist a day after the surgery. Enteral nutrition was routinely initiated a day after the surgery. The perioperative management protocol remained unchanged during the study period.

Definition of morbidities

Morbidities were decided in accordance with the definitions proposed by the Society of Thoracic Surgeons General Thoracic Surgery [23]. The details of the morbidities are available elsewhere [24]. Any morbidity and severe morbidity constitutes any conditions with a Clavien–Dindo classification (CDc) $\geq$ II and $\geq$ IIIb, respectively [25].

Statistical methods

The statistical analysis was performed with aid of the software package StatView^{TM} version 5.0 created by Abacus Concepts, Inc., Berkeley, CA, USA. Comparisons

between the groups were conducted using the Chi-square test. For comparisons of unpaired samples, the Mann–Whitney *U* test or Student's *t* test were conducted. Multivariate analysis was performed for severe morbidity, pneumonia and any pulmonary morbidity. The following elements were assessed for the independent risk factors for those morbidities: age at surgery (per 10 years), sex (male vs. female), Eastern Cooperative Oncology Group (ECOG) performance status (0 vs. ≥ 1), body mass index (< 18.5 vs. ≥ 18.5 kg/m^2), past smoking [Brinkman index, year x number/day (number-years)], duration of smoking cessation, American Society of Anesthesiologists Physical Status (ASAPS) (1 vs. ≥ 2), presence of diabetes mellitus, respiratory comorbidities, cardiovascular comorbidities, % volume capacity (VC) (< 80 vs. ≥ 80%), forced expiratory volume (FEV) 1% (< 70 vs. ≥ 70%), clinical T stage (T1, 2 vs. T3, 4), clinical N stage (N0 vs. N1–3), preoperative treatment (present vs. absent), operative time (per 60 min), intraoperative bleeding (per 100 g), and use of laparoscopy (yes vs. no). The factors at a probability level ≤ 0.1 were used for subsequent multivariate analysis. Significant risk factors were taken to be at a probability level < 0.05 in logistic regression analysis.

Results

Clinical features of patients

Patients' characteristics are listed in Table 1 in accordance with the length of cessation. A total of 198 patients with past smoking, 180 (90.9%) were males. The overall average age in patients who had stopped smoking ≥ 91 days was significantly higher than those in other groups. NAC and NACRT were performed in 44 and 6 patients, respectively. Forty-five (22.7%) patients had diabetes mellitus. Fifty-seven (28.8%) and 111 (56.1%) patients had respiratory and cardiovascular comorbidity, respectively. There were no significant differences in the incidence of those comorbidities among groups. One hundred and fifty-seven (79.3%) patients underwent laparoscopic surgery in the abdomen.

Relation between length of cessation and morbidity

Table 2 shows postoperative morbidities after MIE in accordance with the duration of cessation. In patients with smoking cessation ≤ 30 days, morbidities of CDc ≥ II, severe morbidities of CDc ≥ IIIb, pneumonia, any pulmonary morbidities were frequently observed than those in other groups. Any morbidities of CDc ≥ II increased as the length of cessation became shorter. Pneumonia and any pulmonary morbidity significantly frequently occurred as the length of cessation became shorter. In patients who had stopped smoking ≥ 31 days, the incidence of severe morbidity reduced to as low as that of a person who had never smoked. In patients who had stopped smoking ≥ 91 days, the occurrence of pneumonia also reduced to as low as that of a person who had never smoked.

Risk factor for postoperative morbidities

Analyses of factors correlated with severe morbidity, pneumonia, and any pulmonary morbidity are shown in Tables 3, 4, and 5 [only in patients with past smoking (n = 198)]. Smoking cessation ≤ 30 days was a significant risk factor for severe morbidity (hazard ratio [HR] 4.89, 95% confidence interval [CI] 1.993–12.011; $P < 0.001$). Smoking cessation ≤ 90 days was also a significant risk factor for pneumonia (HR 3.98, 95% CI 1.442–10.971; $P = 0.008$), as well as past smoking (per 100 increase in Brinkman index, HR 1.10, 95% CI 1.001–1.209; $P = 0.047$) and cardiovascular comorbidity (HR 3.09, 95% CI 1.037–9.186; $P = 0.043$). Regarding any pulmonary morbidity, smoking cessation ≤ 30 days was a significant risk factor (HR 3.13, 95% CI 1.351–7.252; $P = 0.008$), as well as past smoking (per 100 increase in Brinkman index, HR 1.09, 95% CI 1.009–1.183; $P = 0.029$).

Discussion

In this study, several interesting results were obtained regarding duration of preoperative cessation and the occurrence of morbidity after MIE. First, in patients with short duration of cessation ≤ 30 days, morbidities of CDc ≥ II, severe morbidities of CDc ≥ IIIb, pneumonia, and any pulmonary morbidities were frequently observed. Second, the occurrence of severe morbidity in patients who had stopped smoking ≥ 31 days reduced to as low as that of a person who had never smoked. The incidence of pneumonia in patients who had stopped smoking ≥ 91 days also reduced to as low as that of a person who had never smoked. Third, smoking cessation ≤ 30 days was a significant risk factor for severe morbidity and any pulmonary morbidity. Smoking cessation ≤ 90 days was also a significant risk factor for pneumonia.

Smoking can induce postoperative morbidities via several mechanisms. It correlates with peripheral bronchoconstriction [26], decline in diffusing capacity, and increased respiratory secretion [27], which can result in pulmonary morbidity. Smoking also induces inflammation and tissue hypoxia, which increase the risk of postoperative wound dehiscence and infection [28, 29]. Smoking cessation abates the bronchial hyper-responsiveness and

Table 1 Characteristics of patients according to the duration of smoking cessation

Variables		Duration of smoking cessation			*P*
		≤ 30 days (*n* = 42)	31–90 days (*n* = 48)	≥ 91 days (*n* = 108)	
Age	Years old	62.7 ± 8.4*	63.6 ± 6.8#	66.4 ± 7.1*#	0.008* 0.020#
Sex	Male: female	38: 4	43: 5	99: 9	0.911
BMI	< 18.5: 18.5–24.9: ≥ 25 kg/m^2	5: 30: 7	5: 33: 10	6: 81: 21	0.674
Brinkman index	1–399: 400–799: ≥ 800	4: 12: 26	2: 15: 31	23: 38: 47	0.019#
Performance status	0: 1: 2	38: 3: 1	44: 4: 0	105: 3: 0	0.171
ASAPS	1: 2: 3	8: 34: 0	10: 35: 3	21: 84: 3	0.529
Diabetes mellitus	Present: absent	9: 33	12: 36	24: 84	0.906
Respiratory comorbidity	Present: absent	14: 28	17: 31	26: 82	0.270
Cardiovascular comorbidity	Present: absent	22: 20	24: 24	65: 43	0.429
Tumor location	Ut: Mt: Lt: Ae	7: 17: 15: 3	5: 26: 16: 1	14: 59: 33: 2	0.520
Clinical T	T1: T2: T3: T4	33: 2: 7: 0	35: 6: 7: 0	62: 16: 28: 2	0.157
Clinical N	N0: N1: N2: N3	35: 4: 2: 1	38: 9: 0: 1	85: 17: 5: 1	0.650
Clinical stage	I: II: III: IV	32: 5: 5: 0	34: 9: 2: 3	69: 23: 14: 2	0.200
Preoperative treatment	None/NAC/NACRT	32: 10: 0	38: 10: 0	78: 24: 6	0.256
Surgery					
Conduit	Stomach: colon	39: 3	47: 1	102: 6	0.516
Dissection field	1: 2: 3	1: 19: 22	2: 14: 32	2: 36: 70	0.487
Use of laparoscopy	Yes: no	34: 8	37: 11	86: 22	0.896

Data are expressed as the number of cases or mean number ± standard deviation

BMI body mass index, *ASAPS* American society of anesthesiologists physical status, *NAC* neoadjuvant chemotherapy, *NACRT* neoadjuvant chemoradiotherapy

*$p < 0.01$,#$p < 0.05$

decreases respiratory secretion. It also improves the value of forced expiratory volume in 1 s (FEV_1), which contributes to reducing morbidities [30, 31]. In this study, short duration of smoking cessation before MIE highly correlated with postoperative morbidities. Although previous studies by Ferguson et al. and Mantziari et al. reported similar results [2, 6], those studies were mainly designed for OE. Thus, to the best of our knowledge, this is the first study to elucidate the importance of cessation in the prevention of postoperative complications in patients who have undergone MIE. For patients who continue smoking at their first visit of the preoperative evaluation, education in smoking cessation is considerably important, even in MIE. When we provide such information to patients before surgery, the current data is certainly helpful.

How long patients should maintain cessation before MIE to prevent postoperative morbidities is an interesting clinical issue. The current results suggested that smoking cessation ≥ 31 days is necessary to decrease severe morbidity and any pulmonary morbidity. For patients with early-stage esophageal cancer, it is probably acceptable to delay surgery to allow the patient to quit smoking ≥ 31 days. For patients with resectable advanced esophageal cancer, neoadjuvant therapy is commonly administered before MIE [32, 33]. NAC and NACRT require administration for 1 to 2 months before surgery. Thus, these patients can achieve sufficient duration of cessation ≥ 31 days. On the other hand, although preoperative cessation ≥ 91 days is considered desirable to reduce the likelihood of pneumonia after MIE, it may be difficult for all patients to achieve it. For patients who cannot sufficiently quit smoking, several precautions against postoperative pneumonia are important. Previous studies or meta-analyses have indicated that preoperative respiratory rehabilitation [34], preoperative oral care [35], perioperative administration of steroids [36, 37], and enforcing an enhanced recovery after surgery (ERAS) program [38] may be useful for preventing pulmonary morbidities.

Table 2 Short-term outcomes after esophagectomy according to the duration of smoking cessation

Variables	Never-smoker (n = 30)	Duration of smoking cessation			P except never-smoker
		≤ 30 days (n = 42)	31–90 days (n = 48)	≥ 91 days (n = 108)	
Any morbidity of CDc ≥ II	6 (20.0)	19 (45.2)	17 (35.4)	35 (32.4)	0.338
Severe morbidity of CDc ≥ IIIb	3 (10.0)	13 (31.0)	4 (8.3)	10 (9.3)	0.001*
Pneumonia	2 (6.7)	9 (21.4)	8 (16.7)	6 (5.6)	0.011#
Any pulmonary morbidity	2 (6.7)	13 (31.0)	8 (16.7)	13 (12.0)	0.022#
Surgical site infection	4 (13.3)	5 (11.9)	5 (10.4)	6 (5.6)	0.349
Anastomotic leakage	1 (3.3)	8 (19.0)	6 (12.5)	15 (13.9)	0.645
Cardiovascular morbidity	3 (10.0)	3 (7.1)	4 (8.3)	5 (4.6)	0.634
In-hospital mortality	0	1 (2.4)[a]	0	1 (0.9)[b]	0.526
Hospital stay (days)	22 ± 4	25 ± 2	21 ± 2	24 ± 1	NS

Data are expressed as the number of cases (%) or median number ± standard error

CDc Clavien–Dindo classification, *NS* not significant

*$p < 0.01$, #$p < 0.05$

[a]Death of respiratory failure

[b]Death of chronic myelomonocytic leukemia

Table 3 Factors associated with postoperative severe morbidity in patients with a history of smoking

Variables		Univariate		Multivariate[a]	
		HR (95% CI)	P	HR (95% CI)	P
Performance status	0	1 (referent)		1 (referent)	
	≥ 1	4.07 (1.106–15.01)	0.035	2.66 (0.661–10.737)	0.168
Smoking (Brinkman index)	Per 100 increase	1.07 (0.994–1.170)	0.071	1.06 (0.965–1.156)	0.236
Smoking cessation	≥ 31 days	1 (referent)		1 (referent)	
	≤ 30 days	4.55 (1.935–10.68)	< 0.001	4.89 (1.993–12.011)	< 0.001
Cardiovascular comorbidities	Absent	1 (referent)		1 (referent)	
	Present	2.51 (1.009–6.251)	0.048	2.58 (0.967–6.867)	0.058

[a]Age at surgery (per 10 years), sex (male vs. female), Cooperative Oncology Group (ECOG) performance status (0 vs. ≥ 1), body mass index (< 18.5 vs. ≥ 18.5 kg/m^2), past smoking [Brinkman index, year x number/day (number-years)], duration of smoking cessation, American society of anesthesiologists physical status (ASAPS) (1 vs. ≥ 2), presence of diabetes mellitus, respiratory comorbidities, cardiovascular comorbidities, % volume capacity (VC) (< 80 vs. ≥ 80%), forced expiratory volume (FEV) 1% (< 70 vs. ≥ 70%), clinical T stage (T1, 2 vs. T3, 4), clinical N stage (N0 vs. N1–3), preoperative treatment (present vs. absent), operative time (per 60 min), intraoperative bleeding (per 100 g), and use of laparoscopy (yes vs. no)

HR hazard ratio, *CI* confidence interval

Several studies on surgical procedures may also be helpful, when MIE is performed on patients with insufficient cessation. Placing the patient in a prone position during MIE may contribute to reducing pulmonary morbidities, compared with morbidities associated with the left lateral position [39]. As for intraoperative ventilation technique, artificial pneumothorax with two-lung ventilation can abate lung injury, which may contribute to reducing pulmonary morbidity [40].

How we collect precise information on smoking status is another important issue. Based on the results of this study, a sufficient duration of smoking cessation preoperatively is integral to preventing morbidities after MIE. We commonly obtain information about duration of cessation via patients' self-reporting only. When patients report false information, we cannot objectively confirm it. We understand that it is important to establish a strategy to objectively determine whether patients have definitely stopped

Table 4 Factors associated with postoperative pneumonia in patients with a history of smoking

Variables		Univariate		Multivariate[a]	
		HR (95% CI)	*P*	HR (95% CI)	*P*
Smoking (Brinkman index)	Per 100 increase	1.14 (1.042–1.240)	0.004	1.10 (1.001–1.209)	0.047
Smoking cessation	$\geq$ 91 days	1 (referent)		1 (referent)	
	$\leq$ 90 days	3.96 (1.489–10.53)	0.006	3.98 (1.442–10.971)	0.008
Cardiovascular comorbidity	Absent	1 (referent)		1 (referent)	
	Present	3.17 (1.128–8.931)	0.029	3.09 (1.037–9.186)	0.043

[a]Age at surgery (per 10 years), sex (male vs. female), Cooperative Oncology Group (ECOG) performance status (0 vs. $\geq$ 1), body mass index ($<$ 18.5 vs. $\geq$ 18.5 kg/m^2), past smoking [Brinkman index, year x number/day (number-years)], duration of smoking cessation, American society of anesthesiologists physical status (ASAPS) (1 vs. $\geq$ 2), presence of diabetes mellitus, respiratory comorbidities, cardiovascular comorbidities, % volume capacity (VC) ($<$ 80 vs. $\geq$ 80%), forced expiratory volume (FEV) 1% ($<$ 70 vs. $\geq$ 70%), clinical T stage (T1, 2 vs. T3, 4), clinical N stage (N0 vs. N1–3), preoperative treatment (present vs. absent), operative time (per 60 min), intraoperative bleeding (per 100 g), and use of laparoscopy (yes vs. no)

HR hazard ratio, *CI* confidence interval

Table 5 Factors associated with postoperative any pulmonary morbidity in patients with a history of smoking

Variables		Univariate		Multivariate[a]	
		HR (95% CI)	*P*	HR (95% CI)	*P*
Smoking (Brinkman index)	Per 100 increase	1.11 (1.029–1.198)	0.007	1.09 (1.009–1.183)	0.029
Smoking cessation	$\geq$ 31 days	1 (referent)		1 (referent)	
	$\leq$ 30 days	2.88 (1.295–6.411)	0.010	3.13 (1.351–7.252)	0.008
American society of anesthesiologists physical status	1	1 (referent)		1 (referent)	
	$\geq$ 2	4.66 (1.067–20.37)	0.041	2.95 (0.584–14.889)	0.191
Cardiovascular comorbidity	Absent	1 (referent)		1 (referent)	
	Present	2.52 (1.108–5.728)	0.027	1.77 (0.698–4.466)	0.230

[a]Age at surgery (per 10 years), sex (male vs. female), Cooperative Oncology Group (ECOG) performance status (0 vs. $\geq$ 1), body mass index ($<$ 18.5 vs. $\geq$ 18.5 kg/m^2), past smoking [Brinkman index, year x number/day (number-years)], duration of smoking cessation, American society of anesthesiologists physical status (ASAPS) (1 vs. $\geq$ 2), presence of diabetes mellitus, respiratory comorbidities, cardiovascular comorbidities, % volume capacity (VC) ($<$ 80 vs. $\geq$ 80%), forced expiratory volume (FEV) 1% ($<$ 70 vs. $\geq$ 70%), clinical T stage (T1, 2 vs. T3, 4), clinical N stage (N0 vs. N1–3), preoperative treatment (present vs. absent), operative time (per 60 min), intraoperative bleeding (per 100 g), and use of laparoscopy (yes vs. no)

HR hazard ratio, *CI* confidence interval

smoking. Estimation of urinary nicotine and exhaled carbon monoxide are useful tests to check the current smoking status in patients. It would be important in the future to determine whether these tests can conclusively predict the occurrence of postoperative morbidities in MIE.

Potential limitations in this study are as follows. First, it was performed at a single institute and the sample size was insufficient. Second, as mentioned above, information about the duration of cessation was based on self-reporting, the truthfulness of which we could not objectively confirm.

In conclusion, smoking cessation is integral to the prevention of postoperative morbidities, even in MIE. Notably, short duration of smoking cessation $\leq$ 30 at the time of surgery correlated with high incidences of postoperative morbidities. Duration of cessation is desirable to be taken as long as possible to decrease postoperative morbidities. At least, preoperative cessation $\geq$ 31 days is preferable to decrease considerable morbidities. We believe the current results could contribute to encouraging patients preoperatively to quit smoking, thus reducing morbidities after MIE.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Takeuchi H, Miyata H, Gotoh M et al (2014) A risk model for esophagectomy using data of 5354 patients included in a Japanese nationwide web-based database. Ann Surg 260:259–266
2. Mantziari S, Hubner M, Demartines N et al (2014) Impact of preoperative risk factors on morbidity after esophagectomy: is there room for improvement? World J Surg 38:2882–2890. https://doi.org/10.1007/s00268-014-2686-9
3. Yoshida N, Watanabe M, Baba Y et al (2014) Risk factors for pulmonary complications after esophagectomy for esophageal cancer. Surg Today 44:526–532
4. Dhungel B, Diggs BS, Hunter JG et al (2010) Patient and perioperative predictors of morbidity and mortality after esophagectomy: American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), 2005-2008. J Gastrointest Surg 14:1492–1501
5. Schieman C, Wigle DA, Deschamps C et al (2012) Patterns of operative mortality following esophagectomy. Dis Esophagus 25:645–651
6. Ferguson MK, Celauro AD, Prachand V (2011) Prediction of major pulmonary complications after esophagectomy. Ann Thorac Surg 91:1494–1500
7. Paul DJ, Jamieson GG, Watson DI et al (2011) Perioperative risk analysis for acute respiratory distress syndrome after elective oesophagectomy. ANZ J Surg 81:700–706
8. Zingg U, Smithers BM, Gotley DC et al (2011) Factors associated with postoperative pulmonary morbidity after esophagectomy for cancer. Ann Surg Oncol 18:1460–1468
9. Baba Y, Yoshida N, Shigaki H et al (2016) Prognostic impact of postoperative complications in 502 patients with surgically resected esophageal squamous cell carcinoma: a retrospective single-institution study. Ann Surg 264:305–311
10. Kataoka K, Takeuchi H, Mizusawa J et al (2017) Prognostic impact of postoperative morbidity after esophagectomy for esophageal cancer: exploratory analysis of JCOG9907. Ann Surg 265:1152–1157
11. Saeki H, Tsutsumi S, Tajiri H et al (2016) Prognostic significance of postoperative complications after curative resection for patients with esophageal squamous cell carcinoma. Ann Surg 265:527–533
12. Biere SS, van Berge Henegouwen MI, Maas KW et al (2012) Minimally invasive versus open oesophagectomy for patients with oesophageal cancer: a multicentre, open-label, randomised controlled trial. Lancet 379:1887–1892
13. Yibulayin W, Abulizi S, Lv H (2016) Minimally invasive oesophagectomy versus open esophagectomy for resectable esophageal cancer: a meta-analysis. World J Surg Oncol 14:304. https://doi.org/10.1186/s12957-016-1062-7
14. Zhou C, Zhang L, Wang H et al (2015) Superiority of minimally invasive oesophagectomy in reducing in-hospital mortality of patients with resectable oesophageal cancer: a meta-analysis. PLoS ONE 10:e0132889
15. Mamidanna R, Bottle A, Aylin P et al (2012) Short-term outcomes following open versus minimally invasive esophagectomy for cancer in England: a population-based national study. Ann Surg 255:197–203
16. Molena D, Mungo B, Stem M et al (2014) Incidence and risk factors for respiratory complications in patients undergoing esophagectomy for malignancy: a NSQIP analysis. Semin Thorac Cardiovasc Surg 26:287–294
17. Yoshida N, Baba Y, Hiyoshi Y et al (2016) Duration of smoking cessation and postoperative morbidity after esophagectomy for esophageal cancer: how long should patients stop smoking before surgery? World J Surg 40:142–147. https://doi.org/10.1007/s00268-015-3236-9
18. Seok Y, Hong N, Lee E (2014) Impact of smoking history on postoperative pulmonary complications: a review of recent lung cancer patients. Ann Thorac Cardiovasc Surg 20:123–128
19. Ji Q, Zhao H, Mei Y et al (2015) Impact of smoking on early clinical outcomes in patients undergoing coronary artery bypass grafting surgery. J Cardiothorac Surg 10:16
20. Ngaage DL, Martins E, Orkell E et al (2002) The impact of the duration of mechanical ventilation on the respiratory outcome in smokers undergoing cardiac surgery. Cardiovasc Surg 10:345–350
21. Sobin LH, Gospodarowicz MK, Wittekind C, International Union against Cancer (2010) TNM classification of malignant tumours, 7th edn. Wiley, Hoboken
22. Kuwano H, Nishimura Y, Oyama T et al (2015) Guidelines for diagnosis and treatment of carcinoma of the esophagus April 2012 edited by the Japan Esophageal Society. Esophagus 12:1–30
23. Society of Thoracic Surgeons (2013) Risk-Adjusted Morbidity and Mortality for Esophagectomy for Cancer. http://www.sts.org/quality-research-patient-safety/quality/quality-performance-measures. Accessed 21 Oct 2017]
24. Yoshida N, Baba Y, Shigaki H et al (2016) Preoperative nutritional assessment by controlling nutritional status (CONUT) is useful to estimate postoperative morbidity after esophagectomy for esophageal cancer. World J Surg 40:1910–1917. https://doi.org/10.1007/s00268-016-3549-3
25. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213
26. Niewoehner DE, Kleinerman J, Rice DB (1974) Pathologic changes in the peripheral airways of young cigarette smokers. N Engl J Med 291:755–758
27. Ngaage DL, Martins E, Orkell E et al (2002) The impact of the duration of mechanical ventilation on the respiratory outcome in smokers undergoing cardiac surgery. Cardiovasc Surg 10:345–350
28. Goltsman D, Munabi NC, Ascherman JA (2017) The association between smoking and plastic surgery outcomes in 40,465 patients: an analysis of the American College of Surgeons National Surgical Quality Improvement Program data sets. Plast Reconstr Surg 139:503–511
29. Marmor S, Kerroumi Y (2016) Patient-specific risk factors for infection in arthroplasty procedure. Orthop Traumatol Surg Res 102(1 Suppl):S113–S119
30. Yamashita S, Yamaguchi H, Sakaguchi M et al (2004) Effect of smoking on intraoperative sputum and postoperative pulmonary complication in minor surgical patients. Respir Med 98:760–766
31. Willemse BW, Postma DS, Timens W et al (2004) The impact of smoking cessation on respiratory symptoms, lung function, airway hyperresponsiveness and inflammation. Eur Respir J 23:464–476
32. Ando N, Kato H, Igaki H et al (2012) A randomized trial comparing postoperative adjuvant chemotherapy with cisplatin and 5-fluorouracil versus preoperative chemotherapy for localized advanced squamous cell carcinoma of the thoracic esophagus (JCOG9907). Ann Surg Oncol 19:68–74
33. van Hagen P, Hulshof MC, van Lanschot JJ et al (2012) Preoperative chemoradiotherapy for esophageal or junctional cancer. N Engl J Med 366:2074–2084
34. Yamana I, Takeno S, Hashimoto T et al (2015) Randomized controlled study to evaluate the efficacy of a preoperative respiratory rehabilitation program to prevent postoperative pulmonary complications after esophagectomy. Dig Surg 32:331–337

35. Akutsu Y, Matsubara H, Shuto K et al (2010) Pre-operative dental brushing can reduce the risk of postoperative pneumonia in esophageal cancer patients. Surgery 147:497–502
36. Engelman E, Maeyens C (2010) Effect of preoperative single-dose corticosteroid administration on postoperative morbidity following esophagectomy. J Gastrointest Surg 14:788–804
37. Gao Q, Mok HP, Wang WP et al (2014) Effect of perioperative glucocorticoid administration on postoperative complications following esophagectomy: a meta-analysis. Oncol Lett 7:349–356
38. Markar SR, Karthikesalingam A, Low DE (2015) Enhanced recovery pathways lead to an improvement in postoperative outcomes following esophagectomy: systematic review and pooled analysis. Dis Esophagus 28:468–475
39. Markar SR, Wiggins T, Antonowicz S et al (2015) Minimally invasive esophagectomy: lateral decubitus vs. prone positioning; systematic review and pooled analysis. Surg Oncol 24:212–219
40. Saikawa D, Okushiba S, Kawata M et al (2014) Efficacy and safety of artificial pneumothorax under two-lung ventilation in thoracoscopic esophagectomy for esophageal cancer in the prone position. Gen Thorac Cardiovasc Surg 62:163–170