Original Article

Clinical characteristics and survival of esophageal cancer patients: annual report of the surgical treatment in Shanghai Chest Hospital, 2017

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Background: Esophageal cancer remains a significant burden of lethal cancers worldwide, particularly in China. This is an annual report of Shanghai Chest Hospital (SCH) on surgical treatment for esophageal cancer patients in 2017.

Methods: All patients who received surgical treatment for esophageal cancer at SCH in 2017 were given a detailed summary of clinical information based on the database of SCH. Kaplan-Meier method was used to present their survival, subgroup analyses, and multivariate Cox regression analysis were used to estimate the potential risk factors for prognosis.

Results: In 2017, a total of 663 patients received surgical treatment (628 esophagectomies and 35 endoscopic resections) for esophageal cancer at SCH. Of the patients who underwent esophagectomy, 292 patients received perioperative treatment, majority of which was postoperative treatment (47.9%). Only 69 (10.4%) patients received preoperative treatment. Minimally invasive techniques were used in 444 (70.7%) patients and robotic-assisted esophagectomies were used in 130 (20.7%) patients. Complete resection (R0) was achieved in 90.3% of esophagectomy patients. The 5-year overall survival (OS) rate after esophagectomy was 52.5%.

Conclusions: The 5-year OS of patients with esophageal cancer can reach 52.5% after surgical treatment in 2017 at SCH. The exact beneficiaries of neoadjuvant therapy are still unclear in the 2017 cohort.

Keywords: Esophageal cancer; esophagectomy; endoscopic resection; multidisciplinary treatment; survival

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Introduction

Esophageal cancer is the seventh most frequently diagnosed cancer and the sixth leading cause of cancer-related deaths in the world (1). China has the highest number of incident cases at the national level (2). As a high-volume center of esophageal cancer in China, the third annual report for Shanghai Chest Hospital (SCH) is summarized here. Baseline characteristics, diagnosis, tumor related information, treatment relevant information, perioperative outcomes, pathology results, and survival information of patients are described in this report.

After the learning curve of the first 2 years, robotic-assisted esophagectomies (RAE) gradually show better surgical efficiency and lymph node dissection capabilities and have been carried out in large numbers in SCH since 2017. To reduce the incidence of anastomotic leakage, the route of conduit pull-up gradually shifts from the retrosternal to the posterior mediastinum. In 2017, preoperative neoadjuvant treatment still had not been recommended in our clinical practice like in Japan. But in the subgroups of different stages in the same period, there was no obvious survival disadvantage compared with the Japanese annual report (3). The beneficiaries of neoadjuvant therapy were still not clear in 2017 at SCH. At that time, immunotherapy was not yet available in neoadjuvant regimen. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-49/rc).

Highlight box

Key findings

- The 5-year overall survival of patients with esophageal cancer can reach 52.5% after surgical treatment in 2017 at Shanghai Chest Hospital (SCH).

What is known and what is new?

- McKeown and Ivor Lewis surgery through the right thoracic approach occupied the mainstream of esophagectomy in 2017 at SCH.
- The survival of patients underwent esophagectomy in 2017 exhibited similar trends with the 2016 cohort.
- With the emphasis on mediastinal lymph node dissection, especially the usage of robotic-assisted esophagectomies, the incidence of recurrent laryngeal nerve injury has increased significantly.

What is the implication, and what should change now?

- Annual reports of a high-volume single center are valuable records of past medical experience and references for treatment guidelines in the future.
- With more standardized and goal-directed multidisciplinary treatment, the benefits of neoadjuvant treatment may be more clearly demonstrated in the upcoming reports.
- Since the survival and safety of patients who received esophagectomy are acceptable, how to reduce postoperative complications and improve the patients' quality of life should be the next key issue.

Methods

Data sources

To record patients' related information, a prospective database of esophageal cancer has been established in 2014. The following patients' information was recorded: baseline characteristics, diagnosis, tumor related information, treatment relevant information perioperative outcomes, pathology results and survival information. For treatment relevant information, postoperative complications were classified by Esophagectomy Complications Consensus Group (ECCG) system and Clavien-Dindo (C-D) grading system (4,5). For residual tumor status, residual tumor was examined at proximal, distal and circumferential margins of the resected esophageal specimen. R0 was defined as negative resection margins; R1 was defined as positive residual tumor in resected esophagus; and R2 was defined as unresectable tumor which invaded adjacent organs. For survival information, follow-up was scheduled every 3 months during the first year after discharge from the SCH, and then every 6 months in the following years until June 2023. Finally, overall survival (OS), cancer-specific survival (CSS) and recurrent free survival (RFS) were calculated.

Clinical data

Clinical data of patients who received surgical treatments (esophagectomy or endoscopic resection) for esophageal cancer in 2017 were retrieved from the esophageal cancer disease database of SCH. Finally, a total of 663 patients who received esophagectomy or endoscopic submucosal dissection (ESD) for esophageal cancer at SCH in 2017 were included, three of them who received esophagectomy the same year after ESD were only included in ESD cohort. To compare the patients' survival between 2016 and 2017, the cohort of 2016 at SCH was also included (6). According to clinical records, baseline characteristics were analyzed in all 663 patients (*Table 1*). For analysis of long-term survival after esophagectomy, the 610 patients who received

Table 1 Baseline characteristics of patients (n=663)

Variables	Cases (%)
Age (years)	
<60	163 (24.6)
60–69	327 (49.3)
70–79	159 (24.0)
≥80	14 (2.1)
Gender	
Male	551 (83.1)
Female	112 (16.9)
BMI (kg/m^2)*	
<18.5	54 (8.1)
18.5–23.0	311 (46.9)
>23.0	298 (44.9)
Location	
Cervical	10 (1.5)
Upper thoracic	96 (14.5)
Middle thoracic	366 (55.2)
Lower thoracic	147 (22.2)
EGJ	44 (6.6)
Initial diagnosis	
Esophageal cancer	651 (98.2)
Esophageal concurrent cancers	12 (1.8)

*, BMI in accordance with the Asia-Pacific standards. BMI, body mass index; EGJ, esophagogastric junction.

esophagectomy were reviewed except for 18 patients who were lost to follow-up in the first year after surgery (*Figure 1*). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) (7). The study was approved by the ethics committee of the Shanghai Chest Hospital (No. KS23067). Individual consent for this retrospective analysis was waived.

Diagnosis and evaluation

The diagnosis of patients was confirmed by esophagogastroduodenoscopy (EGD) for location and biopsy of the lesion. Contrast-enhanced computed tomography (CT) scan of esophagus (including neck, chest and abdomen) was routinely used for tumor and metastatic lymph node staging. For intramucosal invasion, endoscopic ultrasonography (EUS) was used for further tumor staging. For cervical esophageal cancer patients, neck ultrasound was used for supraclavicular lymph node staging (lymph nodes between the supraclavicular paratracheal space and apex of the lung). For suspected distant metastases, additional enhanced magnetic resonance imaging (MRI) for brain or bone radionuclide scans were performed. The staging was based on the 8th edition of the American Joint Committee on Cancer (AJCC) tumor-node-metastasis (TNM) staging criteria for esophageal cancer (8).

To assess patients' general condition, evaluation of cardiopulmonary function was conducted, such as echocardiography, treadmill test, pulmonary function, and

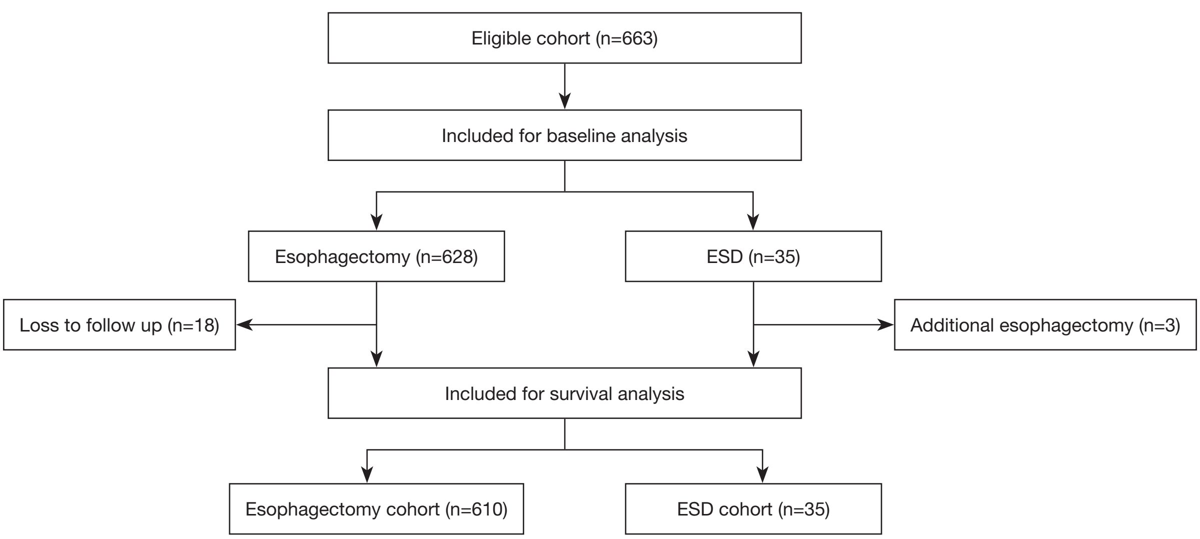


Figure 1 Flowchart of this report. ESD, endoscopic submucosal dissection.

Table 2 Approaches of therapy (n=663)

Approaches	Cases (%)
ESD	35 (5.3)
Esophagectomy	628 (94.7)
McKeown	508 (76.6)
Ivor-Lewis	44 (6.6)
Sweet	42 (6.3)
Trans-hiatal	17 (2.6)
TPLE	7 (1.1)
Cervical esophagectomy*	2 (0.3)
Total gastrectomy (EGJ)	3 (0.5)
Others	5 (0.8)

*, ascending colon substitute through retrosternal was used in one patient, jejunum substitute through posterior mediastinal was used in another. ESD, endoscopic submucosal dissection; TPLE, total pharyngo-laryngo-esophagectomy; EGJ, esophagogastric junction.

arterial blood gas. Additionally, nutritional assessment was mandatory for admission.

Esophagectomy or endoscopic resection

McKeown and Ivor-Lewis approaches through right thoracic approach were common options for esophagectomy at SCH in 2017. Minimally invasive esophagectomy (thoracoscopic or robotic-assisted) were the mainstream in our center, but some cases of open approach were still performed depending on the decision of surgeons, most for the suspected adjacent organ invaded (T4b) cases. Considering the reduced surgical tolerance in certain patients, these individuals underwent Sweet procedure with a left thoracic approach or trans-hiatal approach (*Table 2*). For lymphadenectomy, extended two-field or selective three-field lymph node dissection was routinely performed (*Table 3*).

Endoscopic resection was used in patients diagnosed with clinical intramucosal invasion accompanied by negative lymph node metastases (cT1N0) confirmed by contrast-enhanced computed tomography (CT) and EUS. For patients who underwent circumferential resection, esophageal stent may be implanted simultaneously to avoid stenosis after operation. For postoperative confirmed staged pT1b or residual tumors, additional esophagectomy or definitive radiotherapy was considered.

Table 3 Outcomes of surgery (n=628)

Outcomes	Cases (%)
Surgical method	
RAE	130 (20.7)
MIE	314 (50.0)
Open	184 (29.3)
Conduit	
Gastric tube	614 (97.8)
Colon	13 (2.1)
None*	1 (0.1)
Reconstruction route	
Posterior mediastinal	540 (86.0)
Retrosternal	87 (13.9)
None*	1 (0.2)
Fields of lymph node dissection	
None	6 (1.0)
One field (thoracic)	20 (3.2)
Two fields (thoracic + abdominal)	540 (86.0)
Three fields (cervical + thoracic + abdominal)**	62 (9.9)

*, one patient did not receive reconstruction of digestive tract after esophagectomy due to poor condition, and received phase 2 reconstruction; **, 26 of the 62 patients confirmed cervical lymph node metastases. RAE, robotic assisted esophagectomy; MIE, minimally invasive esophagectomy; Open, esophagectomy through open approach.

Multidisciplinary treatment

Multidisciplinary treatment was mainly used in patients with advanced tumors. In 2017, neoadjuvant therapy had not been routinely applied for preoperative treatment, but was mainly used for suspected lymph node metastasis or adjacent tissue invade (T3 to T4a) (*Table 4*). And the specific treatment regimen varied depending on the physician and patients' preference (*Table 5*). For patients with a tumor located in the upper thoracic esophagus or neck or confirmed with lymph node metastases after postoperative pathology, postoperative adjuvant therapy was routinely recommended.

Statistical analysis

For this report, categorical variables were documented as numbers and percentages. Continuous variables were

Table 4 Predominant treatments of esophageal cancer (n=663)

Treatments	Cases (%)
Endoscopic resection alone*	27 (4.1)
Esophagectomy alone**	273 (41.2)
Preoperative therapy + esophagectomy	37 (5.6)
Esophagectomy + adjuvant therapy	286 (43.1)
Preoperative therapy + esophagectomy + adjuvant therapy	32 (4.8)
Endoscopic resection + adjuvant therapy	8 (1.2)

*, due to dissatisfied endoscopic resection, 3 cases received additional surgery; **, 1 case received esophagectomy as well as endoscopic resection at the same time.

Table 5 Neoadjuvant regimen

Regimen	Cases (%)
Preoperative chemotherapy	28 (40.6)
TC	16 (23.2)
TP	5 (7.2)
DP	4 (5.8)
Others	3 (4.3)
Preoperative radiotherapy	2 (2.9)
Preoperative chemoradiotherapy	39 (56.5)
TP + RT	22 (31.9)
PF + RT	9 (13.0)
DP + RT	3 (4.3)
Others	5 (7.2)

TC, paclitaxel + carboplatin; TP, paclitaxel + cisplatin; DP, docetaxel + cisplatin; PF, cisplatin + 5-fluorouracil; RT, radiotherapy.

documented as mean ± standard deviation (SD) for normal distribution data or median [interquartile range (IQR)] for non-normal distribution data. Survival data were graphed and analyzed by Kaplan-Meier method and compared by log-rank test. Multivariate Cox regression analysis was conducted to explore prognostic factors affecting long-term outcome. To explore the probable survival benefits of neoadjuvant therapy, propensity score match (PSM) was used in ESCC patients. A two-tailed test P value less than 0.05 two-sided was considered statistically significant. All analyses were performed by SPSS software version 25.0 (IBM Corporation, Armonk, NY, USA) and were plotted by GraphPad Prism 9 software (GraphPad Software, San Diego, CA, USA).

Results

Baseline characteristics

A total of 663 patients received surgical treatment at SCH in 2017 (*Figure 1*). The majority of patients were male (83.1%), with 49.3% of patients aging 60–69 years. In 54 (8.1%) patients, their body mass index (BMI) were less than 18.5 kg/m^2 which was considered as malnourished. The tumor was mainly located at the middle thoracic esophagus (55.2%) and initially diagnosed as esophageal cancer (98.2%) (*Table 1*).

Resection

Of the 663 patients who received tumor resection, 628 (94.7%) received esophagectomy and 35 (5.3%) received ESD (*Table 2*). Due to unsatisfactory results of endoscopic resection, three cases received additional surgery in the same year (*Figure 1*).

Esophagectomy

Of all the esophagectomy approaches (n=628), McKeown approach accounted for the majority (76.6%), followed by Ivor-Lewis (6.6%), Sweet (6.3%), trans-hiatal (2.6%), total pharyngo-laryngo-esophagectomy (TPLE) (1.1%), and so on (*Table 2*). Minimally invasive techniques were used in 70.7% of patients (n=444), including RAE in 130 patients (20.7%) (*Table 3*). Complete resection (R0) was achieved in 90.3% of patients (*Table 6*). The gastric tube was used in 97.8% of patients for conduit, and the posterior mediastinum was the most commonly chosen route (*Table 3*). For lymph node dissection, two fields (thoracic + abdominal) dissection was performed in 540 (86%) patients, which accounted for the majority (*Table 3*). A total of 622 patients underwent lymph node dissection, with a median of 17 lymph nodes examined (*Table 7*), meeting the National Comprehensive Cancer Network (NCCN) guidelines (9).

Endoscopic submucosal dissection

In the 35 patients diagnosed with clinical intramucosal invasion accompanied with no lymph node metastases, ESD was performed. No severe complications after ESD were recorded. Eight patients received adjuvant therapy after resection and salvage esophagectomies were performed in three patients (*Table 4*).

Table 6 Residual tumor stage after esophagectomy (n=628)

Residual tumor (R)	Cases (%)
R0	567 (90.3)
R1	29 (4.6)
R2	32 (5.1)

R0: negative discovery in both resection margins; R1: positive residual tumor in resected esophagus; R2: unresectable tumor which invaded adjacent organs.

Table 7 Length of in-hospital stay and number of lymph node dissections

Variables	Median [IQR]
Length of postoperative stay (days)	11 [9–16]
Length of ICU stay (days)	2 [1–3]
Number of lymph node examined (n=622*)	17 [12–23]

*, six patients did not undergo lymph node dissection during esophagectomy. ICU, intensive care unit; IQR, interquartile range.

Pathological evaluation

In pathological evaluation, esophageal squamous cell carcinoma (ESCC) was the most prevalent type at SCH, accounting for 587 out of 663 patients (*Tables 8,9*), prominent for moderate to poor differentiation (86.1%) (*Table 10*). The pathological depth of tumor invasion was most commonly pT3 (invasion of the adventitia) in esophagectomy cases, representing 317 cases (50.5%) (*Table 11*). Lymph node metastases were observed in 329 patients (52.4%), comprising 181 cases staged as pN1 (28.8%) and 107 cases staged as pN2 (17.0%) (*Table 12*). Notably, 251 cases (40.0%) were categorized as pStage III and 78 cases (12.4%) were categorized as pStage IV after esophagectomy (*Table 13*). 117 patients (18.7%) exhibited no lymphovascular invasion (*Table 12*).

Regarding the ESD specimens, the pathological depth of tumor invasion was dominated by pStage T1a-M3 (invade the muscularis mucosa) in ESD cases, accounting for 12 (34.3%) cases (*Table 14*). Unfortunately, the depth of tumor invasion of three cases failed to be defined (one in pT1a and two in pT1b).

Table 8 Histological classification of esophagectomy specimens

Histological classification	Cases (%)
Squamous cell carcinoma	558 (89.0)
Absolute squamous cell carcinoma	556 (88.7)
Mixed with sarcoma	2 (0.3)
Adenocarcinoma	38 (6.1)
Absolute adenocarcinoma	36 (5.7)
Mixed with signet-ring cell carcinoma	2 (0.3)
Adeno-squamous carcinoma	1 (0.2)
Neuroendocrine carcinoma	2 (0.3)
Small cell carcinoma	2 (0.3)
Multiple carcinoma	17 (2.7)
Mixed neuroendocrine-squamous cell carcinoma	12 (1.9)
Mixed neuroendocrine-adenocarcinoma	3 (0.5)
Mixed neuroendocrine-adeno-squamous cell carcinoma	1 (0.2)
Mixed adenocarcinoma-squamous cell carcinoma	1 (0.2)
Others	11 (1.8)
Basement like squamous cell carcinoma	3 (0.5)
Sarcoma	3 (0.5)
Melanoma	2 (0.3)
Epithelial carcinoma	1 (0.2)
Schwannoma	1 (0.2)
Barret	1 (0.2)
Total	627
Loss of pathology	1

Table 9 Histological classification of endoscopic treatment specimens (n=35)

Histological classification	Cases (%)
Squamous cell carcinoma	29 (82.8)
Adenocarcinoma	1 (2.9)
High grade dysplasia	5 (14.3)

Multidisciplinary treatment

Perioperative multidisciplinary treatment was performed in the 355 esophagectomy patients and eight ESD patients. Of the patients who received perioperative treatment, 37 patients received preoperative therapy before esophagectomy without postoperative therapy, 286 patients

Table 10 Differentiation of all pathological specimens

Differentiation	Esophagectomy (n=628), cases (%)	ESD (n=35), cases (%)
G1—well	59 (9.4)	5 (14.3)
G2—moderately	266 (42.4)	7 (20.0)
G3—poorly/undifferentiated	268 (42.7)	7 (20.0)
GX—undefined	35 (5.6)	16 (45.7)

ESD, endoscopic submucosal dissection.

Table 11 Pathological depth of tumor invasion of esophagectomy specimens, pT (AJCC TNM 8th) (n=628)

Pathological depth of tumor invasion	Cases (%)
pT0	34 (5.4)
pT1a	25 (4.0)
pT1b	86 (13.7)
pT2	102 (16.2)
pT3	317 (50.5)
pT4a	32 (5.1)
pT4b*	32 (5.1)

*, all pT4b patients received R2 resection, eight of them combined with adjacent organ excision such as part of azygos vein (four patients), spleen artery (one patient), spleen (one patient), part of trachea (one patient) and paraaortic tissue (one patient). AJCC, American Joint Committee on Cancer; TNM, tumor-node-metastasis.

Table 12 Pathological grading of lymph node metastasis and lymphovascular invasion, pN (AJCC TNM 8th) (n=628)

Pathological grading of pN and Lymphovascular invasion	Cases (%)
Lymph node metastasis	
pN0	299 (47.6)
pN1	181 (28.8)
pN2	107 (17.0)
pN3	41 (6.5)
Lymphovascular invasion	
Positive	511 (81.4)
Negative	117 (18.6)

AJCC, American Joint Committee on Cancer; TNM, tumor-node-metastasis.

Table 13 Pathological stage (AJCC TNM 8th)

pTNM stage	Esophagectomy (n=628), cases (%)	ESD (n=35), cases (%)
0	12 (1.9)	5 (14.3)
I	98 (15.6)	28 (80.0)
II	189 (30.1)	–
III	251 (40.0)	–
IV	78 (12.4)	–
Unknown	–	2 (5.7)

AJCC, American Joint Committee on Cancer; TNM, tumor-node-metastasis; ESD, endoscopic submucosal dissection.

Table 14 Pathological depth of tumor invasion of endoscopic treatment specimens, pT (AJCC TNM 8th) (n=35)

Pathological depth of tumor invasion	Cases (%)
pT0/Tis-M1	4 (11.4)
pT1a	14 (40.0)
M2	1 (2.9)
M3	12 (34.3)
Undefined	1 (2.9)
pT1b	10 (28.6)
SM1	3 (8.6)
SM2	5 (14.3)
Undefined	2 (5.7)
High grade dysplasia*	5 (14.3)
Loss of records	2 (5.7)

*, the pathological records of five patients were high grade dysplasia instead of tumor. AJCC, American Joint Committee on Cancer; TNM, tumor-node-metastasis.

received postoperative therapy without preoperative therapy, and 32 patients received both. Eight patients received postoperative adjuvant therapy after ESD (*Table 4*). The preoperative neoadjuvant regimens are summarized in *Table 5*.

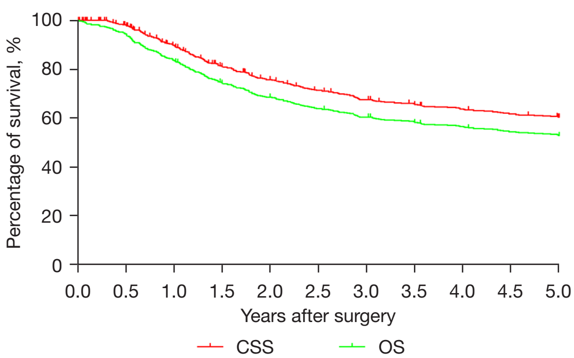
Complications

Following esophagectomy, our patients were routinely admitted to the ICU to prevent postoperative emergencies. As a result, the median length of ICU stay is two days (*Table 7*). A total of 309 (49.2%) patients who received

Table 15 Total complications after esophagectomy (n=628)

Complications	Cases (%)
Total complications (ECCG)	309 (49.2)
Clavien-Dindo complications ≥ III	87 (13.9)
Pulmonary	
Pneumonia	83 (13.2)
Pleural effusion	56 (8.9)
Pneumothorax	13 (2.1)
Respiratory failure	14 (2.2)
Acute respiratory distress syndrome	29 (4.6)
Cardiovascular	
Cardiac arrhythmia	21 (3.3)
Gastrointestinal	
Anastomotic leakage	56 (8.9)
Gastrointestinal bleeding	4 (0.6)
Thromboembolic	
Deep venous thrombosis	5 (0.8)
Neurologic/psychiatric	
Recurrent nerve injury (VCP)	89 (14.2)
Delirium	4 (0.6)
Infection	
Wound infection	6 (1.0)
Chyle leak	7 (1.1)

ECCG, Esophagectomy Complications Consensus Group system; VCP, vocal cord paralysis.



	Years after surgery				
	1	2	3	4	5
OS	83.5%	68.6%	60.4%	56.5%	52.9%
CSS	89.7%	75.8%	67.6%	63.8%	60.5%

Figure 2 The survival of overall cohort. OS, overall survival; CSS, cancer specific survival.

esophagectomy experienced postoperative complications, with major complications (C-D ≥ III) documented in 87 patients. In 2017, recurrent laryngeal nerve injury emerged as the most common complication at SCH, with a prevalence of 14.2%, followed by postoperative pneumonia at 13.2%. Other notable complications included pleural effusion (8.9%), anastomotic leakage (8.9%), and acute respiratory distress syndrome (ARDS) (4.6%) (*Table 15*). The postoperative mortality was 0.008% (5 cases) for 30-day and 0.021% (14 cases) for 90-day.

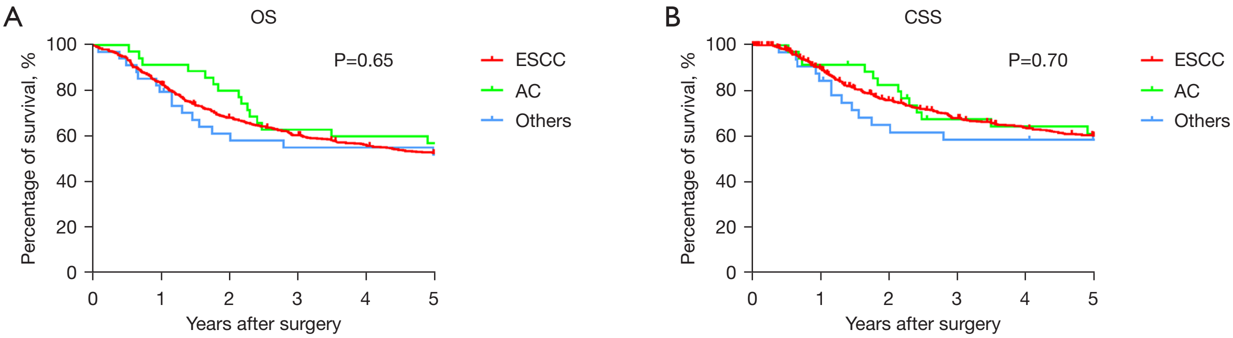
Survival analysis

Most patients were followed up until June 2023. The median follow-up time was 60.2 (IQR, 36.33–60.87) months in the ESD cohort and 60.87 (IQR, 60.4–60.93) months in the esophagectomy cohort. Eighteen patients with follow-up of less than 1 year were excluded from the survival analysis (*Figure 1*). Overall, the 1-, 2-, 3-, 4-, and 5-year OS rates were 83.5%, 68.6%, 60.4%, 56.5%, and 52.9% (*Figure 2*). Notably, there were no statistically significant differences between the survival outcomes among patients with different histology of esophageal cancer (*Figure 3*). Furthermore, patients with ESCC who underwent esophagectomy at SCH in 2016 and 2017 exhibited similar survival trend (*Figure 4*). Although the 5-year OS of 2017 cohort is slightly higher than that of 2016 cohort (52.5% *vs.* 51.8%), 1-year OS presents opposite results (83.2% *vs.* 86.5%). Subgroup analyses were conducted by clinical stage (cStage), pathological stage (pTNM, pT, pN) and residual tumor (R) in patients with ESCC (*Figures 5-10*). To explore the probable survival benefits of neoadjuvant therapy, 68 pairs of ESCC patients with neoadjuvant treatment or not were analyzed through PSM (*Figure 11*, Table S1). Kaplan-Meier survival curves were plotted for them to evaluate their efficacy. However, there were no substantial differences in survival between the two cohorts.

In multivariate Cox regression analysis, open surgery approach, deeper tumor invasion layers, and more lymph nodes metastasis were prognostic factors associated with poor OS, CSS and RFS in esophagectomy cohort. Postoperative adjuvant treatment was factor associated with better OS (*Table 16*).

Discussion

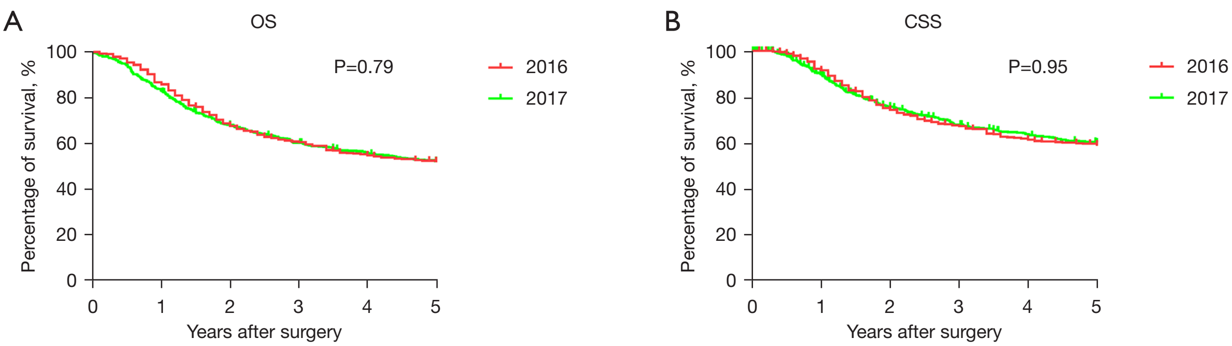
This is a report of esophageal cancer from a high-volume center in China. With more than 600 esophagectomies



OS	Years after surgery				
	1	2	3	4	5
ESCC	83.2%	68.2%	60.4%	56.2%	52.5%
AC	91.4%	80.0%	62.9%	59.9%	56.9%
Others	79.4%	61.1%	55.0%	55.0%	51.7%

CSS	Years after surgery				
	1	2	3	4	5
ESCC	89.8%	75.9%	68.0%	63.9%	60.3%
AC	91.4%	82.6%	67.5%	64.3%	61.1%
Others	84.5%	65.0%	58.5%	58.5%	58.5%

Figure 3 The survival of patients who received esophagectomy with different histological pathology. (A) The OS of patients who received esophagectomy with different histological pathology; (B) the CSS of patients who received esophagectomy with different histological pathology. OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AC, adenocarcinoma.



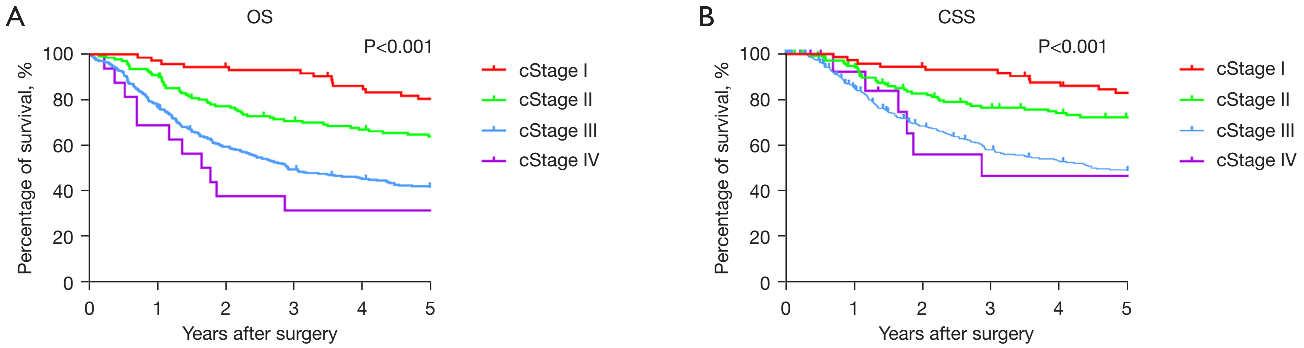
OS	Years after surgery				
	1	2	3	4	5
2016	86.5%	67.8%	59.9%	54.5%	51.8%
2017	83.2%	68.2%	60.4%	56.2%	52.5%

CSS	Years after surgery				
	1	2	3	4	5
2016	91.8%	74.2%	66.6%	61.2%	59.1%
2017	89.8%	75.9%	68.0%	63.9%	60.3%

Figure 4 The survival of ESCC patients who received esophagectomy in 2016 and 2017. (A) The OS of ESCC patients who received esophagectomy in 2016 and 2017; (B) the CSS of ESCC patients who received esophagectomy in 2016 and 2017. OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma.

every year are of huge workload. Our surgeries come from eight surgeons, and most of them had performed more than 400 surgeries. The remaining five are senior fellows, who can complete the surgery independently or with the assistance of supervisor. The quality of esophagectomy can be fully guaranteed.

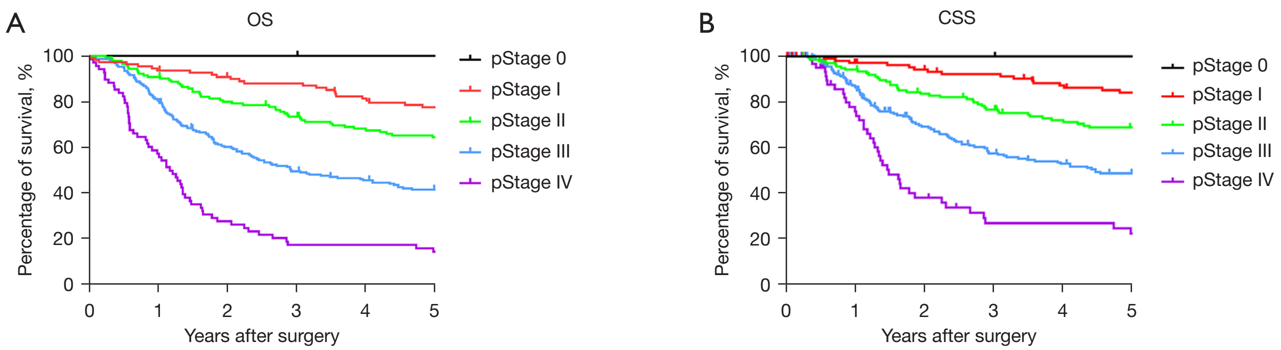
EUS is recommended by many guidelines as an important tool for T or N staging of esophageal cancer (1,10). However, in the 2017 cohort of SCH, it was still only used for rough screening of superficial lesions. For advanced tumors, the main concerning point was whether the adjacent organs were invaded (staging T4b), and the most important tool for judging this was still CT scan. Although MRI was recommended for possible adjacent organ invasion (T4b), and PET scan was recommended for staging, they were still not commonly used. This principle was also presented in Japan's JCOG1510 study (11). Therefore, we insisted not to use EUS as a T staging tool for advanced esophageal cancer. Superficial lesions were mainly distinguished between T1a and T1b, because it seems that these two types have to



OS	Years after surgery				
	1	2	3	4	5
cStage I	97.3%	94.5%	93.1%	86.1%	80.5%
cStage II	90.8%	77.2%	70.7%	67.0%	63.9%
cStage III	77.1%	59.4%	49.5%	45.1%	41.7%
cStage IV	68.8%	37.5%	31.3%	31.3%	31.3%

CSS	Years after surgery				
	1	2	3	4	5
cStage I	97.3%	94.5%	93.1%	87.5%	83.2%
cStage II	94.9%	82.8%	76.6%	74.1%	72.4%
cStage III	85.4%	68.4%	58.0%	53.3%	48.9%
cStage IV	92.3%	55.9%	46.6%	46.6%	46.6%

Figure 5 The survival of ESCC patients who received esophagectomy with different clinical stage (AJCC 8th edition). (A) The OS of ESCC patients who received esophagectomy with different clinical stage (AJCC 8th edition); (B) the CSS of ESCC patients who received esophagectomy with different clinical stage (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AJCC, American Joint Committee on Cancer.



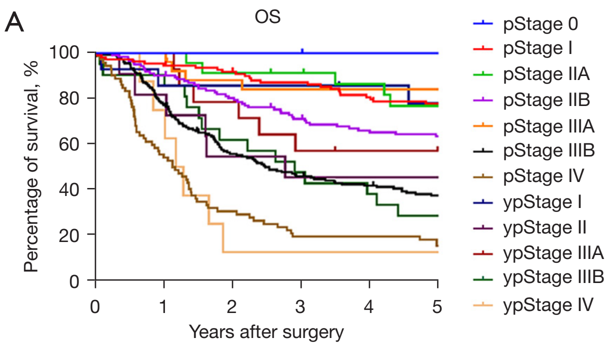
OS	Years after surgery				
	1	2	3	4	5
pStage 0	100.0%	100.0%	100.0%	100.0%	100.0%
pStage I	93.6%	90.8%	88.0%	81.4%	77.6%
pStage II	90.8%	80.0%	73.4%	68.2%	64.5%
pStage III	80.4%	60.3%	49.7%	45.8%	41.7%
pStage IV	57.4%	27.9%	17.6%	17.6%	14.7%

CSS	Years after surgery				
	1	2	3	4	5
pStage 0	100.0%	100.0%	100.0%	100.0%	100.0%
pStage I	97.2%	94.3%	92.3%	87.3%	84.2%
pStage II	94.2%	83.7%	76.9%	71.4%	69.0%
pStage III	86.3%	69.4%	57.7%	53.2%	49.0%
pStage IV	76.0%	38.4%	27.3%	27.3%	22.8%

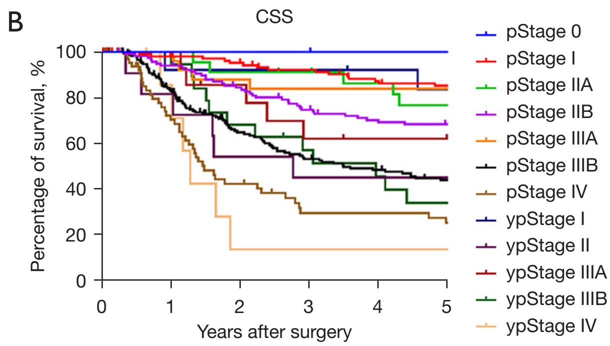
Figure 6 The survival of ESCC patients who underwent esophagectomy according to pathological stage (AJCC 8th edition). (A) The OS of ESCC patients who underwent esophagectomy according to pathological stage (AJCC 8th edition); (B) the CSS of ESCC patients who underwent esophagectomy according to pathological stage (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AJCC, American Joint Committee on Cancer.

be treated separately in recent years, but JCOG0508 has presented that low-risk T1b patients can also choose non-surgical treatment (12). The depth of the invasion has become the most important basis for surgery. However, correct staging by EUS is critical (13).

Minimally invasive surgery became the preferred approach at SCH in 2017. Of the different surgical approaches, patients who received RAE showed the best survival (Figure S1). However, this result may be influenced by patient selection and therefore unreliable. Open surgeries

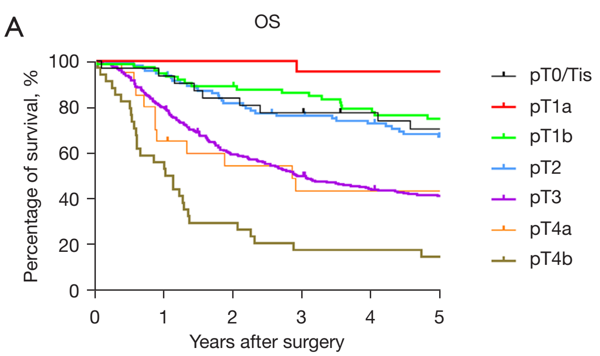


OS	Years after surgery				
	1	2	3	4	5
pStage 0	100.0%	100.0%	100.0%	100.0%	100.0%
pStage I	94.5%	91.8%	87.2%	80.7%	77.9%
pStage IIA	100.0%	91.3%	91.3%	86.5%	76.9%
pStage IIB	90.2%	80.3%	71.1%	66.1%	63.5%
pStage IIIA	100.0%	88.1%	84.1%	84.1%	84.1%
pStage IIIB	77.1%	55.8%	46.5%	41.8%	37.4%
pStage IV	54.2%	30.6%	19.4%	19.4%	15.3%
ypStage I	85.7%	85.7%	85.7%	85.7%	78.0%
ypStage II	81.8%	54.5%	45.5%	45.5%	45.5%
ypStage IIIA	100.0%	78.6%	64.3%	57.1%	57.1%
ypStage IIIB	85.7%	61.9%	52.4%	42.9%	28.6%
ypStage IV	75.0%	12.5%	12.5%	12.5%	12.5%

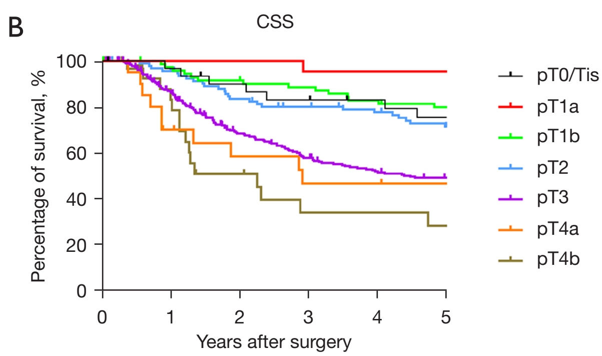


CSS	Years after surgery				
	1	2	3	4	5
pStage 0	100.0%	100.0%	100.0%	100.0%	100.0%
pStage I	98.1%	95.3%	92.3%	87.3%	85.4%
pStage IIA	100.0%	91.3%	91.3%	86.5%	76.9%
pStage IIB	94.1%	84.6%	75.0%	70.5%	68.7%
pStage IIIA	100.0%	88.1%	84.1%	84.1%	84.1%
pStage IIIB	83.1%	65.1%	53.6%	48.8%	44.4%
pStage IV	70.6%	42.7%	30.1%	30.1%	25.8%
ypStage I	92.3%	92.3%	92.3%	92.3%	83.9%
ypStage II	81.8%	54.5%	45.5%	45.5%	45.5%
ypStage IIIA	100.0%	85.7%	62.3%	62.3%	62.3%
ypStage IIIB	94.7%	68.4%	57.4%	46.0%	34.5%
ypStage IV	85.7%	14.3%	14.3%	14.3%	14.3%

Figure 7 The survival of ESCC patients who underwent esophagectomy according to pathological and neoadjuvant stage (AJCC 8th edition). (A) The OS of ESCC patients who underwent esophagectomy according to pathological and neoadjuvant stage (AJCC 8th edition); (B) the CSS of ESCC patients who underwent esophagectomy according to pathological and neoadjuvant stage (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AJCC, American Joint Committee on Cancer.

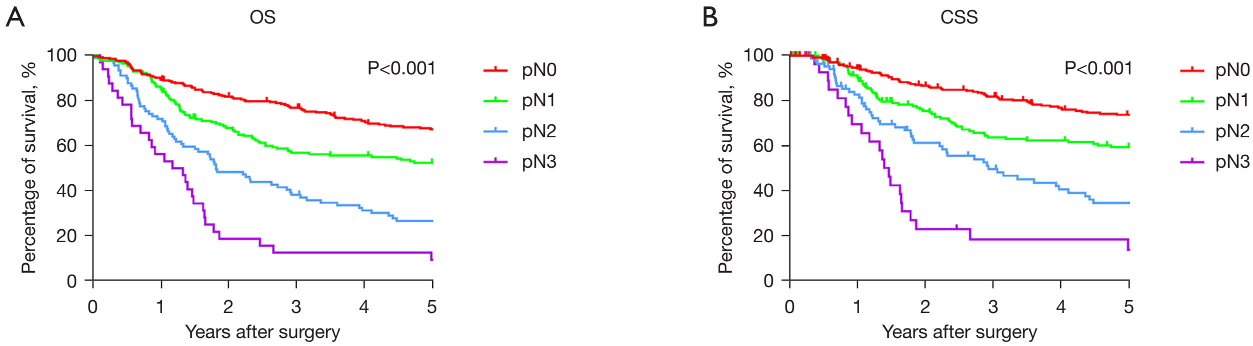


OS	Years after surgery				
	1	2	3	4	5
pT0/Tis	93.5%	83.9%	77.4%	77.4%	70.4%
pT1a	100.0%	100.0%	95.5%	95.5%	95.5%
pT1b	94.5%	89.0%	86.2%	79.1%	74.9%
pT2	93.5%	81.6%	76.1%	72.8%	67.0%
pT3	79.1%	59.3%	49.8%	44.3%	41.2%
pT4a	65.0%	54.2%	43.3%	43.3%	43.3%
pT4b	52.9%	29.4%	17.6%	17.6%	14.7%



CSS	Years after surgery				
	1	2	3	4	5
pT0/Tis	96.7%	89.9%	83.0%	83.0%	75.4%
pT1a	100.0%	100.0%	95.5%	95.5%	95.5%
pT1b	97.2%	91.5%	88.6%	82.7%	79.8%
pT2	95.7%	83.4%	80.1%	77.6%	71.5%
pT3	86.1%	68.4%	57.7%	51.8%	49.1%
pT4a	70.0%	58.3%	46.7%	46.7%	46.7%
pT4b	83.1%	50.8%	33.9%	33.9%	28.2%

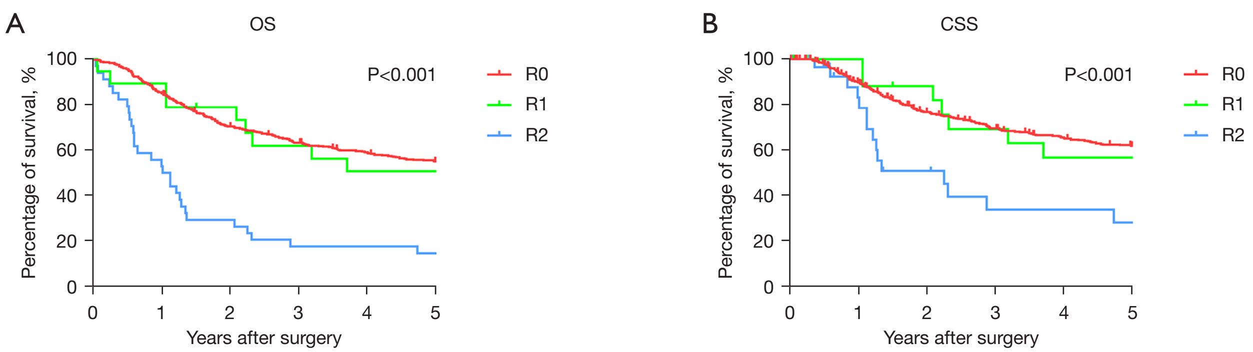
Figure 8 The survival of ESCC patients who received esophagectomy with different depth of tumor invasion (AJCC 8th edition). (A) The OS of ESCC patients who received esophagectomy with different depth of tumor invasion (AJCC 8th edition); (B) the CSS of ESCC patients who received esophagectomy with different depth of tumor invasion (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AJCC, American Joint Committee on Cancer.



OS	Years after surgery 1	2	3	4	5
pN0	89.3%	81.7%	76.8%	71.0%	67.3%
pN1	85.0%	68.0%	56.8%	55.6%	52.4%
pN2	71.9%	48.3%	38.2%	31.3%	26.6%
pN3	56.3%	18.8%	12.5%	12.5%	9.4%

CSS	Years after surgery 1	2	3	4	5
pN0	94.3%	86.6%	81.9%	77.0%	73.8%
pN1	90.0%	75.6%	63.8%	62.4%	59.5%
pN2	82.7%	61.3%	49.8%	40.7%	34.7%
pN3	69.6%	23.2%	18.6%	18.6%	13.9%

Figure 9 The survival of ESCC patients who received esophagectomy with different lymph node metastasis (AJCC 8th edition). (A) The OS of ESCC patients who received esophagectomy with different lymph node metastasis (AJCC 8th edition); (B) the CSS of ESCC patients who received esophagectomy with different lymph node metastasis (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous cell carcinoma; AJCC, American Joint Committee on Cancer.



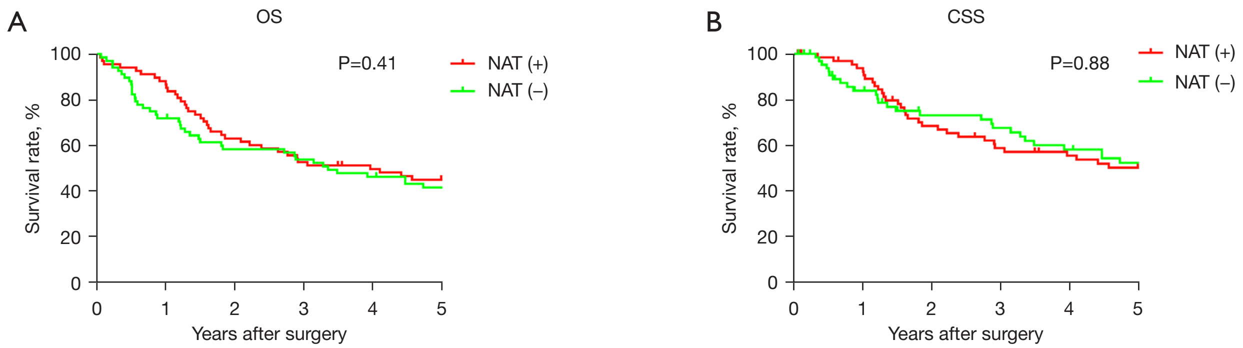
OS	Years after surgery 1	2	3	4	5
R0	85.0%	70.5%	63.4%	59.1%	55.2%
R1	89.5%	78.9%	62.0%	50.8%	50.8%
R2	52.9%	29.4%	17.6%	17.6%	14.7%

CSS	Years after surgery 1	2	3	4	5
R0	89.8%	76.7%	69.6%	65.6%	61.9%
R1	100.0%	88.2%	69.3%	56.7%	56.7%
R2	83.1%	50.8%	33.9%	33.9%	28.2%

Figure 10 The survival of ESCC patients with different postoperative residual tumor status (AJCC 8th edition). (A) The OS of ESCC patients with different postoperative residual tumor status (AJCC 8th edition); (B) the CSS of ESCC patients with different postoperative residual tumor status (AJCC 8th edition). OS, overall survival; CSS, cancer specific survival; ESCC, esophageal squamous-cell carcinoma; AJCC, American Joint Committee on Cancer.

were more commonly used for patients with T4b tumor. Most of open surgeries were through the left chest because it is easier to remove esophageal cancer with aorta invasion, and any necessary combined aortic resection can be performed at the same time. Combined tracheal resection was used in attempt to treat esophageal cancer with airway invasion, but the results were not ideal (*Table 17*). The postoperative 5-year OS of patients staged pT4b was only 14.7%.

Multidisciplinary treatment in 2017 was still mainly postoperative adjuvant treatment. There are many reasons for this. The CROSS regimen (carboplatin + paclitaxel +



OS	Years after surgery				
	1	2	3	4	5
NAT (+)	86.8%	63.2%	52.9%	49.9%	45.2%
NAT (–)	72.1%	58.5%	54.0%	46.5%	41.9%

CSS	Years after surgery				
	1	2	3	4	5
NAT (+)	92.2%	68.6%	58.9%	55.5%	50.3%
NAT (–)	83.9%	73.2%	67.6%	58.2%	52.4%

Figure 11 The survival of neoadjuvant therapy in ESCC patients (propensity score matching, n=55). (A) The OS of neoadjuvant therapy in ESCC patients (propensity score matching, n=55); (B) the CSS of neoadjuvant therapy in ESCC patients (propensity score matching, n=55). OS, overall survival; CSS, cancer specific survival; NAT, neoadjuvant therapy; ESCC, esophageal squamous-cell carcinoma.

Table 16 Multivariate Cox analysis of prognostic factors affecting OS, CSS and RFS, respectively in esophagectomy cohort of ESCC (AJCC TNM 8th)

Variables	OS		CSS		RFS	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Age	0.997 (0.979–1.014)	0.72	0.994 (0.974–1.014)	0.54	0.992 (0.974–1.010)	0.36
Gender (male/female)	1.303 (0.906–1.873)	0.15	1.351 (0.883–2.067)	0.17	1.247 (0.857–1.814)	0.25
BMI	0.984 (0.943–1.028)	0.48	0.992 (0.944–1.041)	0.73	1.000 (0.957–1.044)	0.99
Tumor location						
Middle thoracic	Reference	–	Reference	–	Reference	–
Cervical/upper thoracic	1.166 (0.842–1.615)	0.36	1.145 (0.785–1.670)	0.48	1.243 (0.882–1.751)	0.21
Lower thoracic/EGJ	1.129 (0.822–1.552)	0.45	1.108 (0.772–1.591)	0.58	1.222 (0.888–1.681)	0.22
Surgery method						
RAE	Reference	–	Reference	–	Reference	–
MIE	1.399 (0.974–2.009)	0.07	1.398 (0.923–2.118)	0.11	1.197 (0.838–1.711)	0.32
Open	1.975 (1.344–2.901)	0.001	2.097 (1.349–3.260)	0.001	1.755 (1.191–2.587)	0.004
Tumor invasion (pT)						
pT0/1	Reference	–	Reference	–	Reference	–
pT2	1.668 (0.996–2.793)	0.05	1.716 (0.966–3.048)	0.07	1.549 (0.966–2.482)	0.07
pT3	2.838 (1.837–4.385)	<0.001	2.620 (1.601–4.287)	<0.001	1.965 (1.309–2.949)	0.001
pT4	4.105 (2.410–6.992)	<0.001	3.270 (1.741–6.139)	<0.001	2.338 (1.342–4.074)	0.003
Lymph node metastasis (pN)						
pN0	Reference	–	Reference	–	Reference	–
pN1	1.862 (1.330–2.606)	<0.001	1.809 (1.232–2.656)	0.003	1.619 (1.157–2.266)	0.005
pN2	3.371 (2.346–4.842)	<0.001	3.185 (2.096–4.841)	<0.001	2.397 (1.634–3.517)	<0.001
pN3	5.428 (3.435–8.575)	<0.001	5.936 (3.507–10.045)	<0.001	4.039 (2.448–6.662)	<0.001
Adjuvant treatment	0.491 (0.368–0.654)	<0.001	0.659 (0.471–0.920)	0.01	0.848 (0.626–1.148)	0.29

BMI in accordance with the Asia-Pacific standards. OS, overall survival; CSS, cancer specific survival; RFS, recurrence-free survival; ESCC, esophageal squamous cell carcinoma; BMI, body mass index; RAE, robot-assist esophagectomy; MIE, minimal invasive esophagectomy; AJCC, American Joint Committee on Cancer; TNM, tumor-node-metastasis; EGJ, esophagogastric junction; HR, hazard ratio; CI, confidence interval.

Table 17 Causes of R2 resection (n=32)

Main invasion spot of R2 resection	Cases (%)
Trachea	18 (56.3)
Aorta	5 (15.6)
Mediastinal pleura	1 (3.1)
Azygos vein	2 (6.3)
Atrium	1 (3.1)
Celiac trunk	1 (3.1)
Vena cava	2 (6.3)
Spleen	2 (6.3)

R2: unresectable tumor which invaded adjacent organs.

radiotherapy) was not included in the NCCN guidelines until 2019 (9,14), and China's 5010 research had not been officially announced until 2018 (15). Another important reason is that most of our patients came from other cities, and the cost of continuous preoperative treatment in Shanghai was too high to afford. They preferred to receive surgery first and then returned to the local area for any additional treatment. Thus, the beneficiaries of neoadjuvant therapy were still unclear in 2017 cohort.

In the past medical record of SCH, the safety of surgery is relatively acceptable. The 30-day surgical mortality rate of the entire group in 2017 was only 0.008%. With the emphasis on mediastinal lymph node dissection and the advantages of RAE, surgeons have more confidence to perform radical lymph node dissection and expose the recurrent laryngeal nerve. Thus, the incidence of recurrent laryngeal nerve injury had increased significantly, which is difficult to see and difficult to accept in West. However, according to recent research in Asia, most recurrent laryngeal nerve injuries are temporary and can recover within 6 months, with no impact on long-term survival (16,17). In the future, the prevention of recurrent laryngeal nerve injury may prove to be essential for optimizing patient outcomes and enhancing overall quality of life.

We recognize that our study has limitations. This is a very typical Asian esophageal cancer cohort, with mainly squamous cell carcinoma. Perhaps our clinical staging is still not accurate enough, and there was not enough analysis of specific causes of death during follow-up, especially non-tumor causes of death and the occurrence of second tumors. In addition, non-surgical patients who received internal medical treatment alone were not included in the analysis.

Conclusions

The focus of this report is to describe the long-term survival after surgical treatment of esophageal cancer in a single center in China. Our 5-year OS is 52.9%, which is lower than Japan's 2015 results (59.9%) (3). But we should notice that 40.7% of patients in the Japanese annual report of 2015 were staged T1, which only accounted for 17.7% in our cohort. In subgroup analysis, especially among stage II–III patients, our survival results were comparable to those in Japan. Therefore, advanced tumor stage may be the main reason for the above differences in OS. We cannot compare these groups directly because of factors such as induction treatment, staging and so on. We hope this report would provide reference for diagnosing and treatment of esophageal cancer in the future.

Acknowledgments

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-49/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-49/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-49/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-49/coif). L.Z.G serves as Associate Editor-in-Chief of *Journal of Thoracic Disease* from April 2024 to April 2025. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of the Shanghai Chest Hospital (No. KS23067). Individual consent for this retrospective analysis was waived.

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