The Sweet Approach Is Still Worthwhile in Modern Esophagectomy

Jun Ma, BA,* Cheng Zhan, MS,* Lin Wang, BA, Wei Jiang, MS, Yongxing Zhang, MD, Yu Shi, MD, and Qun Wang, MD

Department of Thoracic Surgery, ZhongShan Hospital, Fudan University, Shanghai, China

Background. **The Ivor Lewis and Sweet approaches are the two most widely used open transthoracic esophagectomy techniques. We evaluated and compared the therapeutic efficacy of these two approaches to determine the appropriate method to treat middle or lower third esophageal carcinomas.**

Methods. **We retrospectively reviewed patients who underwent esophagectomy with the Sweet (n = 748) and Ivor Lewis (n = 167) approaches at Zhongshan Hospital, Fudan University between January 2007 and December 2010. Patients with preoperatively identified superior mediastinal lymph node metastases, high-level lesions (above the carina), and benign tumors were excluded. Perioperative-related indicators and 5-year survival rates were compared between groups.**

Results. **Compared with the Ivor Lewis approach, the Sweet approach has a shorter operative time (181 ± 71 minutes versus 208 ± 63 minutes; $p < 0.001$), less blood loss (167 ± 71 mL versus 179 ± 87 mL; $p = 0.043$), and a lower incidence of transfusion (8.7% versus 13.8%; $p = 0.044$) and postoperative complications (12.3% versus 20.4%; $p = 0.002$). The Ivor Lewis approach was more likely to result in wound infection (3.2% versus 7.8%; $p = 0.010$) and delayed gastric emptying (1.7% versus 4.7%; $p = 0.046$). There was no significant difference between groups with regard to the number of lymph nodes harvested or total number of patients with lymph node metastases. There was no significant difference in locoregional recurrence, distant recurrence, or 5-year survival between approaches.**

Conclusions. **The Sweet approach has many advantages for the treatment of middle or lower third esophageal carcinomas. It is a safe, effective, and worthwhile approach in modern thoracic surgery.**

(Ann Thorac Surg 2014;■:■–■)

Esophageal cancer is a common solid tumor, the fifth leading cause of cancer-related death in men, and the eighth in women [1]. Radical esophagectomy with lymphadenectomy remains the mainstay of curative therapy. The surgical approach for these cancers impacts mortality and may influence the ability to achieve tumor clearance, and thus survival [2]. Nevertheless, no standard surgical approach exists for esophagectomy. The surgical approach is determined by tumor type, anatomic location, the patient's physiologic state, probability of cure, and surgeon preference.

An international survey on esophageal cancer showed that in the case of open transthoracic esophagectomy, the Ivor Lewis approach is the most routinely performed approach by most surgeons, although a few still tend to perform the Sweet approach [3]. In China, the Sweet approach is still widely used, remaining one of the primary surgical approaches for treating middle or lower third lesions. We evaluated and compared the therapeutic efficacy of the Sweet and Ivor Lewis approaches to determine the most appropriate method for treating middle and lower third esophageal carcinomas.

Patients and Methods

All patients with esophageal carcinoma who underwent esophagectomy at Zhongshan Hospital, Fudan University between January 2007 and December 2010 were retrospectively reviewed. Patients with preoperative superior mediastinum lymph node metastasis, higher lesion location (above the level of the carina), and benign tumors were excluded. Surgical approaches are shown in Table 1. The Sweet and the Ivor Lewis approaches were most frequently used in middle or lower third esophageal lesions. Both operations were performed by all surgeons, with each surgeon having performed more than 100 esophagectomies. Minimally invasive esophagectomy, the Ivor Lewis approach with cervical incision, the Sweet approach with cervical incision, and the left thoracoabdominal approach were also excluded. This study was approved by the appropriate ethics committees of Zhongshan Hospital, Fudan University (Approval No. B2012-120).

Data on clinical variables including gender, age, preoperative evaluation, date of surgery, postoperative complications, locoregional and distant recurrence, and date of death were retrospectively reviewed. Pulmonary

Accepted for publication Jan 17, 2014.

*Jun Ma and Cheng Zhan contributed equally to this work.

Address correspondence to Dr Qun Wang, Department of Thoracic Surgery, ZhongShan Hospital, Fudan University, 180 Fenglin Rd, Shanghai, China; e-mail: wang.qun@zs-hospital.sh.cn.

Published by Elsevier Inc

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2014.01.034

Table 1. Surgical Approach

Surgical Approach	No.
Sweet approach	748 (65.7%)
Ivor Lewis approach	167 (14.7%)
Minimally invasive esophagectomy	130 (11.4%)
Ivor Lewis approach + cervical incision	77 (6.8%)
Sweet approach + cervical incision	15 (1.3%)
Left thoracoabdominal	1 (0.1%)
Total	1,138 (100%)

complications included pneumonia, pleural effusion, atelectasis, pulmonary embolism, and respiratory failure. Delayed gastric emptying was defined as weak gastric peristalsis under radiographic fluoroscopy, contrast agent not passing the pylorus, or greater than 400 mL of gastric fluid from the gastric tube daily. Wound infection referred to thoracotomy or laparotomy incision infection. Pathologic pattern including tumor size, lymph node status, and metastasis were obtained from the pathologists' original reports. Tumor stage was redefined according to the Union for International Cancer Control TNM Staging (7th edition, 2009). Operative mortality was defined as death within the first 30 postoperative days or during the same hospital stay. Tumor location was defined by the results of surgery, endoscopy, and computed tomography scans. Locoregional recurrence was defined as recurrence at the site of the primary tumor, the anastomotic site, or periesophageal lymph nodes, whereas distant recurrence was defined as occurring in the lung, pleura, liver, or other distant organs.

All patients were followed for 24 to 72 months (median, 33.6 months). The last date of follow-up was December 30, 2012. Surviving patients and patients lost to follow-up were censored at the date of last follow-up. Patients who died of noncancer causes were censored at the date of death.

Data were analyzed and compared using the χ^2 test, the Student's t test, and Wilcoxon signed-rank test when justified. Survival analysis was performed using the Kaplan-Meier method, based on the last follow-up date. All tests were performed using SPSS statistical software, version 19. A probability value of less than 0.05 was considered to be statistically significant.

Surgical Technique

In the Sweet approach, a left posterolateral thoracotomy is performed through the fifth or sixth intercostal incision. Sharp and blunt dissection of the esophagus was performed at least 5 cm above lesions. Care was taken to avoid injury to the thoracic duct, the left vagus nerve, and the recurrent laryngeal nerve. Once the esophagus was completely freed, the diaphragm was entered though a 5- to 6-cm radial incision. The stomach was mobilized through the left thoracic cavity, preserving the right gastroepiploic artery and arcades; the left gastric artery and vein were ligated at their origins. If possible, a complete upper abdominal and distal mediastinal lymph node dissection was performed with en bloc resection of the distal esophagus and proximal stomach. Standard preparation of the stomach tube was performed in the left chest through diaphragmatic incision with a mechanical esophagogastric anastomosis above or below the aortic arch.

In the Ivor Lewis approach, the stomach is first mobilized through the abdominal incision, preserving the right gastroepiploic artery and arcades; the left gastric artery and vein were ligated at their origins. Then, esophagectomy is performed through the fifth or sixth intercostal incision. The esophagus is resected and the stomach is brought into the right chest through the esophageal hiatus, followed by a mechanical esophagogastric anastomosis.

A double-lumen endotracheal tube was routinely used during general anesthesia, combined with epidural analgesia. All patients undergoing the Sweet approach had a nasogastric tube and a nasojejunal tube placed for postoperative feeding. Patients undergoing the Ivor Lewis approach only had a nasogastric tube inserted, and were fed peripherally postoperatively. If there was anastomotic leakage or delayed gastric emptying, a nasojejunal feeding tube was inserted endoscopically. Preoperative chemoradiotherapy was not used in any cases. Adjuvant treatment was administered according to the postoperative histopathologic diagnosis.

Results

As shown in Table 2, there was no statistically significant difference between surgical approaches with regard to age, sex, TNM stage, and pathologic pattern. Twenty-one patients had pathologic celiac lymph node metastasis (M1a, stage IV).

As shown in Table 3, there was no significant difference in the number of lymph nodes dissected between the Sweet and Ivor Lewis approaches, thoracic or abdominal. However, in the Ivor Lewis approach, there was a higher rate of positive thoracic lymph nodes (28.7% versus 38.7%; $p < 0.0001$). There was no significant difference in the total number of lymph node metastases between the two approaches (42.5% versus 45.2%; $p = 0.103$).

Intraoperative conditions are shown in Table 4. Compared with the Sweet approach, the Ivor Lewis approach had longer operative times (181 ± 71 minutes versus 208 ± 63 minutes; $p < 0.001$) and more blood loss (167 ± 71 mL versus 179 ± 87 mL; $p = 0.043$). Transfusion rates between the Sweet and the Ivor Lewis approaches were 8.7% and 13.8%, respectively ($p = 0.044$).

Postoperative complications are listed in Table 5. Compared with the Sweet approach, there were more postoperative complications than with the Ivor Lewis approach (12.3% versus 20.4%; $p = 0.002$). There were more wound infections (3.2% versus 7.8%; $p = 0.010$) and delayed gastric emptying (1.7% versus 4.7%; $p = 0.046$) in the Ivor Lewis approach compared with the Sweet approach. The incidence of anastomotic leak was also higher with the Ivor Lewis approach (2.1% versus 4.2%;

Table 2. Clinicopathologic Features

Clinical Feature	Sweet Approach	Ivor Lewis Approach	No.	*p* Value
No.	748 (81.7%)	167 (18.3%)	915 (100%)	
Sex				0.340
Male	608 (81.3%)	141 (84.4%)	749 (81.9%)	
Female	140 (18.7%)	26 (15.6%)	166 (18.1%)	
Age				0.657
≥60 y	371 (49.6%)	86 (51.5%)	457 (50%)	
<60 y	377 (51.4%)	81 (48.5%)	458 (50%)	
Pathologic pattern				0.689
Squamous carcinoma	681 (91.1%)	155 (92.8%)	836 (91.4%)	
Adenocarcinoma	33 (4.4%)	5 (3.0%)	38 (4.2%)	
Others	34 (4.5%)	7 (4.2%)	41 (4.4%)	
Location				0.899
Middle thoracic	501 (67%)	111 (66.5%)	612 (66.9%)	
Lower thoracic	247 (33%)	56 (33.5%)	303 (33.1%)	
TNM stage				0.090
0	11 (1.5%)	3 (1.8%)	14 (1.5%)	
I	173 (23.1)	30 (18.0%)	203 (22.2%)	
II	282 (37.7%)	53 (31.7%)	335 (36.6%)	
III	264 (35.3)	78 (46.7%)	342 (37.4%)	
IV	18 (2.4%)	3 (1.8%)	21 (2.3%)	

$p = 0.099$), although this difference did not reach statistical significance.

As shown in Table 6, the Ivor Lewis approach resulted in a longer postoperative hospital stay, with a greatly increased number of patients hospitalized for more than a month.

Two groups of patients were followed for 24 to 72 months (median, 33.6 months). In all 915 patients, 618 patients had complete follow-up data, including locoregional and distant recurrence. There was no significant difference between groups with regard to postoperative locoregional and distant recurrence (Table 7). The overall 5-year survival rate for the entire series was 47.42%. There was no significant difference in overall 5-year survival between the Sweet and Ivor Lewis approaches (46.56% versus 48.35%; $p = 0.388$). The median survival between the Sweet and Ivor Lewis approaches was 52 and 48 months, respectively (Fig 1).

Comment

Esophagectomy remains the mainstay of therapy for esophageal carcinoma; however, no standard surgical procedure exists. Open transthoracic esophagectomy includes the Sweet, Ivor Lewis, and left thoracoabdominal approaches, each of which can be combined with a cervical incision for the anastomosis [4]. Each surgical approach has its advantages and disadvantages. Several studies advocated three-field lymph node dissection. However, this results in more surgical stress and

Table 3. Lymphadenectomy

Lymph Node Dissection	Sweet Approach	Ivor Lewis Approach	*p* Value
Number of lymph node dissections			
Thoracic	10.36 ± 6.595	11.59 ± 8.044	0.066
Abdominal	7.09 ± 5.399	7.30 ± 5.316	0.643
Total	17.45 ± 8.591	18.89 ± 10.085	0.087
Thoracic lymph node metastasis			0.000
No	529 (71.3%)	93 (61.3%)	
Yes	219 (28.7%)	74 (38.7%)	
Abdominal lymph node metastasis			0.108
No	551 (74.0%)	133 (81.4%)	
Yes	197 (26.0%)	34 (18.6%)	
Total lymph node metastasis			0.103
No	428 (57.5%)	84 (54.8%)	
Yes	320 (42.5%)	83 (45.2%)	

Table 4. Intraoperative Conditions

Variable	Sweet Approach	Ivor Lewis Approach	*p* Value
Operating time (min)	181 ± 71	208 ± 63	<0.001
Bleeding volume (mL)	165 ± 73	179 ± 87	0.031
Transfusion status			0.044
No	683 (91.3%)	144 (86.2%)	
Yes	65 (8.7%)	23 (13.8%)	

postoperative complications, and impairs quality of life [5]. Conversely, some authors do not favor lymphadenectomy, considering lymph node involvement to be a systemic disease without hope for cure, with the primary goal of surgical intervention being palliative with low morbidity and mortality; in these cases, a transhiatal approach is preferred [6]. However, the disadvantage of the transhiatal technique is the inability to perform an adequate lymphadenectomy. Futhermore, it may predispose one to bleeding and may prove hazardous if the tumor involves contiguous structures [7]. Thus, these two surgical approaches involve only a smaller proportion in China.

The two most common surgical approaches in our unit were the Ivor Lewis and Sweet approaches. The Sweet approach was first described by Churchill and Sweet [8]. It offers several advantages for tumors in the middle and lower third of the esophagus. It excellently exposes the hiatus, requiring simple patient positioning with a single incision. At the same time, it offers adequate exposure of the stomach and excellent access to the short and left gastric arteries through the opening in the left hemidiaphragm [9]. Wound opening and closing are rapid and simple, reducing operative times, postoperative complications, and hospital stay. The Ivor Lewis approach was proposed by Ivor Lewis in the 1940s [10], in which it is more convenient to dissect the upper mediastinal lymph nodes, segregate the lesion, resect the subtotal esophagus, and identify and ligate the thoracic duct. If the tumor was too large, invading the azygos vein and aortic arch, resection rates are higher for Ivor Lewis esophagectomy.

Complete resection of the esophagus and regional lymph nodes are essential to improve long-term survival [11]. Although it is difficult to dissect the superior mediastinal lymph nodes through the Sweet approach, in our study we did not find a significant difference in the number of lymph nodes harvested between approaches for thoracic, abdominal, or total lymph nodes dissected. The Ivor Lewis approach had a higher positive thoracic lymph node metastasis rate, of which 21 patients (12.6%) had superior mediastinal lymph node metastases. With regard to total lymph node metastases, there was no significant difference between approaches. This indicates that in middle or lower third esophageal carcinoma, only a small number of patients have superior mediastinal lymph node metastasis. For these patients, postoperative chemoradiotherapy may influence long-term survival. Therefore, there is no significant difference in long-term survival between approaches. As this study was retrospective and adjuvant therapy was not uniform, it lacks equilibrium and comparability. When lymph nodes metastasize to the superior mediastinum, this generally indicates widespread disease [12]. Whether patients with middle or lower third esophageal lesions benefit from superior mediastinum lymph node dissection needs further exploration.

Comparing the Sweet and Ivor Lewis approaches, an additional abdominal incision is required, which then increases surgical insult, operative times, blood loss, allogeneic blood transfusion, and wound infection rates, which subsequently prolong postoperative hospital stay. Some surgeons attempt to improve the surgical approach to shorten operative times by placing the patient in the 45-degree left lateral decubitus position, and through a right anterolateral thoracotomy, dissecting the esophagus, making an upper midline abdominal incision, and exploring the abdomen. In this method, the posterior mediastinal exposure is poor and it is difficult to resect a larger, more invasive tumor; lymph node dissection is also not optimal as with a posterolateral incision.

In our experience, the incidence of delayed gastric emptying with the Ivor Lewis approach is higher than in the Sweet approach, different from those reported in the literature [13]. Both approaches are performed without pyloroplasty; as the rate of delayed gastric emptying was 2.3%, we thought pyloroplasty to be unnecessary. The

Table 5. Postoperative Complications

Complication	Sweet Approach	Ivor Lewis Approach	No.	*p* Value
No.	748	167	915	
Total complications	96 (12.3%)	34 (20.4%)	130 (14.2%)	0.002
Pulmonary complications	23 (3.1%)	5 (3.0%)	28 (3.2%)	0.472
Vocal cord palsy	1 (0.1%)	1 (0.6%)	2 (0.3%)	0.110
Arrhythmia	9 (1.2%)	2 (1.2%)	11 (1.5%)	0.504
Anastomotic leakage	16 (2.1%)	7 (4.2%)	23 (2.5%)	0.099
Delayed gastric emptying	13 (1.7%)	8 (4.7%)	21 (2.2%)	0.046
Wound infection	24 (3.2%)	13 (7.8%)	37 (5.0%)	0.010
Chylothorax	8 (1.0%)	2 (1.2%)	10 (1.0%)	1.000
Pyothorax	5 (0.7%)	2 (1.2%)	7 (0.7%)	0.639
Mortality	17 (2.3%)	3 (1.8%)	16 (3.0%)	0.161

Table 6. Postoperative Hospital Stay and Transfusion Status

Postoperative Hospital Stay	Sweet Approach	Ivor Lewis Approach	*p* Value
Median (Q1–Q3)	10 (9–13) days	11 (10–18) days	<0.001
Mean ± SD	13.2 ± 11.0 days	17.3 ± 15.6 days	0.002
≥30 days	33 (4.4%)	21 (12.6%)	<0.001
<30 days	715 (95.6%)	146 (87.4%)	

Q1–Q3, first through third quartile.

main cause of delayed gastric emptying was that the hiatus is located at the left diaphragm. In the Ivor Lewis approach, the stomach tube is brought up into the right chest through the hiatus. The tubular stomach, traversing the diaphragm, may be compressed by the liver, which can easily lead to gastric retention. In the Sweet approach, the tubular stomach is placed in the left chest, and is less likely to be affected by the liver.

Pulmonary complications were the second most common complication in this study, different from previous reports [14]. which may be related to the use of a gastric tube, pressing on the intrathoracic lung. There was no evidence that opening the diaphragm would impact pulmonary function. In this study, the Sweet approach requires opening the diaphragm through a longitudinal incision, with no significant difference between approaches with regard to pulmonary complications. Age, operative times, and tumor location are risk factors for pulmonary complications [15].

The Sweet approach is primarily performed in the middle and lower third of the esophagus. For higher lesion locations or the inability to complete the intrathoracic anastomosis during the operation, a cervical incision can be added, although this is not routine. Combining the cervical incision with the Sweet approach is safe compared with other approaches [9]. During the operation, the incision can also be extended to the abdominal wall for distal esophageal and esophagogastric junction carcinomas, as well as those that are difficult to access or with a large tumor bulk.

Although in this study we found that the Sweet approach has many advantages for the treatment of lower third lesions, the study was retrospective and with many shortcomings. We look forward to further randomized controlled trials to confirm the results of this study. The

Table 7. Locoregional Recurrence and Distant Recurrence

Recurrence	Sweet Approach	Ivor Lewis Approach	*p* Value
Locoregional recurrence			0.695
No	437	91	
Yes	76	14	
Distant recurrence			0.247
No	357	79	
Yes	156	26	

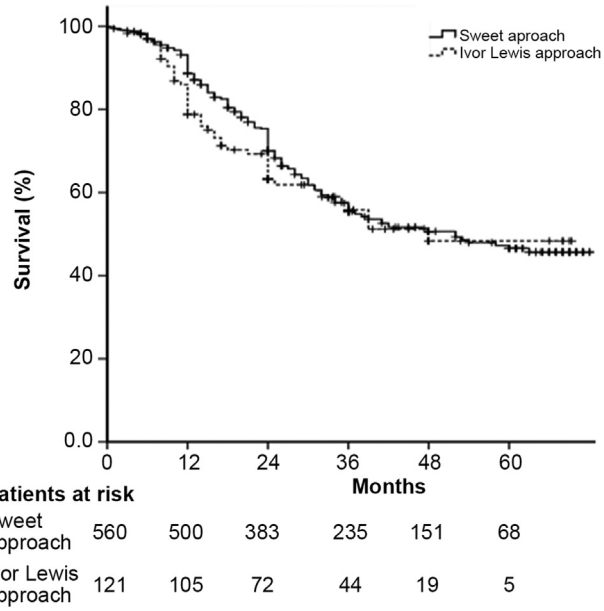

Fig 1. Survival rates.

predominant cell type in this study is squamous carcinoma; whether these data apply to adenocarcinoma, the predominant cell type in Western countries, requires further exploration. In recent years, the number of patients who undergo minimally invasive esophagectomy has increased. Minimally invasive esophagectomy has many advantages in lymph node dissection, such as reducing pulmonary infection, shortening hospital stay, and improving short-term quality of life [16, 17]. However, in hospitals without the capabilities for minimally invasive surgery, or for patients with advanced esophageal cancer, we still advocate open transthoracic esophagectomy, especially the Sweet approach.

Although none of these approaches have made any significant difference in long-term survival, we believe that the Sweet approach is safe, effective, and worthwhile in modern thoracic surgery. It has many advantages in the treatment of middle or lower third esophageal carcinoma, especially with regard to the lower incidence of postoperative complications and shorter hospital stay.

This work was supported by Doctoral Program Foundation of Institutions of Higher Education of China (No. 20110071120066).

References

1. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. CA Cancer J Clin 2011;61:69–90.
2. Suttie SA, Nanthakumaran S, Mofidi R, et al. The impact of operative approach for oesophageal cancer on outcome: the transhiatal approach may influence circumferential margin involvement. Eur J Surg Oncol 2012;38:157–65.
3. Boone J, Livestro DP, Elias SG, Borel Rinkes IH, van Hillegersberg R. International survey on esophageal cancer: part I surgical techniques. Dis Esophagus 2009;22:195–202.

4. Page RD, Khalil JF, Whyte RI, Kaplan DK, Donnelly RJ. Esophagogastrectomy via left thoracophrenotomy. Ann Thorac Surg 1990;49:763–6.
5. Nozoe T, Kakeji Y, Baba H, Maehara Y. Two-field lymph-node dissection may be enough to treat patients with submucosal squamous cell carcinoma of the thoracic esophagus. Dis Esophagus 2005;18:226–9.
6. Bogoevski D, Bockhorn M, Koenig A, et al. How radical should surgery be for early esophageal cancer? World J Surg 2011;35:1311–20.
7. Nandy N, Dasanu CA. Incidence of second primary malignancies in patients with esophageal cancer: a comprehensive review. Curr Med Res Opin 2013;29:1055–65.
8. Churchill ED, Sweet RH. Transthoracic resection of tumors of the esophagus and stomach. Ann Surg 1942;115:897–920.
9. Han S, Sakinci U, Dural K. Left thoracophrenotomy and cervical approach in the surgery of distal third oesophageal and cardia tumours. ANZ J Surg 2005;75:1045–8.
10. Lewis I. The surgical treatment of carcinoma of the oesophagus; with special reference to a new operation for growths of the middle third. Br J Surg 1946;34:18–31.
11. Wu J, Chai Y, Zhou XM, Chen QX, Yan FL. Ivor Lewis subtotal esophagectomy with two-field lymphadenectomy for squamous cell carcinoma of the lower thoracic esophagus. World J Gastroenterol 2008;14:5084–9.
12. Lagarde SM, Cense HA, Hulscher JB, et al. Prospective analysis of patients with adenocarcinoma of the gastric cardia and lymph node metastasis in the proximal field of the chest. Br J Surg 2005;92:1404–8.
13. Song L, Liu Y, Wang Z, Ren WG, Liu XY. Curative effect comparison between Ivor-Lewis esophagectomy and left transthoracic esophagectomy in treatment of middle thoracic esophagus carcinoma. Hepatogastroenterology 2012;59:738–41.
14. Hii MW, Smithers BM, Gotley DC, et al. Impact of postoperative morbidity on long-term survival after oesophagectomy. Br J Surg 2013;100:95–104.
15. Law S, Wong KH, Kwok KF, Chu KM, Wong J. Predictive factors for postoperative pulmonary complications and mortality after esophagectomy for cancer. Ann Surg 2004;240:791–800.
16. Osugi H, Takemura M, Higashino M, Takada N, Lee S, Kinoshita H. A comparison of video-assisted thoracoscopic oesophagectomy and radical lymph node dissection for squamous cell cancer of the oesophagus with open operation. Br J Surg 2003;90:108–13.
17. Khan O, Nizar S, Vasilikostas G, Wan A. Minimally invasive versus open oesophagectomy for patients with oesophageal cancer: a multicentre, open-label, randomised controlled trial. J Thorac Dis 2012;4:465–6.