World J Surg (2019) 43:2483–2489
https://doi.org/10.1007/s00268-019-05057-0

ORIGINAL SCIENTIFIC REPORT

Comparison of Outcomes with Semi-mechanical and Circular Stapled Intrathoracic Esophagogastric Anastomosis following Esophagectomy

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Published online: 20 June 2019

Abstract

Background Several techniques have been described for esophagogastric anastomosis following esophagectomy. This study compared the outcomes of circular stapled anastomoses with semi-mechanical technique using a linear stapler.

Methods Perioperative data were extracted from a contemporaneously collected database of all consecutive esophagectomies for cancer with intrathoracic anastomoses performed in the Trent Oesophago-Gastric Unit between January 2015 and April 2018. Anastomotic techniques: circular stapled versus semi-mechanical, were evaluated and outcomes were compared. The primary outcome was anastomotic leak rate. Secondary outcomes included anastomotic stricture, overall complication rates, length of stay (LOS) and 30 day all-cause mortality.

Results One hundred and fifty-nine consecutive esophagectomies with intrathoracic anastomosis were performed during the study period. There were no significant differences between the two groups in terms of age, American Society of Anaesthesiologists score, Charlson comorbidity index and neoadjuvant therapies received. Circular stapled anastomoses were performed in 85 patients, while 74 patients received a semi-mechanical anastomosis. Clavien–Dindo complications II or more were higher in the circular stapled group ($p = 0.02$). There were 16 (10%) anastomotic leaks overall, three (4%) in semi-mechanical group versus 13 (15%) in the circular stapled group ($p < 0.019$). There was no statistically significant difference between the two groups in terms of LOS, 30-day mortality or the need for endoscopic dilatation of the anastomosis at 3 months follow-up.

Conclusion The move from a circular stapled to a semi-mechanical intrathoracic anastomosis has been associated with a reduced postoperative anastomotic leak rate following esophagectomy for esophageal cancer.

Introduction

While perioperative outcomes following esophagectomy continue to improve, morbidity is still common [1, 2]. Both short- and long-term morbidity and mortality are driven by perioperative complications [3, 4]. While many studies have focused on centralization of cancer care, enhanced recovery following surgery and neoadjuvant and adjuvant therapies [5-11], a key unanswered question is the ideal anastomotic technique.

Several techniques have been described for esophagogastric anastomosis. The most commonly employed

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techniques are hand-sewn or circular stapled techniques. Circular stapled anastomoses are not thought to reduce the incidence of anastomotic leaks when compared to hand-sewn techniques and may increase stricture rates; however, circular stapled anastomoses are less time-consuming [12].

A semi-mechanical technique, using a linear stapler to form a side-to-side anastomosis followed by suture closure of the enterotomies, is described and generally used in cervical anastomosis following esophagectomy [13-15]. Recent reports have described its use for intrathoracic anastomoses with evidence of improved stricture rates [16].

In Trent Oesophago-Gastric Unit (TOGU), semi-mechanical technique has been gradually introduced by thoracic surgery team for cervical anastomoses. Given the above reports and favorable experiences by the local thoracic surgery team, it started to gain favor over other techniques, circular and hand-sewn.

This study evaluates the outcomes of semi-mechanical and circular stapler techniques for patients undergoing esophagectomy with intrathoracic anastomosis and how local change in practice has influenced anastomosis-related complications.

Methods

Perioperative data were extracted from a contemporaneously collected database of all consecutive esophagectomies with intrathoracic anastomoses performed in the Trent Oesophago-Gastric Unit (TOGU), Nottingham University Hospitals, between January 2015 and April 2018. TOGU is a regional referral center of esophagogastric cancer. All esophagectomies included in this study were performed for cancer. All surgery was performed in a single high-volume center (TOGU), which performs more than 100 cases of esophagogastric cancer resections per annum [17] with each surgeon performing 20 or more esophageal and gastric cancer resections each year. Figure 1 shows a flowchart of cases included in this study.

Exclusion criteria

1. Patients found to have inoperable disease at surgery.
2. Hand-sewn anastomosis (as only one case performed during study period)
3. Esophagectomy with cervical anastomosis (transhiatal and McKeown's three-stage esophagectomy) for tumors starting at 28 cm or higher on endoscopic preoperative staging.

The primary outcome of this study was to compare the rates of anastomotic leak, defined as a full thickness gastrointestinal defect involving esophagus, staple line or conduit irrespective of presentation or method of identification. Secondary outcomes included anastomotic stricture (causing dysphagia and/or vomiting, confirmed endoscopically and requiring one or more endoscopic dilatations) within 3 months of surgery, overall complication rates, length of stay (LOS) and 30-day all-cause mortality. Anastomotic leak, conduit necrosis and chyle leak were graded according to the Esophagectomy Complications Consensus Group (ECCG) definitions [18]. The length of follow-up was 3 months.

All included patients routinely underwent preoperative staging using an agreed protocol depending on the site and histological type of the tumor using, computed tomography (CT), staging laparoscopy (except if histologically squamous cell carcinoma) and fluorodeoxyglucose positron emission tomography/computed tomography (PET-CT). Decision to offer surgery ± neoadjuvant or adjuvant treatment was agreed by a multidisciplinary team (MDT).

All patients underwent radical two-field lymphadenectomy. An approach to abdominal phase, either open or laparoscopic, was decided prior to the start of surgery. In some patients, this was determined by a randomization process as TOGU was a major recruiting center for the ROMIO study [19]. All open abdominal procedures were combined with pyloroplasty. Laparoscopic abdominal phase was not combined with pyloroplasty. Gastric tube (at least 3 cm width) was created using linear staplers with or without inversion of staple line with continuous or interrupted stitches. The technique of intrathoracic esophagogastric anastomosis was determined by the operating surgeon at time of surgery.

In the circular anastomosis, a size 25- or 28-mm circular stapler (Covidien/Medtronic CEEA) was used in all patients. The used stapler size was determined by the main surgeon depending on the diameter of the esophagus. In the semi-mechanical anastomosis technique, the top of the gastric conduit tube is placed below the divided open distal end of the upper esophagus creating at least 3 cm overlap and secured with stay sutures (PDS 2/0) (Fig. 2). A small gastrostomy is performed just distal to the edge of esophagus and a 30-mm linear stapler is used (Covidien/Medtronic Endo GIA) to create a side-to-side anastomosis (Figs. 3, 4). The anterior esophageal edge was approximated with the distal gastrostomy edge using a single layer of interrupted or continuous 2/0 PDS (Fig. 5). It is not routine practice in TOGU to perform an anastomotic 'air leak' test or wrapping the anastomosis with pedicled omentum.

All esophagectomy patients are routinely admitted to the critical care unit immediately postoperatively and then subjected to an enhanced recovery program. Resumption of oral intake is based on the clinical and biochemical picture. Radiological or endoscopic checks for anastomotic

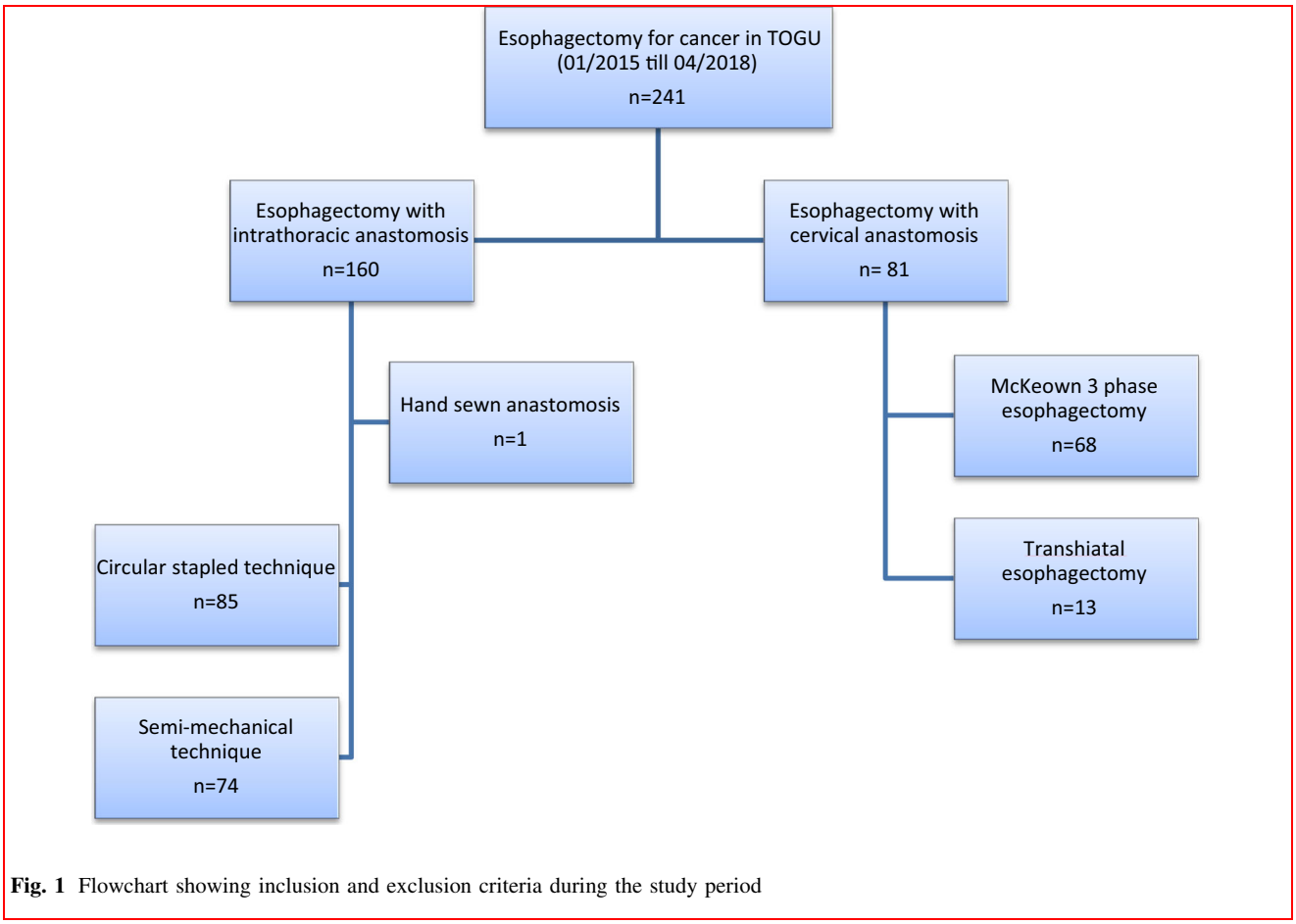

Fig. 1 Flowchart showing inclusion and exclusion criteria during the study period

Fig. 2 Top of the gastric conduit is placed beneath the bottom end of divided esophagus in preparation of side-to-side anastomosis

integrity are not routinely employed unless clinical or intraoperative concerns are raised.

Data collected included patients' demographics, approach to abdominal phase of esophagectomy (all chest procedures were performed via open approach), Charlson comorbidity index (CCI) scores, American Society of Anaesthesiologists (ASA) score, lengths of ITU/HDU (intensive care/high dependency located at same unit) stay, length of hospital stay, postoperative histology results (hence 21% were stage IV disease) and stage of cancer using the eighth edition of the American Joint Committee on Cancer (AJCC) (TNM8) [20]. All postoperative complications were recorded and graded using the Clavien–Dindo complications classification [21]. These included operative re-intervention and 30-day all-cause mortality.

Statistical analysis

Analysis was carried out using GraphPad Prism version 8.00 for Windows 64 bits (GraphPad Software, 2365 Northside Dr. Suite 560, San Diego, CA 92108). Chi-squared analysis was performed for categorical data, and Mann–Whitney *U* tests were employed for continuous data.

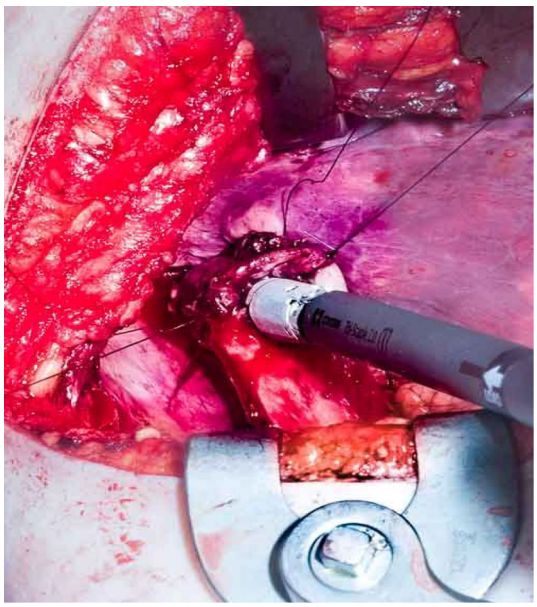

Fig. 3 30-mm linear stapler is then placed to staple the back of esophageal end to front of gastric conduit

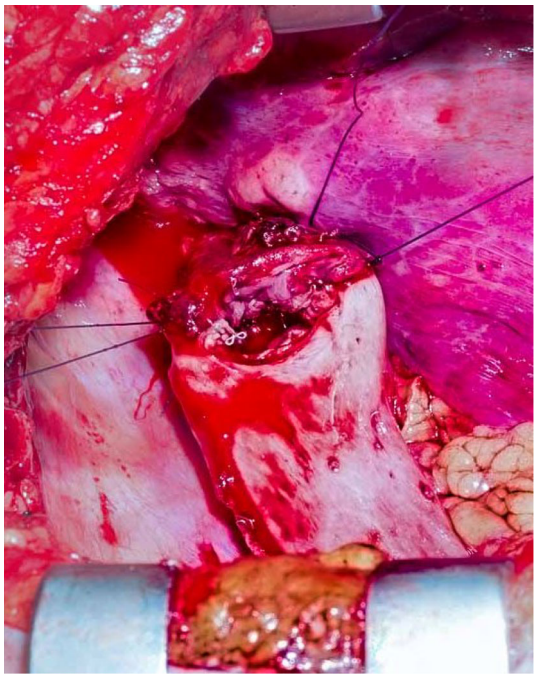

Fig. 4 Side-to-side anastomosis achieved followed by closure of enterotomies

Results

Between January 2015 and April 2018, 159 patients underwent esophagectomy with circular stapled or semi-mechanical intrathoracic anastomosis for lower esophageal or gastroesophageal junction cancer. The median age of patients was 67 (range 34–85) years. The majority of resections were performed for adenocarcinoma of the esophagus (86.2%).

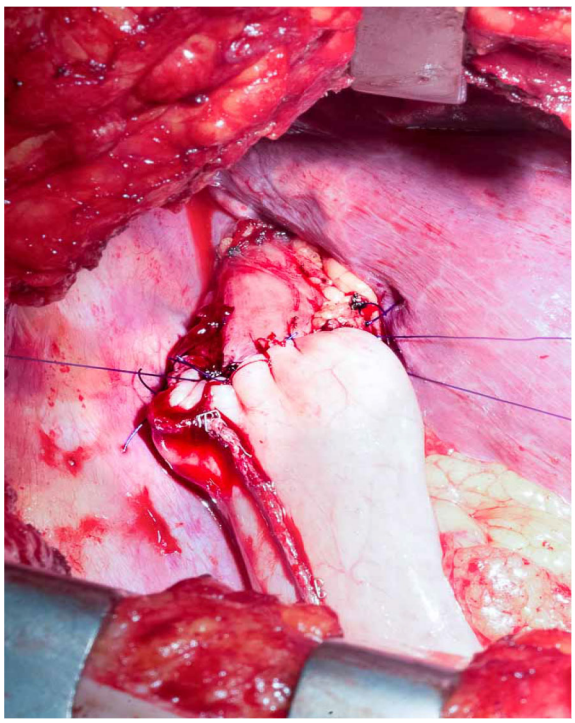

Fig. 5 Enterotomies closed after passing the NG tube down the conduit

Esophagogastric anastomosis was performed using circular staplers in 85 patients (53%) and a semi-mechanical anastomosis in 74 patients (47%). No significant differences were identified between the two groups in terms of age, gender, ASA grade, Charlson comorbidity index or neoadjuvant therapies received (Table 1). The circular stapled anastomotic technique was employed more commonly in those undergoing an open abdominal operative approach.

In the postoperative period (Table 2), Clavien–Dindo II or more complications were significantly higher in the circular stapled group compared to the semi-mechanical group, reflecting a significantly longer critical care LOS in the circular stapled group though this did not translate into a longer overall LOS.

Sixteen (10%) patients developed anastomotic leak, of whom 13 (15%) were from the circular stapler group and three (4%) were from the semi-mechanical group ($p = 0.019$). Out of the 13 leaks in circular stapler group, six required re-look thoracotomy (type III leak). Two of the three leaks in semi-mechanical group were managed conservatively without intervention (type I) and one required re-thoracotomy with wash and drainage (type III leak).

Table 1 Patients' demographics

	Circular (n = 85)	Semi-mechanical (n = 74)	Overall (n = 159)	p value (test)
Age (median)	68	65.5		0.121 (*MW-U*)
Gender				0.996 (X^2)
Neoadjuvant treatment				0.839 (X^2)
ASA grade				0.868 (X^2)
Charlson comorbidity index (median)	5	5		0.097 (*MW-U*)
Preexisting morbidities				
DM	19 (22.3)	9 (12.2)	28 (17.6)	0.092 (X^2)
Cardiac disorder	11 (12.9)	10 (13.5)	21 (13.2)	0.915 (X^2)
PVD	5 (5.9)	5 (6.8)	10 (6.3)	0.820 (X^2)
Chronic kidney disease	4 (4.7)	4 (5.4)	8 (5.0)	0.841 (X^2)
Respiratory disorder	14 (16.5)	6 (8.1)	20 (12.6)	0.112 (X^2)

ASA American Society of Anaesthesiologists physical status classification system, X^2 Chi-square test (MW-U): Mann–Whitney U test. Values in parentheses are percentages

[a]*DM* diabetes mellitus

[b]*PVD* peripheral vascular disease

Table 2 Perioperative outcomes

	Circular (n = 85)	Semi-mechanical (n = 74)	Overall (n = 159)	p value (test)
Approach				0.002 (X^2)
Laparoscopic	25 (29.4)	39 (52.7)	64 (40.3)	
Open	57 (67)	29 (39.2)	86 (54.1)	
Open ILO	46 (54.1)	26 (35.1)	72 (45.3)	
Left thoraco-laparotomy	11 (12.9)	3 (4)	14 (8.8)	
Laparoscopy to open	3 (3.5)	6 (8)	9 (5.7)	
LOS ITU/HDU (median)	3	2		0.007 (*MW-U*)
Staging p (TNM8)				0.778 (X^2)
Histology				0.299 (X^2)
Clavien–Dindo complications classification				0.019 (X^2)
Anastomotic leak	13 (15.3)	3 (4.1)	16 (10.1)	0.019 (X^2)
Type I	6 (7.1)	2 (2.7)	8 (5.3)	
Type II	1 (1.2)	0	1 (0.6)	
Type III	6 (7.1)	1 (1.4)	7 (4.4)	
Conduit necrosis	2 (2.4)	1 (1.4)	3 (1.9)	0.643 (X^2)
Dilatation	8 (9.4)	4 (5.4)	12 (7.5)	0.340 (X^2)
Mortality				
30 days	1 (1.2)	3 (4.1)	4 (2.5)	0.249 (X^2)
90 days	1 (1.2)	5 (6.8)	6 (3.8)	0.066 (X^2)

ILO Ivor Lewis esophagogastrectomy, *LOS* length of stay, *ITU* intensive care unit, *HDU* high-dependency unit, *TNM8* eighth edition of the American Joint Committee on Cancer (AJCC). X^2 Chi-square test, *MW-U* Mann–Whitney U test. Values in parentheses are percentages

Overall three (1.9%) patients developed focal or total conduit necrosis, two (2.4%) in the circular stapler group, of whom one was focal necrosis of conduit tip and treated conservatively (type I) and the other required thoracotomy (type III). One patient (1.4%) in the semi-mechanical group suffered conduit necrosis and required but refused intervention.

Four (2.5%) patients died within 30 days of surgery. One (1.2%) patient (ASA III) in the circular stapler group died from multiorgan failure following an anastomotic leak and re-thoracotomy. Three (4%) patients died within 30 days in the semi-mechanical group. One patient suffered a postoperative myocardial infarction and cardiogenic shock on postoperative day 3 with no evidence of anastomotic leak. The second patient suffered from type III ischemic gastric conduit detected endoscopically but refused any further operations. Another patient died following a surgical site infection and multiorgan failure following a combined esophagectomy and hysterectomy. CT scan with oral contrast and endoscopic examination did not identify an anastomotic leak.

Twelve (7.5%) patients developed symptomatic stricture at the anastomotic site within 3 months. Eight (9.4%) were in circular stapled group. All were diagnosed and treated endoscopically. Four of these eight patients developed the stricture following an anastomotic leak. Four patients (5.4%) in the semi-mechanical group developed an anastomotic stricture and required endoscopic dilatation. None of these patients had suffered an anastomotic leak.

Discussion

To the authors' knowledge, this is the first study to demonstrate a significant reduction in anastomotic leak rate using a semi-mechanical compared to circular stapled technique for intrathoracic esophagogastric anastomosis. Furthermore, the proportion of severe Clavien–Dindo complications and length of critical care stay were also reduced in the semi-mechanical anastomosis group. Despite the significantly lower anastomotic leak rate, there were no significant differences in overall length of stay, mortality or need for endoscopic dilatation. Following review of these outcomes, the TOGU team now employs a semi-mechanical anastomosis as its default technique for intrathoracic anastomosis following esophagectomy.

One of the most important contributors to perioperative morbidity and mortality following esophagectomy is anastomotic leak [2, 3, 22]. Anastomotic leaks are associated with longer-term cancer recurrence [23]. In the medium-term, anastomotic stricture can also cause patient morbidity and the need for further invasive procedures [24]. The current study demonstrated that in the circular stapler group, 50% of those requiring endoscopic dilatation of an anastomotic stricture had experienced an anastomotic leak.

There has been a gradual shift from hand-sewn to stapled esophagogastric anastomosis probably linked to similar safety data between the two techniques while saving time [12]. The semi-mechanical anastomosis employed by the TOGU team was described by Collard et al. [25] for cervical anastomosis. Descriptive studies suggest it is superior to hand-sewn anastomosis when comparing leakage and stricture rates in cervical anastomosis [13-15]. Others have described using an intrathoracic semi-mechanical anastomosis and when compared with circular and hand-sewn showed superiority in stricture but not leakage rates [16]. Similarly, two retrospective analyses comparing intrathoracic semi-mechanical, circular and hand-sewn techniques again found significantly fewer strictures with the semi-mechanical technique [26, 27].

The current study demonstrates a significantly reduced anastomotic leak rate when comparing the semi-mechanical to circular stapled intrathoracic esophagogastric anastomoses. Within the TOGU, it resulted in a 75% relative reduction in anastomotic leaks. Transthoracic esophagectomy with intrathoracic anastomosis is one of the most commonly performed approaches with 82.5% of esophagectomies in England and Wales being performed in this way in the 2018 National Esophagogastric Cancer Audit [17].

This study has some limitations which must be acknowledged when interpreting the generalizability of its findings. This study compares different anastomotic techniques but not as part of a randomized controlled trial. It is a single-center study with modest numbers of patients to reflect this. The semi-mechanical technique was gradually introduced in the latter half of 2016. It is therefore possible that the increased focus and standardization of anastomotic steps could be responsible for the improved anastomotic leak outcomes. Some steps were not standardized between surgeons, e.g., wrapping the anastomosis with pedicled omentum which may be associated with a reduction in leak rates [28, 29]. In order to try and mitigate some of these limitations, although patients were not randomized, the data have been extracted from a contemporaneously collected database of TOGU esophagogastric resections and statistical analysis was performed to identify any evidence of differences in age, preoperative comorbidities or pathological stage of disease with no significant differences found between the two groups. A significant difference was observed in the operative approach with proportionally more hybrid operations in the semi-mechanical group. This might have contributed to the longer length of critical care stay in the circular stapled group. However, the chest phase of all operations was performed open. A recently published randomized controlled trial comparing a hybrid approach to a fully open approach for esophagectomy [30] did not show any difference in anastomotic leak rates.

Conclusion

This study demonstrates a significantly reduced rate of anastomotic leak following esophagectomy for cancer when employing a semi-mechanical intrathoracic esophagogastric anastomotic technique compared with a circular stapled technique. While a randomized controlled trial comparing both techniques in intrathoracic anastomosis is the gold standard, based on the available evidence the TOGU team now employs a semi-mechanical anastomosis as its default technique for intrathoracic anastomosis following esophagectomy.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest. The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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