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ORIGINAL SCIENTIFIC REPORT

International Variation in Surgical Practices in Units Performing Oesophagectomy for Oesophageal Cancer: A Unit Survey from the Oesophago-Gastric Anastomosis Audit (OGAA)

Oesophago-Gastric Anastomosis Study Group on behalf of the West Midlands Research Collaborative[1]

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Abstract

Background Anastomotic leaks are associated with significant risk of morbidity, mortality and treatment costs after oesophagectomy. The aim of this study was to evaluate international variation in unit-level clinical practice and resource availability for the prevention and management of anastomotic leak following oesophagectomy.

Method The Oesophago-Gastric Anastomosis Audit (OGAA) is an international research collaboration focussed on improving the care and outcomes of patients undergoing oesophagectomy. Any unit performing oesophagectomy worldwide can register to participate in OGAA studies. An online unit survey was developed and disseminated to lead surgeons at each unit registered to participate in OGAA. High-income country (HIC) and low/middle-income country (LMIC) were defined according to the World Bank whilst unit volume were defined as < 20 versus 20–59 versus ≥ 60 cases/year in the unit.

Results Responses were received from 141 units, a 77% (141/182) response rate. Median annual oesophagectomy caseload was reported to be 26 (inter-quartile range 12–50). Only 48% (68/141) and 22% (31/141) of units had an Enhanced Recovery After Surgery (ERAS) program and ERAS nurse, respectively. HIC units had significantly higher rates of stapled anastomosis compared to LMIC units (66 vs 31%, $p = 0.005$). Routine post-operative contrast-swallow anastomotic assessment was performed in 52% (73/141) units. Stent placement and interventional radiology drainage for anastomotic leak management were more commonly available in HICs than LMICs (99 vs 59%, $p < 0.001$ and 99 vs 83%, $p < 0.001$).

Conclusions This international survey highlighted variation in surgical technique and management of anastomotic leak based on case volume and country income level. Further research is needed to understand the impact of this variation on patient outcomes.

Introduction

Oesophageal cancer is the sixth most common cause of cancer-related mortality worldwide with the number of deaths increasing by 13% to 436,000 per year over the last decade [1]. Oesophagectomy remains the mainstay of curative treatment for oesophageal cancers, but is associated with significant morbidity and mortality [2]. Anastomotic leaks occur in 10–20% of patients, with an associated mortality of between 5 and 10% [3–5]. In addition, between 20 and 50% of patients suffer pulmonary

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complications [4, 6, 7]. These complications are further associated with increased length of hospital stay, treatment costs and decreased quality of life for patients [8, 9]. Additionally, cancer research and treatment has been identified as a key priority in global surgery research [10].

Single unit studies suggest global variation in pre-, peri- and post-operative management of oesophageal cancer patients [11–14]. This variation may reflect international heterogeneity in clinical guidelines and resource availability [15–17]. However, few studies have directly explored variation across multiple global settings in contemporary practices regarding centralisation of surgery, multi-disciplinary input, enhanced recovery programmes, and the detection and management of complications.

The aim of this study was to evaluate international variation in unit-level clinical practice and resource availability for the prevention and management of anastomotic leak following oesophagectomy.

Methods

OGAA collaborative

The Oesophago-Gastric Anastomosis Audit (OGAA) Collaborative is an international multi-unit research network focused on improving the care and outcomes of patients undergoing treatment for oesophago-gastric cancer. Any unit worldwide performing oesophagectomy for oesophageal cancer is eligible to participate. Invitations to join the OGAA Collaborative were disseminated through national surgical associations, social media and existing research networks. Unit registration commenced in April 2018. Each unit has a lead surgeon (consultant/attending grade), with other team members including junior doctors, medical students, specialist cancer nurses and other members of the multi-disciplinary team. Ethical approval was not required to complete this survey as it contained no patient data.

Unit survey questionnaire

An electronic survey evaluating practice patterns at time of entry into the collaborative was disseminated to lead surgeons on 1 July 2018. Serial reminders were sent to the lead surgeons to complete the survey, with the survey closing on 1 December 2018. The survey focussed on the key principal areas: (1) institutional data, (2) on-call availability, (3) enhanced recovery protocol implementation, (4) standardised approaches within the unit to lower 1/3 adenocarcinoma, (5) preferred anastomotic technique, (6) post-operative anastomosis assessment and anastomotic leak management strategies (Supplementary Table 1).

Units were split into those performing less than 20 oesophagectomies per year (low volume), 20–59 per year (medium volume) and greater than or equal to 60 per year (high volume), as previously described [16, 18–20]. Current papers in the literature are heterogenous in reporting cut-offs for high-volume units including papers cited in this paper. Many different definitions of "high-volume hospital" have been proposed in the recent literature, ranging from 5 to 86 oesophagectomies for oesophageal cancer resections annually. Consequently, there is no consensus about what should be considered a high-volume hospital and minimum volume standards for oesophagectomies to vary per country or region. In the Netherlands, the minimum was recently set at 20 oesophagectomies per year. In Great Britain and Ireland, AUGIS advises $\geq$60 oesophagogastric cancer resections per unit per year. A recent study showed that indeed outcome was directly related with a plateau reached at 60 cases yearly [20]. Hence, these numbers indeed are now generally accepted in the literature to describe the case volume of the centres and were used in this study.

Low- and middle-income countries (LMICs) were identified based on the list published by the World Bank [21]. Institution size was measured as total hospital beds and total intensive therapy unit (ITU) beds. ITU was defined as any area providing level 3 care [22]. High dependency units (HDU) were defined as any area providing level 2 care. Consultant specialty indicates the self-reported area of expertise of consultants undertaking oesophagectomy within each unit.

Anastomotic leaks were defined according to the oesophageal complications consensus group [4]. Standardised approach to lower 1/3 adenocarcinoma were defined as the unit-wide preferred standard approach for these cases. Similarly, preferred anastomotic technique was the most commonly used anastomotic technique within the unit. Post-operative destination was defined as the most common destination of patients following oesophagectomy, including intensive care, high dependency units and normal wards. Anastomotic leak treatments used included any treatments used within the unit for any anastomotic leak to encompass the variation in management strategies. This included parenteral nutrition, endoscopic clips, endoscopic stenting, EndoVac^{TM} therapy and interventional drainage of collections.

Statistical methods

Nonparametric data were presented as median and interquartile range. Mann–Whitney *U* tests were used to compare nonparametric data where data were split into two groups and Kruskal–Wallis tests were used, where this was split into three groups. Binary data were presented as

number and percentage and analysed using Pearson's $N-1$ Chi-square test. In cases where there were groups with a count of less than 5, Fishers exact test was used. Significance was established at $p < 0.05$.

Results

Response rates

As of 1 December 2018, there were 182 units registered to participate in OGAA from across 41 countries. Lead surgeons from 141 of 182 units (77%) responded to the survey. The distribution of centres with < 20 cases/year, 20–59 cases/year and ≥60 cases/year were 65, 53 and 23, respectively. More units were situated in HICs (79%, 112/141) compared to LMICs (21%, 29/141). There were 104 European units (of which 33 were from the UK), 9 North American, 21 Australasian, 2 African, and 5 South American units who responded (Fig. 1). Centres with < 20 cases/year, 20–59 cases/year and ≥60 cases/year from HIC (67 vs 87 vs 96%) were significantly higher than that from LMIC (32 vs 13 vs 4%, $p = 0.004$). From the 41 units not responding to the unit survey within the deadline, there were 21 European units, 3 North American, 8 Australasian, 5 African and 4 South American. Of the centres that responded, response rates were significantly higher in European centres compared to Australasia, African and North American centres (71 vs 18 vs 1 vs 7%, $p = 0.004$).

Unit size and case volume

There was a median of 3 (IQR 2–4, range 1–20) consultants per unit. Median annual oesophagectomy volume was 26 (IQR 12–50, range 1–116) unit (Table 1). At most units, oesophagectomies were performed by oesophago-gastric surgeons (64%, 90/141 units). In addition, general surgeons performed oesophagectomies at 42% (59/141) of units, as well as thoracic surgeons (27%, 38/141) and surgical oncologists (16%, 23/141). In addition, oesophagectomies were more likely performed by oesophago-gastric surgeons in HIC units compared to LIC units (74 vs 21%, $p < 0.001$) (Table 1).

On-call cover

Overall 77% (110/141) units reported having 24-h on-call cover for oesophago-gastric surgery patients, 11% (16/141) had daytime (0900–1700) cover only, and 12% had no cover at any times. Similarly, 72% (103/141) units had interventional radiology cover at all times, 16% (22/141) had daytime hour interventional radiology cover and 12% (16/141) had no interventional radiology services. HIC units had significantly higher rates of 24-h on-call interventional radiology services compared to LMICs (81 vs 31%, $p < 0.001$).

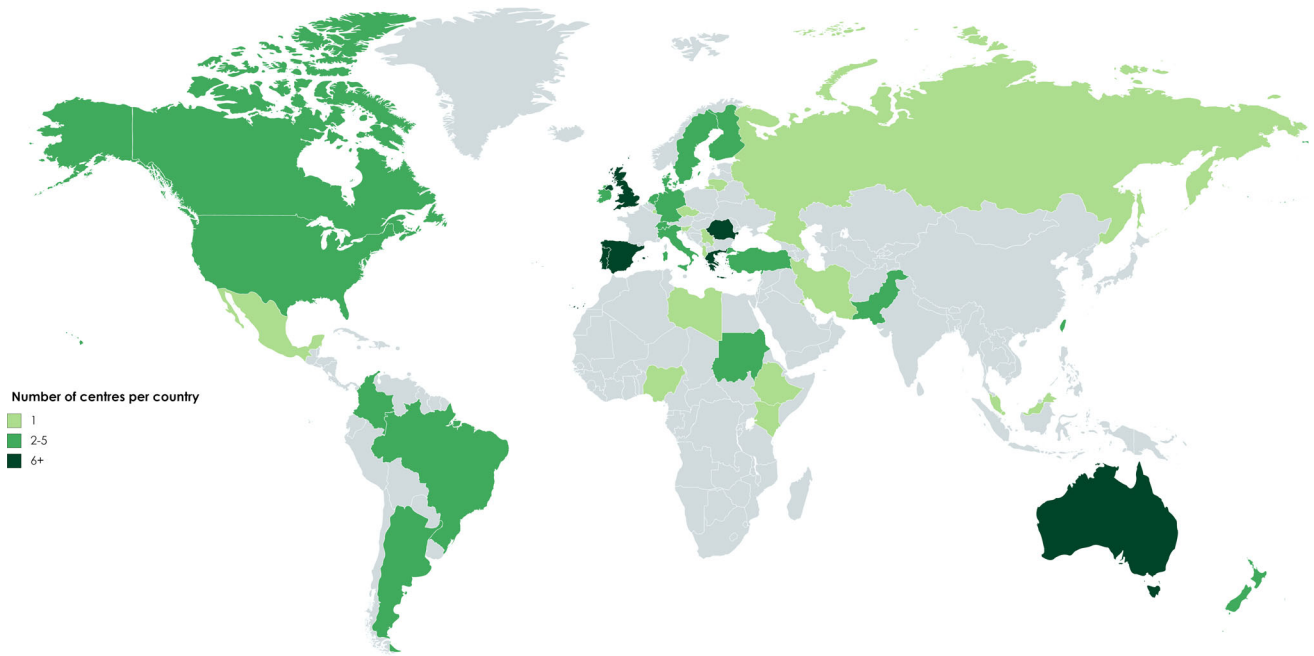

Fig. 1 Map of units participating in the Oesophago-Gastric Anastomosis Audit Unit Survey internationally

Table 1 Pre-operative variation in units performing oesophagectomy

	Total n = 141	Unit volume				Country income		
		< 20 n = 65	20–59 n = 53	60+ n = 23	p value	HIC n = 112	LMIC n = 29	p value
Institutional data								
Attending consultants*	3 (2–4)	3 (2–4)	4 (2–4)	4 (3–5)	**0.003**	3 (2–4)	3 (2–5)	0.842
Oesophagectomy number*	26 (12–50)	12 (8–15)	40 (30–50)	72 (65.5–76.5)	–	32 (15–51)	12 (8–28)	**0.004**
Total beds*	686 (300–1010)	500 (300–907)	800 (300–1085)	975 (482–1275)	**0.045**	750 (350–1050)	400 (200–731)	0.107
Total ICU beds*	24 (15–37)	20 (14–32)	24 (14–33)	34 (19.75–50)	0.102	24 (17–36)	21 (11–40)	0.76
*Specialty of attending oesophagectomy consultant***								
Thoracic	38 (26.8)	14 (21.5)	16 (30.2)	8 (34.8)	**0.002**	30 (26.8)	8 (27.6)	**< 0.001**
Oesophago-gastric	90 (63.4)	35 (53.8)	35 (66)	19 (82.6)	–	83 (74.1)	6 (20.7)	–
General surgery	59 (41.5)	35 (53.8)	15 (28.3)	9 (39.1)	–	40 (35.7)	19 (65.5)	–
Surgical oncologist	23 (16.2)	10 (15.4)	5 (9.4)	7 (30.4)	–	14 (12.5)	8 (27.5)	–
*On-call oesophageal team***								
Every day, 24 h	107 (75.35)	45 (69.2)	42 (79.2)	20 (87)	0.235	87 (77.68)	20 (68.97)	0.327
Every day, daytime 0800–1700	4 (2.81)	2 (3.1)	2 (3.8)	0 (0)	–	3 (2.68)	1 (3.45)	–
Weekdays, 24 h	3 (2.13)	3 (4.6)	0 (0)	0 (0)	–	1 (0.89)	2 (6.9)	–
Weekdays, daytime 0800–1700	12 (8.45)	7 (10.8)	2 (3.8)	3 (13)	–	10 (8.93)	2 (6.9)	–
None	15 (10.56)	8 (12.3)	7 (13.2)	0 (0)	–	11 (9.82)	4 (13.79)	–
*On-call interventional radiology***								
Every day, 24 h	100 (70.42)	41 (63.1)	42 (79.2)	17 (73.9)	0.181	91 (81.25)	9 (31.03)	**< 0.001**
Every day, daytime 0800–1700	7 (4.93)	3 (4.6)	4 (7.5)	0 (0)	–	6 (5.36)	1 (3.45)	–
Weekdays, 24 h	3 (2.11)	3 (4.6)	0 (0)	0 (0)	–	1 (0.89)	2 (6.9)	–
Weekdays, daytime 0800–1700	15 (10.56)	7 (10.8)	4 (7.5)	4 (17.4)	–	10 (8.93)	5 (17.24)	–
None	16 (11.27)	11 (16.9)	3 (5.7)	2 (8.7)	–	4 (3.57)	12 (41.38)	–
*Enhanced recovery***								
Established ERAS protocol	68 (47.9)	22 (33.8)	30 (56.6)	16 (69.6)	**< 0.001**	61 (54.46)	7 (24.14)	**0.004**
Dedicated ERAS nurse	31 (21.8)	10 (15.4)	13 (24.5)	8 (34.8)	**0.006**	26 (23.21)	5 (17.24)	0.496
Dedicated physiotherapist	124 (87.3)	52 (80)	49 (92.5)	22 (95.7)	0.055	103 (91.96)	20 (68.96)	**0.001**
Gastric preconditioning	4 (2.8)	0 (0)	4 (7.5)	0 (0)	**0.033****	4 (3.57)	0 (0)	0.305****

Bold values indicate statistical significance at the 95% confidence level

< 20, units undertaking less than 20 oesophagectomies per year; > 20, units undertaking greater than 20 oesophagectomies per year

HIC, high-income country; LMIC, low/middle-income country; ICU, intensive care unit; ERAS, Enhanced Recovery After Surgery programme

*Median (inter-quartile range)

**Number (percentage)

***Fishers exact test was performed

Standard operative approach for lower third adenocarcinoma

Two-stage transthoracic oesophagectomy (65/141, 46%) was the most common standard approach, followed by hybrid two-stage transthoracic (laparoscopic abdomen) (46/141, 32%), 2-stage minimal access oesophagectomy (46/141, 32%) and open trans-hiatal oesophagectomy (22/141, 15%, Table 2). Trans-hiatal oesophagectomy was the preferred approach in 18/112 (16%) HIC units versus 15/29 (51%) of LMIC units.

Anastomotic technique

Circular stapled was the most common technique for thoracic anastomosis (47%), followed by hand-sewn (23%), stapled side-to-side (13%) and OrVil^{TM} (8%) (Table 3, Fig. 1). There were no significant differences in the anastomotic techniques between high-, medium- and low-volume units. However, HIC units had significantly higher rates of stapled anastomosis compared to LMIC units (66 vs 31%, $p = 0.005$) (Fig. 2).

Hand-sewn was the most common technique for neck anastomosis (60%), followed by stapled side-to-side (18%), circular stapled (11%) and OrVil^{TM} (1%). There were no significant differences in this anastomotic technique between HIC and LMIC units. Analyses were also done stratified by unit volume and country income, but did not demonstrate any association with anastomotic technique, both cervical and thoracic.

Post-operative care

Most units (137/141, 98%) admit patients to either an intensive care unit post-operatively or a high dependency units (Table 4). Only 1% routinely admit patients directly to the ward. Enhanced recovery after surgery programmes were in place in 48% (68/141) units. This differed significantly between high-, medium- and low-volume units (70 vs 57 vs 33%, $p < 0.001$) and between HICs and LMICs (54 vs 24%, $p = 0.004$). Only 21% (31/141) units reported having a dedicated enhanced recovery nurse. In contrast, 87% (124/141) units have a dedicated physiotherapist input every day post-operatively at least once per day. There were significant differences in physiotherapist input between high-, medium- and low-volume units (96 vs 93 vs 81%, $p = 0.035$) and between HICs and LMICs (92 vs 69%, $p = 0.001$). Only a small number of units performed gastric ischaemic preconditioning (3%, 4/141).

Table 2 Reported operative approaches for lower 1/3 adenocarcinoma

	Total $n = 141$	Unit volume				Country income		
		< 20 $n = 65$	20–59 $n = 53$	≥ 60 $n = 23$	p value	HIC $n = 112$	LMIC $n = 29$	p value
2-Stage transthoracic	65 (46)	29 (44.6)	22 (41.5)	14 (60.9)	**0.009***	52 (46)	13 (45)	0.071*
Open left thoracoabdominal oesophagectomy	15 (10)	6 (9.2)	7 (13.2)	2 (8.7)	–	12 (11)	3 (10)	–
Open trans-hiatal oesophagectomy	22 (15)	15 (23.1)	4 (7.5)	3 (13)	–	12 (11)	10 (34)	–
Laparoscopic trans-hiatal oesophagectomy	11 (7)	6 (9.2)	3 (5.7)	2 (8.7)	–	6 (5)	5 (17)	–
Hybrid 2-stage transthoracic oesophagectomy (laparoscopic abdomen/open chest)	46 (32)	15 (23.1)	19 (35.8)	12 (52.2)	–	42 (38)	4 (14)	–
Hybrid 2-stage transthoracic oesophagectomy (open abdomen/thoracoscopic chest)	7 (4)	2 (3.1)	3 (5.7)	2 (8.7)	–	5 (4)	2 (7)	–
2-Stage minimal access oesophagectomy	46 (32)	14 (21.5)	24 (45.3)	8 (34.8)	–	40 (36)	6 (21)	–
3-Stage minimal access oesophagectomy	13 (9)	11 (16.9)	1 (1.9)	1 (4.3)	–	9 (8)	4 (14)	–
Hybrid 3-stage minimal access oesophagectomy (laparoscopic abdomen/open chest and neck)	1 (1)	0 (0)	1 (1.9)	0 (0)	–	1 (1)	0 (0)	–
Hybrid 3-stage minimal access oesophagectomy (open abdomen and neck/thoracoscopic chest)	10 (7)	6 (9.2)	3 (5.7)	1 (4.3)	–	6 (5)	4 (14)	–
Robotic oesophagectomy	9 (6)	1 (1.5)	2 (3.8)	6 (26.1)	–	8 (7)	1 (3)	–
Other	4 (2)	2 (3.1)	2 (3.8)	0 (0)	–	4 (4)	0 (0)	–

Bold value indicates statistical significance at the 95% confidence level

Data reported as number (percentage)

< 20, units undertaking less than 20 oesophagectomies per year; > 20, units undertaking greater than 20 oesophagectomies per year

HIC, high-income country; LMIC, low/middle-income country

*Fishers exact test was performed

Table 3 Anastomotic techniques

	Total $n = 141$	Unit volume				Country income		
		< 20 $n = 65$	20–59 $n = 53$	≥60 $n = 23$	p value	HIC $n = 112$	LMIC $n = 29$	p value
Thoracic								
Circular stapled	67 (47.18)	24 (36.9)	26 (49.1)	17 (73.9)	0.060*	58 (51.79)	9 (31.03)	**0.005***
Hand-sewn	33 (23.24)	20 (30.8)	12 (22.6)	1 (4.3)	–	21 (18.75)	12 (41.38)	–
Stapled side to side with suturing (Orringer style)	19 (13.38)	8 (12.3)	8 (15.1)	3 (13)	–	16 (14.29)	3 (10.34)	–
OrVil™	11 (7.75)	5 (7.7)	4 (7.5)	2 (8.7)	–	11 (9.82)	0 (0)	–
Other	2 (1.41)	1 (1.5)	1 (1.9)	0 (0)	–	2 (1.79)	0 (0)	–
Not applicable—do not perform	9 (6.34)	7 (10.8)	2 (3.8)	0 (0)	–	4 (3.57)	5 (17.24)	–
Neck								
Circular stapled	15 (10.56)	6 (9.2)	6 (11.3)	3 (13)	0.888*	12 (10.71)	3 (10.34)	0.535*
Hand-sewn	86 (60.56)	40 (61.5)	30 (56.6)	16 (69.6)	–	66 (58.93)	20 (68.97)	–
Stapled side to side with suturing (Orringer style)	26 (18.31)	14 (21.5)	9 (17)	3 (13)	–	20 (17.86)	6 (20.69)	–
OrVil™	2 (1.41)	1 (1.5)	1 (1.9)	0 (0)	–	2 (1.79)	0 (0)	–
Other	1 (0.7)	0 (0)	1 (1.9)	0 (0)	–	1 (0.89)	0 (0)	–
Not applicable—do not perform	11 (7.75)	4 (6.2)	6 (11.3)	1 (4.3)	–	11 (9.82)	0 (0)	–

Bold value indicates statistical significance at the 95% confidence level

Data reported as number (percentage)

< 20, units undertaking less than 20 oesophagectomies per year; > 20, units undertaking greater than 20 oesophagectomies per year

HIC, high-income country; LMIC, low/middle-income country

*Fishers exact test was performed

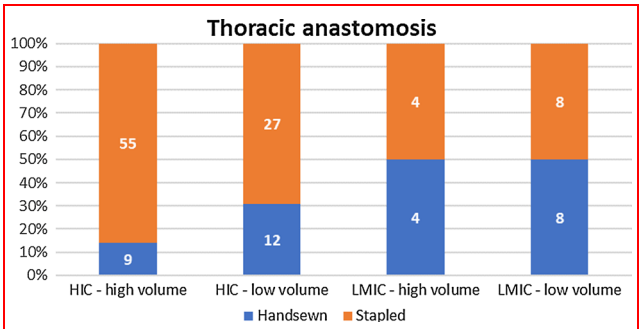

Fig. 2 Number of centres performing hand-sewn (blue) and stapled (orange) anastomoses as their primary intrathoracic anastomosis type by country income and centre volume. Abbreviations: *HIC* high-income country, *LMIC* low/middle-income country

Anastomotic assessment

Intraoperative indocyanine green assessment was available in 23% (33/141) units. Routine post-operative anastomotic assessments (assessments made even where there are no concerns about anastomotic integrity) were carried out in 53% (73/141) of units. Of the units performing routine anastomotic assessment, contrast swallow was performed in 93% (68/73) units followed by computed tomography (14%, 10/73) and endoscopy (4%, 3/73).

Management of anastomotic leaks

Almost all units had access to total parenteral nutrition (98%, 138/141) as a strategy to manage anastomotic leaks, followed by interventional drains (96%, 135/141) and endoscopic radiologic stents (91%, 128/141). Only 45% (63/141) units have access to EndoVac therapy to treat anastomotic leaks. HICs were more likely to have access to all modalities for management of anastomotic leaks than LMICs, including endoscopic clips (91 vs 45%, $p < 0.001$), endoscopic radiologic stents (99 vs 59%, $p < 0.001$), EndoVac therapy (52 vs 17%, $p < 0.001$), and interventional radiologic drainage of collections (99 vs 83%, $p < 0.001$).

Interaction between centre volume and country income

To understand the interaction between centre volume and country income, pre-operative, anastomotic formation and post-operative variation were analysed as presented in Table 5. HIC with ≥60 cases/year had significantly higher

Table 4 Post-operative patient management

	Total $n = 141$	Unit volume				Country income		
		< 20 $n = 65$	20–59 $n = 53$	≥ 60 $n = 23$	p value	HIC $n = 112$	LMIC $n = 29$	p value
Post-operative destination								
Intensive care unit	94 (66.67)	48 (73.8)	31 (58.5)	15 (65.2)	**0.042***	72 (64.29)	22 (75.86)	0.624*
General high dependency unit	36 (25.53)	13 (20)	18 (34)	5 (21.7)	–	31 (27.68)	5 (17.24)	–
Dedicated gastrointestinal HDU	7 (4.96)	4 (6.2)	3 (5.7)	0 (0)	–	5 (4.46)	2 (6.9)	–
Other	3 (2.13)	0 (0)	1 (1.9)	2 (8.7)	–	3 (2.68)	0 (0)	–
Ward	1 (0.71)	0 (0)	0 (0)	1 (4.3)	–	1 (0.89)	0 (0)	–
Anastomosis check details								
Routine anastomotic check	73 (51.77)	39 (60)	27 (50.9)	7 (30.4)	0.051	56 (50)	17 (58.62)	0.41
Indocyanine availability	33 (23.4)	12 (18.5)	12 (22.6)	9 (39.1)	0.130	30 (26.79)	3 (10.34)	0.063*
Post-operative day of routine check*	5 (5–7)	6 (5–7)	5 (4.5–6)	5 (4.5–6)	**0.025**	5 (5–6)	7 (6–8)	**< 0.001**
Routine barium swallow	68 (93.18)	36 (55.4)	25 (47.2)	7 (30.4)	0.752	51 (91.07)	17 (100)	0.466
Routine CT	10 (13.69)	7 (10.8)	3 (5.7)	0 (0)	0.395*	7 (12.5)	3 (17.65)	0.893*
Routine Endoscopy	3 (4.1)	2 (3.1)	1 (1.9)	0 (0)	0.813*	2 (3.58)	1 (5.88)	0.999*
Treatments availability								
Parenteral nutrition	138 (97.87)	65 (100)	50 (94.3)	23 (100)	0.078	111 (99.11)	27 (93.1)	**0.046**
Endoscopic clips	115 (81.56)	53 (81.5)	43 (81.1)	19 (82.6)	0.988	102 (91.07)	13 (44.83)	**< 0.001**
Endoscopic radiologic stent	128 (90.78)	56 (86.2)	49 (92.5)	23 (100)	0.124	111 (99.11)	17 (58.62)	**< 0.001**
EndoVac^{TM} therapy	63 (44.68)	22 (33.8)	26 (49.1)	15 (65.2)	**0.024**	58 (51.79)	5 (17.24)	**< 0.001**
Interventional drainage of collections	135 (95.74)	62 (95.4)	51 (96.2)	22 (95.7)	0.975	111 (99.11)	24 (82.76)	**< 0.001**

Bold values indicate statistical significance at the 95% confidence level

< 20, units undertaking less than 20 oesophagectomies per year; > 20, units undertaking greater than 20 oesophagectomies per year

HIC, high-income country; LMIC, low/middle-income country; HDU, high dependency unit

*Fishers exact test was performed

total overall ($p = 0.005$) and ICU ($p = 0.030$) beds than the other groups. Oesophago-gastric surgeons were more likely to perform oesophagectomies in centres in HIC with ≥ 60 cases/year, whilst general surgeons were more likely to perform oesophagectomies in centres in LMC with 0–20 or 21–59 cases/year. There were no significant differences on-call oesophageal teams, neck or thoracic anastomosis, post-operative destination and anastomosis assessment across these groups.

Discussion

This international unit survey demonstrates significant variation in the management and surgical practices surrounding oesophageal cancer worldwide. This variation is found both within and between high and low-volume units and HICs and LMICs. This degree of variation is consistent with a lack of consensus regarding optimal care for patients undergoing surgery or requiring treatment for post-operative complications [4, 23].

Oesophagectomy has a strong volume-outcome association with better short- and long-term outcomes reported at high-volume units [20, 24]. In this study, differences in the reported management of patients between high and low-volume units were observed; however, this survey did not explore the impact of this variation on clinical outcomes. High-volume units had greater access to specialist post-operative services, such as enhanced recovery after surgery protocols and dedicated physiotherapy input. Another factor previously shown to affect resource availability and hence practice is country income [25]. LMICs in this survey appeared similarly to have decreased access to both services such as enhanced recovery nurses and management strategies for anastomotic leaks. This may increase the likelihood of "failure to rescue" and therefore mortality.

Routine anastomotic assessment after oesophagectomy was performed in half of the units, with 90% of routine contrast assessments performed via routine barium swallow. The utility of routine anastomosis assessment is disputed due to problems with sensitivity of contrast swallow

Table 5 Pre-operative, anastomotic techniques and post-operative variation stratified by country income and centre volume

	LMIC, < 20, *n* = 21	LMIC, 20–59, *n* = 7	LMIC, 60+, *n* = 1	HIC, < 20, *n* = 44	HIC, 20–59, *n* = 46	HIC, 60+, *n* = 22	*p* value
Institutional data							
Attending consultants*	3 [2, 4]	5 [2, 6]	2 [2, 2]	3 [2, 3]	4 [2, 4]	4 [3, 5]	**0.006**
Oesophagectomy number*	9 [7, 12]	30 [30, 46]	72 [72, 72]	14 [10, 15]	40 [32, 50]	72 [65, 77]	**< 0.001**
Total beds*	500 [200, 1000]	300 [230, 400]	195 [195, 195]	510 [315, 856]	882 [371, 1100]	1000 [728, 1300]	**0.005**
Total ICU beds*	25 [20, 40]	11 [7, 27]	10 [10, 10]	20 [12, 31]	24 [20, 36]	36 [25, 50]	**0.030**
*Specialty of attending oesophagectomy consultant***							
Thoracic	4 (19)	4 (57)	0 (0)	10 (23)	12 (26)	8 (36)	0.338
Oesophago-gastric	4 (19)	2 (29)	0 (0)	31 (70)	33 (72)	19 (86)	**< 0.001**
General surgery	15 (71)	4 (57)	0 (0)	20 (45)	11 (24)	9 (41)	**0.009**
Surgical oncologist	6 (29)	1 (14)	1 (100)	4 (9)	4 (9)	6 (27)	**0.019**
*On-call oesophageal team***							0.747***
Every day, 24 h	13 (62)	6 (86)	1 (100)	32 (73)	36 (78)	19 (86)	
Every day, daytime 0800–1700	1 (5)	0 (0)	0 (0)	1 (2)	2 (4)	0 (0)	
Weekdays, 24 h	2 (10)	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	
Weekdays, daytime 0800–1700	2 (10)	0 (0)	0 (0)	5 (11)	2 (4)	3 (14)	
None	3 (14)	1 (14)	0 (0)	5 (11)	6 (13)	0 (0)	
*On-call interventional radiology***							**< 0.001***
Every day, 24 h	6 (29)	2 (29)	1 (100)	35 (80)	40 (87)	16 (73)	
Every day, daytime 0800–1700	1 (5)	0 (0)	0 (0)	2 (5)	4 (9)	0 (0)	
Weekdays, 24 h	2 (10)	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	
Weekdays, daytime 0800–1700	3 (14)	2 (29)	0 (0)	4 (9)	2 (4)	4 (18)	
None	9 (43)	3 (43)	0 (0)	2 (5)	0 (0)	2 (9)	
*Enhanced recovery***							
Established ERAS protocol	3 (14)	3 (43)	1 (100)	18 (41)	28 (61)	15 (68)	**0.003***
Dedicated ERAS nurse	3 (14)	1 (14)	1 (100)	7 (16)	12 (26)	7 (33)	0.189***
Dedicated physiotherapist	13 (62)	6 (86)	1 (100)	39 (89)	43 (93)	20 (91)	**0.019**
Gastric preconditioning	0 (0)	0 (0)	0 (0)	0 (0)	4 (9)	0 (0)	0.131***
Thoracic							0.124***
Circular stapled	6 (29)	2 (29)	1 (100)	18 (41)	24 (52)	16 (73)	
Hand-sewn	8 (38)	4 (57)	0 (0)	12 (27)	8 (17)	1 (5)	
Stapled side to side with suturing (Orringer style)	2 (10)	1 (14)	0 (0)	6 (14)	7 (15)	3 (14)	
OrVil™	0 (0)	0 (0)	0 (0)	5 (11)	4 (9)	2 (9)	
Other	0 (0)	0 (0)	0 (0)	1 (2)	1 (2)	0 (0)	
Not applicable—do not perform	5 (24)	0 (0)	0 (0)	2 (5)	2 (4)	0 (0)	
Neck							0.968***
Circular stapled	1 (5)	2 (29)	0 (0)	5 (11)	4 (9)	3 (14)	
Hand-sewn	16 (76)	3 (43)	1 (100)	25 (57)	26 (57)	15 (68)	
Stapled side to side with suturing (Orringer style)	4 (19)	2 (29)	0 (0)	9 (20)	8 (17)	3 (14)	
OrVil™	0 (0)	0 (0)	0 (0)	1 (2)	1 (2)	0 (0)	
Other	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	0 (0)	
Not applicable—do not perform	0 (0)	0 (0)	0 (0)	4 (9)	6 (13)	1 (5)	
Post-operative destination							0.137***
Intensive care unit	15 (71)	7 (100)	0 (0)	33 (75)	24 (52)	15 (68)	
General high dependency unit	4 (19)	0 (0)	1 (100)	9 (20)	18 (39)	4 (18)	
Dedicated gastrointestinal HDU	2 (10)	0 (0)	0 (0)	2 (5)	3 (7)	0 (0)	

Table 5 continued

	LMIC, < 20, *n* = 21	LMIC, 20–59, *n* = 7	LMIC, 60+, *n* = 1	HIC, < 20, *n* = 44	HIC, 20–59, *n* = 46	HIC, 60+, *n* = 22	*p* value
Other	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	2 (9)	
Ward	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	
Anastomosis check details							
Routine anastomotic check	14 (67)	3 (43)	0 (0)	26 (59)	23 (50)	7 (32)	0.175***
Post-operative day of routine check*	7 [7, 8]	5 [4, 6]	NA [NA, NA]	5 [5, 6]	5 [4, 6]	5 [4, 6]	**0.001**
Indocyanine availability	2 (10)	1 (14)	0 (0)	10 (23)	11 (24)	9 (41)	0.247***
Routine barium swallow	14 (67)	3 (43)	0 (0)	23 (52)	21 (46)	7 (32)	0.248***
Routine CT	3 (14)	0 (0)	0 (0)	4 (9)	3 (7)	0 (0)	0.517***
Routine endoscopy	1 (5)	0 (0)	0 (0)	1 (2)	1 (2)	0 (0)	0.929***
Treatments availability							
Parenteral nutrition	21 (100)	5 (71)	1 (100)	44 (100)	45 (98)	22 (100)	**< 0.001****
Endoscopic clips	11 (52)	2 (29)	0 (0)	42 (95)	41 (89)	19 (86)	**< 0.001****
Endoscopic radiologic stent	12 (57)	4 (57)	1 (100)	44 (100)	45 (98)	22 (100)	**< 0.001****
EndoVac^{TM} therapy	2 (10)	3 (43)	0 (0)	19 (44)	24 (52)	15 (68)	**0.004****
Interventional drainage of collections	18 (86)	5 (71)	1 (100)	44 (100)	46 (100)	21 (95)	**0.002****

Bold values indicate statistical significance at the 95% confidence level

< 20, Units undertaking less than 20 oesophagectomies per year; > 20, units undertaking greater than 20 oesophagectomies per year

HIC, high-income country; LMIC, low/middle-income country; ICU, intensive care unit; ERAS, Enhanced Recovery After Surgery programme

*Median (inter-quartile range)

**Number (percentage)

***Fishers exact test was performed

and the chances of aspiration, increasing the risk of patient harm [26, 27]; however, this must be balanced against the potential advantages of early detection of anastomotic leak. Indocyanine availability was greater in high-volume units, which may indicate earlier adoption of new technologies in these units [28]. Whilst there is limited evidence of benefit, further large-scale randomised controlled trials are required before wide-scale adoption of this technology in oesophago-gastric cancer [29], as are currently being undertaken in rectal cancer [30].

Furthermore, introduction of the Enhanced Recovery after Surgery (ERAS) pathways have led to improved outcomes and early discharge in patients undergoing major abdominal surgery such as hepatobiliary and colorectal surgery as well as cardiothoracic surgery [31–35]. Within oesophago-gastric surgery, ERAS protocols have recently gained popularity amongst oesophageal surgeons [15, 36]. In this study, ERAS protocols are significantly higher in high-volume centres compared to low-volume centre and higher in HIC compared to LMIC. Currently, these ERAS protocols may encompass a variety of pre-operative, intraoperative and post-operative factors. Despite this, current evidence for these individual factors are largely weak highlighting the need for further high-quality research.

This survey represents an in-depth multi-continental snapshot of current surgical practices and care worldwide for oesophageal cancer. Whilst recent surveys have examined surgical approaches and operation types for oesophageal and gastro- oesophageal junction tumours [22, 25], they were not focussed on anastomotic techniques and managements of anastomotic leaks worldwide. Many previous studies of medical and surgical practice have found similar variations in practice. However, large variations in practice between units performing similar caseloads and in similarly wealthy countries suggest that there is a substantial lack of consensus as to the best treatments available in oesophageal cancer management. However, it is possible that some of the differences found in this survey could be due to LMIC units lacking adequate resources, rather than not agreeing on the optimum strategy for operative approach or leak management should all options be available. Similarly, the differences observed between low- and high-volume hospitals could also simply reflect

the resource availability in those hospitals, rather than lack of consensus. Although the evidence for improved outcomes for centralised care for patients undergoing oesophagectomy is fairly strong [37], most evidence comes from HICs and it may not adequately translate to other LMIC healthcare settings which face a higher financial burden and have different social issues.

Limitations of this study include the self-reported nature of the data collected. This study relied on lead surgeons to accurately report information regarding their unit and practice. In this survey, higher numbers of oesophagectomies were carried out in HICs compared to LMICs. This may mean that analysis of practice variations between HICs and LMICs may be confounded by case volume. Additionally, 23% of units did not respond to the request to complete the unit survey, although these units were distributed geographically similarly to those who did respond to the request to complete the survey.

Conclusion

This study demonstrates significant variation in the management and surgical practices surrounding oesophageal cancer worldwide. Further large-scale studies are required to determine what the best operative and post-operative techniques are to minimise complications and morbidity.

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