Robot Assisted Minimally Invasive Esophagectomy

Perioperative care in Esophagectomy: ERAS

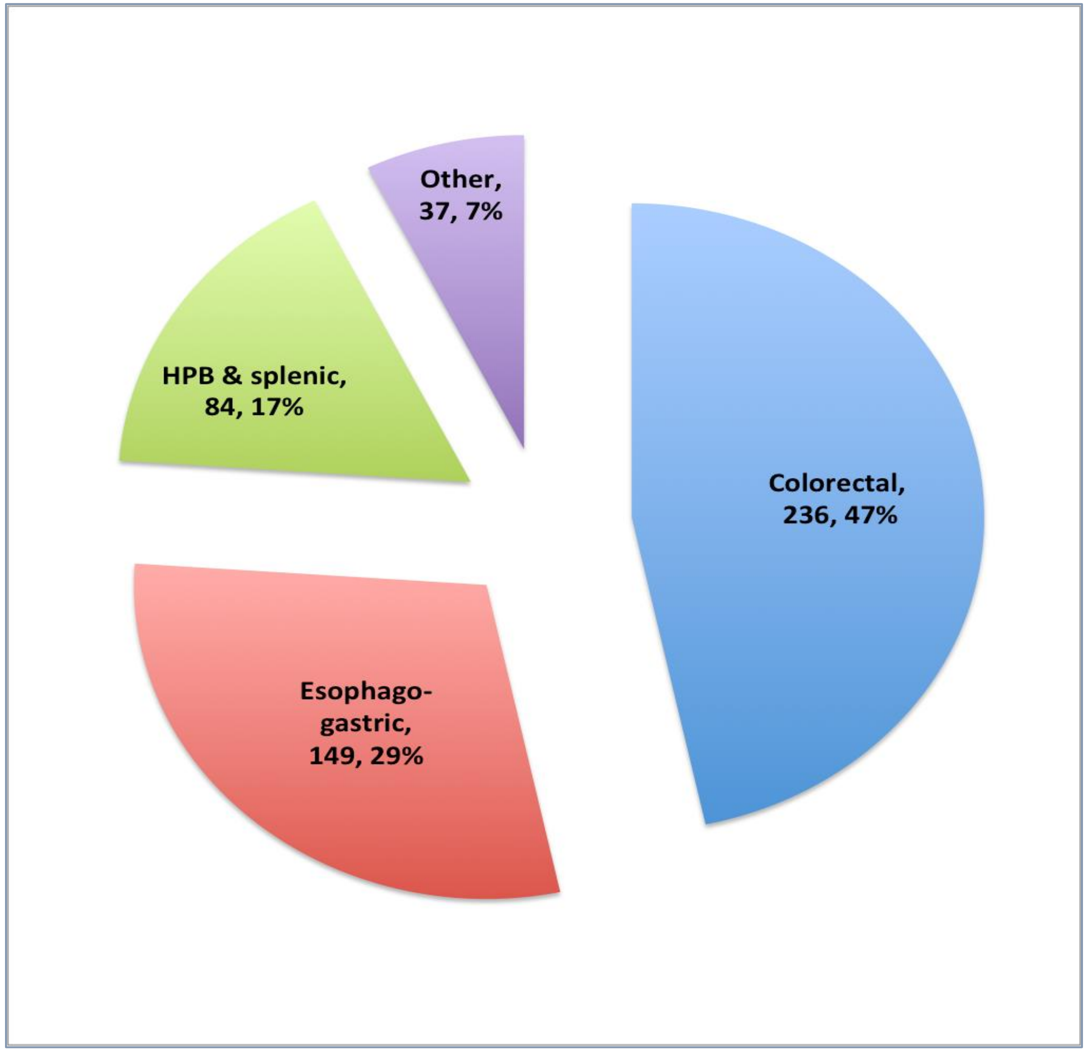
Felice Borghi

Department of Surgery
General and Oncologic Surgery Unit
S.Croce & Carle Hospital, Cuneo Italy

Institutional Experience

2013, May- 2019, August

506 dV® Si™ Procedures



Department of Surgery
General and Oncologic Surgery unit
S.Croce & Carle Hospital, Cuneo Italy

Esophagectomy has been identified as a particularly complex surgical procedure due to high levels of perioperative morbidity and mortality:

- Overall complication rate > 50% vith 17% of patients sustaining complications of IIIb or greater utilising the Clavien-Dindo severity grading system.

- 30 and 90-day mortality rates of 2,4% and 4,5% respectively in high volume esophageal centers

- 30 and 90-day mortality rates above 5% and 13% respectively from national audit

Outcomes

Multimodal treatment

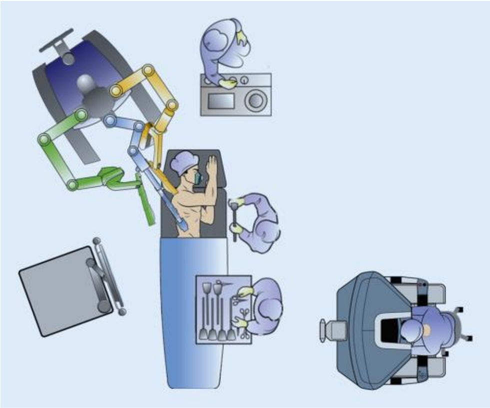
High volume center

- R0-resection
- ↓ Morbidity and mortality
- Functional outcomes (QoL)

Minimally invasive surgery

Multidisciplinary team

Robot **A**ssisted **M**inimally **I**nvasive **E**sophagectomy



RAMIE includes three types of robotic esophagectomy:

1 Transhiatal esophagectomy (RATHE)

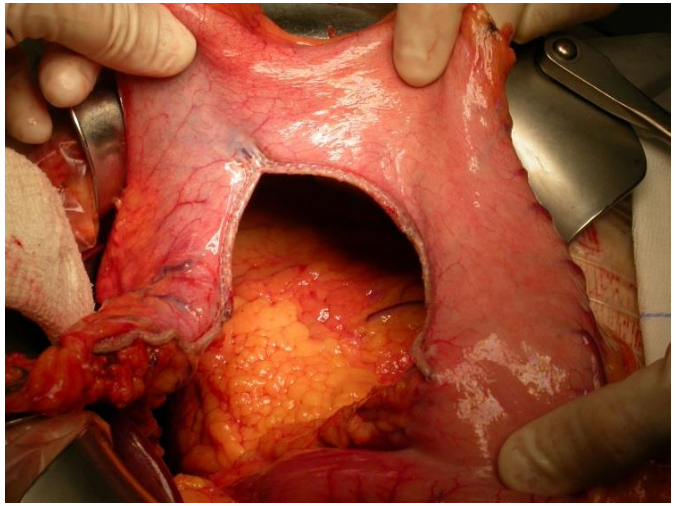
2 McKeown esophagectomy (RAMIME) → **NECK ANASTOMOSIS**

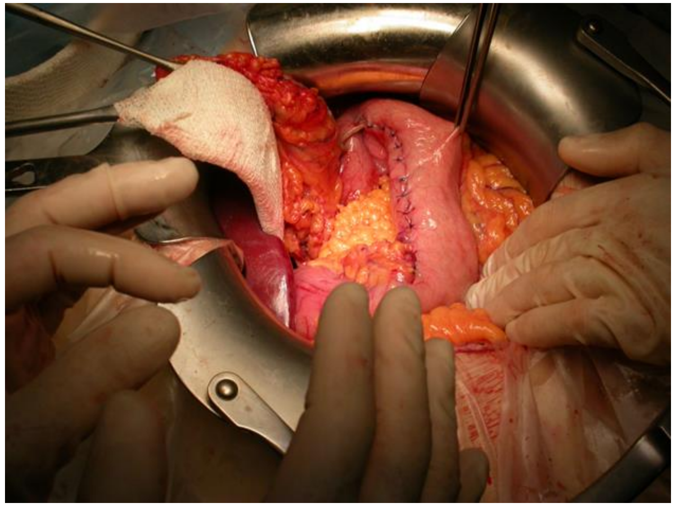
3 Ivor-Lewis esophagectomy (RAILE) → **INTRATHORACIC ANASTOMOSIS**

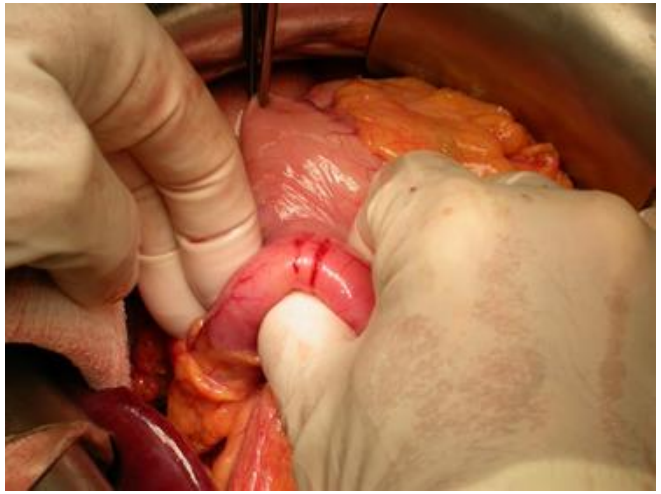
EN BLOC RESECTION
RECONSTRUCTION

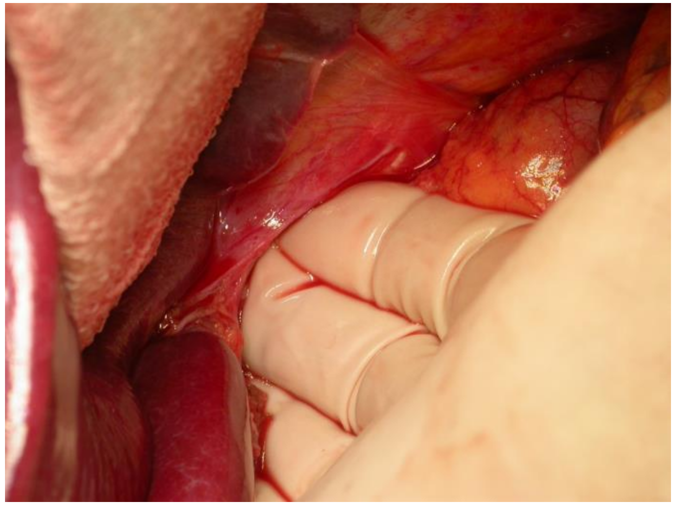
(Procedures are usually performed with hybrid approaches and the different techniques are difficult to compare)

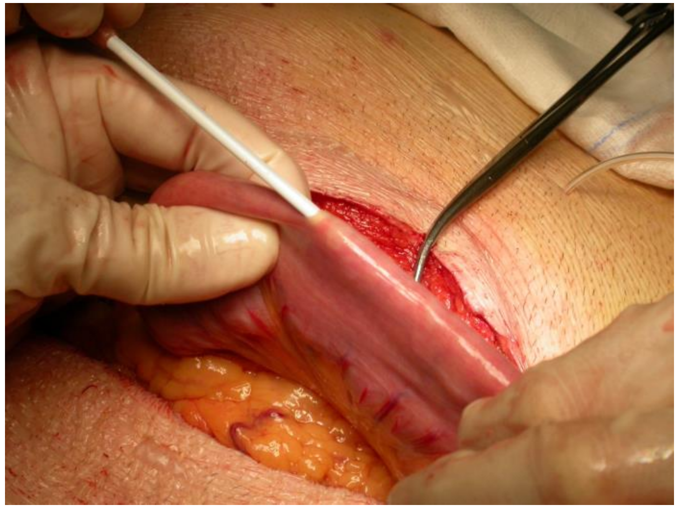
- Vascularization
- Gastric tubulization tecnique
- Gastric tube torsion
- Transhiatal outflow
- Pyloroplasty
- Jejunostomy
- Anastomosis technique

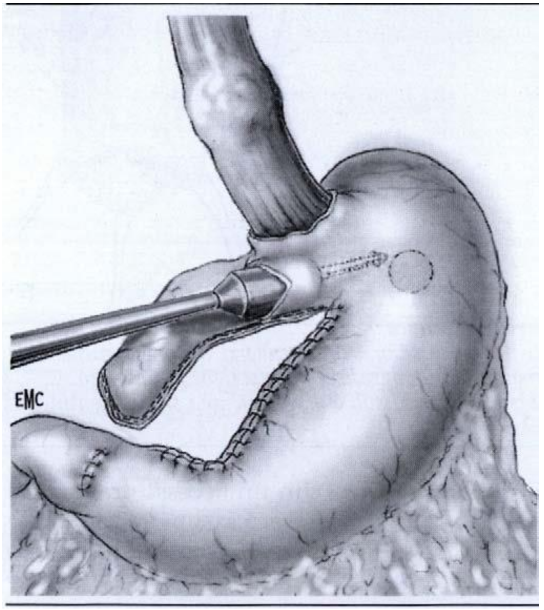


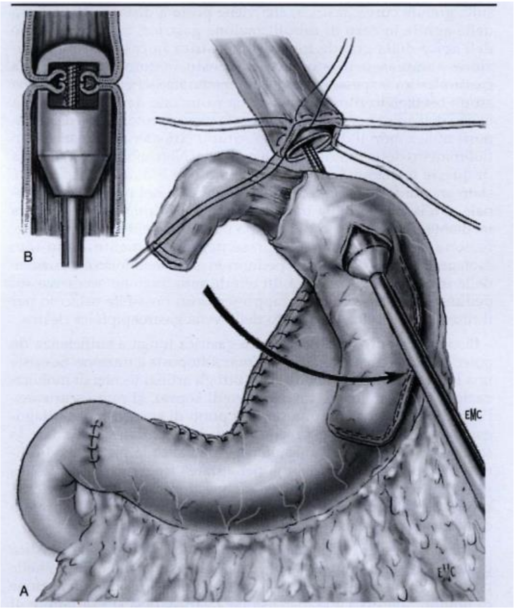


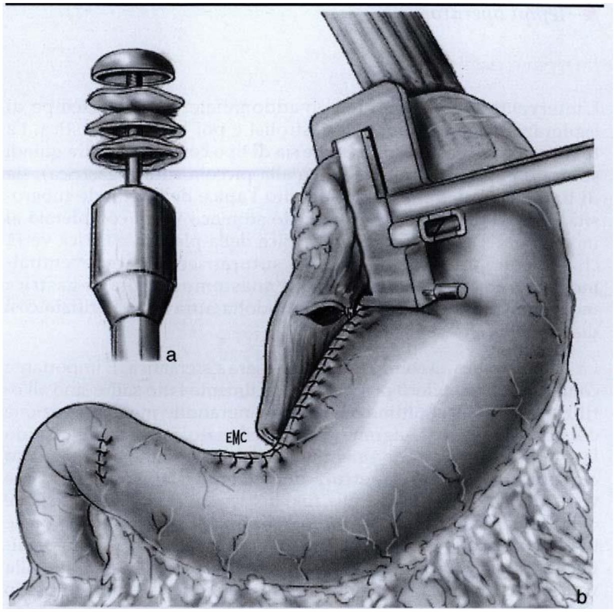


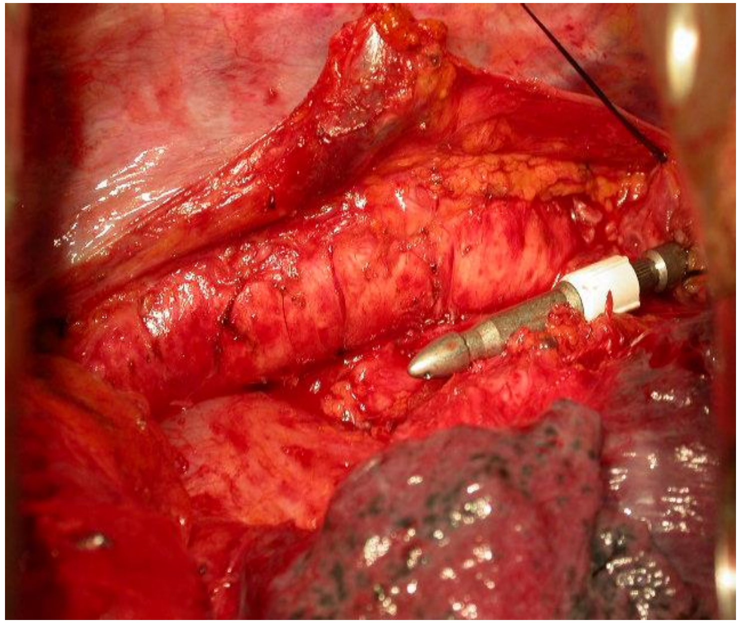


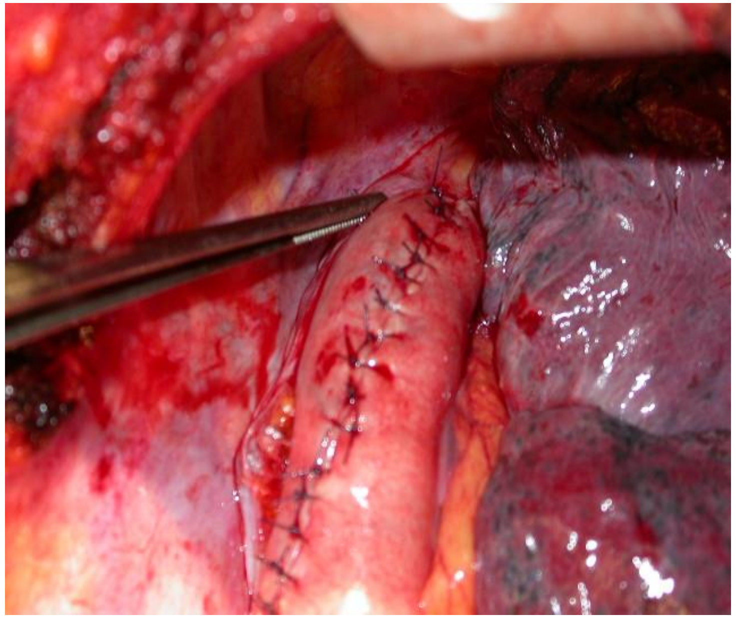



EMC


B
EMC
A
EMC


a
EMC
b





Minimally invasive surgery

Robot-assisted Minimally Invasive Thoracolaparoscopic Esophagectomy Versus Open Transthoracic Esophagectomy for Resectable Esophageal Cancer

A Randomized Controlled Trial

ANNALS OF SURGERY

	RAMIE (n = 54)	OTE (n = 55)	P
Wound infections	2 (4)	8 (14)	0.09¶
Cervical	2 (4)	1 (2)	0.61¶
Thoracic	0 (0)	5 (9)	0.06¶
Abdominal	0 (0)	2 (4)	0.50¶
Anastomotic leakage†			0.57
Type I (conservative)	0 (0)	0 (0)	
Type II (nonsurgical intervention)	1 (2)	0 (0)	
Type III (surgical intervention)	12 (22)	11 (20)	
Mediastinitis	12 (22)	11 (20)	0.42
Thoracic empyema	2 (4)	3 (6)	1.00¶
Gastric conduit necrosis†			1.00¶
Type III (conduit necrosis extensive, treated with resection and diversion)	1 (2)	2 (4)	
Chylothorax†			0.69
Type I (dietary, low-fat elemental formula gavage)	9 (17)	6 (11)	
Type II (total parenteral nutrition)	6 (11)	5 (9)	
Type III (operative)	2 (4)	1 (2)	
Recurrent laryngeal nerve injury†			0.78
Type I (no therapy)	5 (9)	6 (11)	
Postoperative bleeding	2 (4)	2 (4)	1.00¶
Dehiscence of abdominal fascia	0 (0)	1 (2)	1.00¶
Readmission intensive care unit	10 (19)	7 (13)	0.41
Reoperations	13 (24)	18 (33)	0.32
In-hospital mortality	2 (4)	1 (2)	0.62¶
30-Day mortality	1 (2)	0 (0)	0.50¶
60-Day mortality	3 (6)	1 (2)	0.36¶
90-Day mortality	5 (9)	1 (2)	0.11¶
Hospital stay (days—IQ range)	14 (11–25)	16 (11–27)	0.33
Intensive care unit stay (days—IQ range)	1 (1–2)	1 (1–3)	0.45
Postoperative anastomotic dilatation	28 (52)	26 (47)	0.50

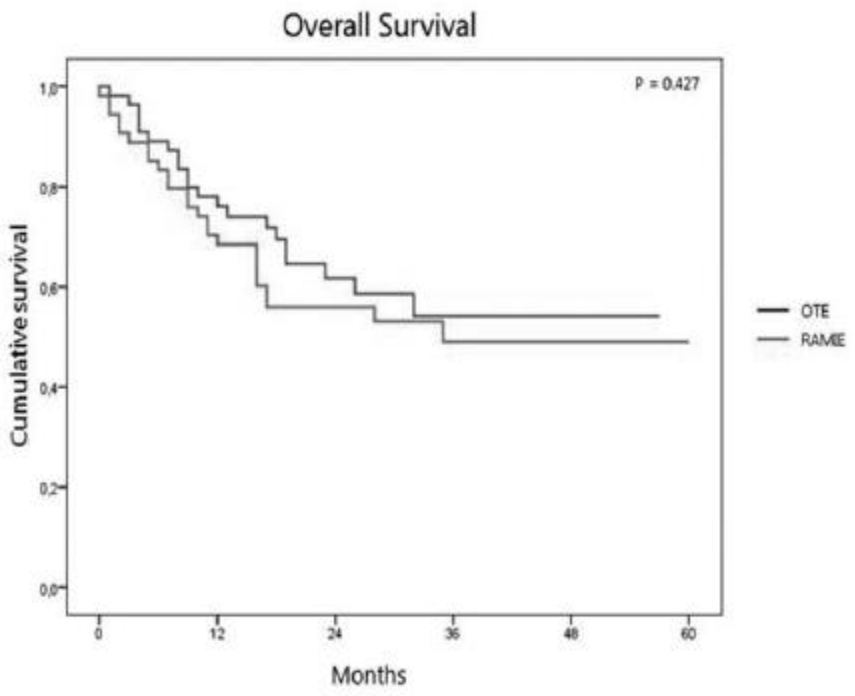
(*Ann Surg* 2019;269:621–630)

Minimally invasive surgery

Robot-assisted Minimally Invasive Thoracolaparoscopic Esophagectomy Versus Open Transthoracic Esophagectomy for Resectable Esophageal Cancer

A Randomized Controlled Trial

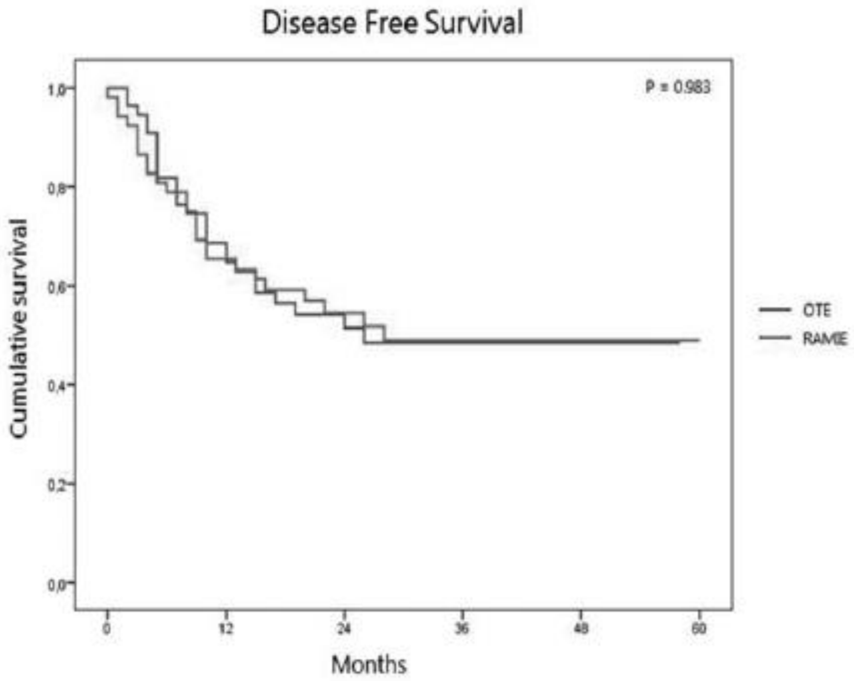
ANNALS OF SURGERY



Number at risk

Months	0	12	24	36	48	60
RAMIE	54	33	19	11	6	1
OTE	55	34	18	9	3	0

A



Number at risk

Months	0	12	24	36	48	60
RAMIE	52	30	18	10	6	1
OTE	55	31	17	9	3	0

B

(*Ann Surg* 2019;269:621–630)

RATTE: early results (case series)

Study	N°	Type	Operative time (min)	Blood loss (ml)	LOS (days)	Nodes (n°)	Pulmonary complications (%)	Anastomotic leak (%)	Cord palsy (%)	M&M (%)
V. Hillegersberg 2006	*21*	MK	450	950	18	20	48	14	14	NA/5
Anderson (2007)	*25*	MK	482	350	11	22	16	16	4	NA
Kernstine (2007)	14	MK	666	400	NA	18	21	14	14	29/7,1
Boone (2009)	47	MK	625	450	18	27	45	21	19	46,5/6,4
Kim (2010)	*21*	MK	410	150	21	38	0	19	29	NA/0
Weksler (2012)	11	MK	439	200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44/NA
Cerfolio (2013)	22	IL	367	65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36.4/0
Sarkaria (2013)	21	MK/IL	556	307	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24(major)/5
Trugeda (2014)	*14*	IL	222	75	13	18	0	28.6	0	42.8/0
Wee (2016)	*20*	IL	455	275	8	23	10	0	0	55/0
Bongiolatti (2016)	*8*	IL	499	73	10	37	0	25	NA	25/0
Wee (2016)	*20*	IL	475	275	8	23	10	0	NA	55/0
Chiu (2017)	*20*	MK	500	356	13	18	5	15	25	10,5/0
Guerra (2017)	*38*	MK/IL	550	80	10	33	8	16	2,6	42/10
Okusanya (2017)	*25*	MK/IL	661	NA	8	26	12	4	0	20/0

Studies are difficult to compare:
- hybrid approaches
-different surgical system (Si & Xi)

RATTE: experienced centers (case series >50)

Study	N°	Type	Operative time (min)	Blood loss (ml)	LOS (days)	Nodes (n°)	Pulmonary complications (%)	Anastomotic leak (%)	Cord palsy (%)	M&M (%)
De La Fuente (2013)	*50*	IL	445	146	11	20	10	4	NA	28/2
Hodari (2015)	54	IL	362	74	12,9	16,2	24,1	5,5	NA	74/1,9
Park (2016)	*62*	MK/IL	490	462	NA	37.3	14.5	8.1	12.9	16/1,6
Van der Sluis (2015)	*108*	MK	381	340	16	26	33	19	9	66/3,7
Puntambekar (2015)	*83*	MK	205	87	10	18	1	4	2	19.3/0
Cerfolio (2016)	85	MK	360	35	8	22	7	4	NA	36,4/10,6
Egberts (2017)	*75*	IL	392	172	16	29	34	16°	NA	73/3.9
Zhang (2018)	61	IL	315	189	10	19	NA	9,8	NA	36,1/0
Park (2018)	140	MK/IL	468	NA	14	41	8,8	5	25	57,9/4,3
Sarkaria (2018)	64	IL (62) MK (2)	400	250	9	25	14.1	3.1	3.1	39.1/1.6
Van der Sluis (2018)	312	IL 8 MK304	375-401	100-250	17	23/25	21-29	17.9	9-17	NA/NA
Espinoza (2019)*	*406*	NA	NA	NA	9	17	NA	NA	NA	NA/7,6

* National cancer database 2004-2015

°9.6% in hand sewn anastomosis

Minimally invasive surgery

A Propensity Score Matched Analysis of Open Versus Minimally Invasive Transthoracic Esophagectomy in the Netherlands

Maarten F. J. Seesing, MD,* Suzanne S. Gisbertz, MD, PhD,† Lucas Goense, MD,* Richard van Hillegersberg, MD, PhD,* Hidde M. Kroon, MD, PhD,‡ Sjoerd M. Lagarde, MD, PhD,‡ Jelle P. Ruurda, MD, PhD,* Annelijn E. Slaman, MD,† Mark I. van Berge Henegouwen, MD, PhD,† and Bas P. L. Wijnhoven, MD, PhD‡

TABLE 2. Perioperative Outcomes

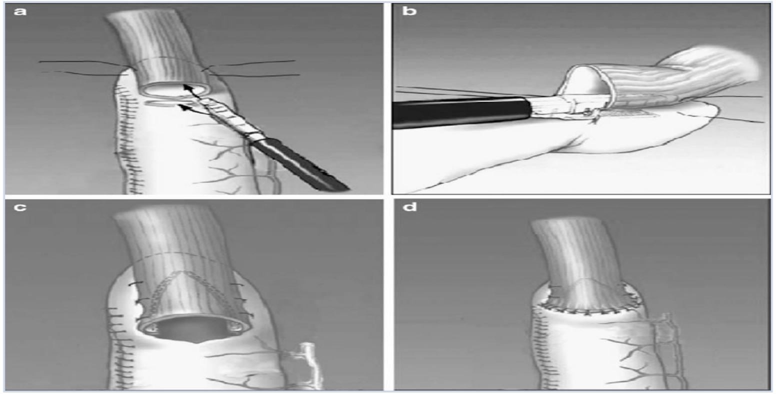
Outcomes		Before Matching: OE (N = 500) n	%	MIE (N = 1227) n	%	*P*	After Matching: OE (N = 433) n	%	MIE (N = 433) n	%	*P*
Conversion rate		n.a.	n.a.	35	2.8	n.a.	n.a.	n.a.	14	3.4	n.a.
Postoperative complications	Total	316	63.2	735	59.9	0.203	271	62.2	260	60.2	0.468
	Grade 1	161	32.2	300	24.4	0.587	117	27.0	97	22.4	0.797
	Grade 2	52	10.4	125	10.2		64	14.8	74	17.1	
	Grade 3	6	1.2	21	1.7		6	1.4	8	1.8	
	Grade 4	20	4.0	31	2.5		13	3.0	13	3.0	
	Grade n.s.	77	15.4	258	21.1		71	16.4	68	15.7	
Pulmonary complications		182	36.4	411	33.5	0.249	148	34.2	154	35.6	0.669
Anastomotic leakage		78	15.6	260	21.2	0.008	67	15.5	92	21.2	0.028
Chylothorax		43	8.6	135	11.0	0.136	38	8.8	46	10.6	0.358
Cardiac complications		71	14.2	174	14.2	0.992	56	12.9	59	13.6	0.764
Postoperative bleeding		8	1.6	14	1.1	0.440	8	1.8	7	1.6	0.795
Wound infection		29	5.8	39	3.2	0.011	22	5.1	17	3.9	0.431
Fascial dehiscence		5	1.0	4	0.3	0.078	3	0.7	2	0.5	0.654
Intra-abdominal abscess		4	0.8	1	0.0	0.012	0	0.0	4	0.9	0.045
Gastric conduit necrosis		2	0.4	29	2.4	0.005	1	0.2	14	3.2	0.001
Recurrent laryngeal nerve injury		21	4.2	53	4.3	0.911	17	3.9	25	5.8	0.206
Reintervention	Total	99	19.8	351	28.6	<0.001	89	21.1	119	28.2	0.017
	Under GA	58	11.6	210	17.1	0.004	52	12.3	76	18.0	0.021
30- d postoperative mortality		20	4.0	54	4.4	0.719	13	3.0	20	4.7	0.209
ICU stay (days)		3	(0–155)	2	(0–125)	<0.001	3	(0–155)	2	(0–82)	0.418
Hospital stay (days)		15	(4–152)	12	(3–197)	<0.001	14	(4–156)	13	(4–200)	0.001
Readmission		60	12.0	189	15.4	0.067	54	12.5	56	12.9	0.704

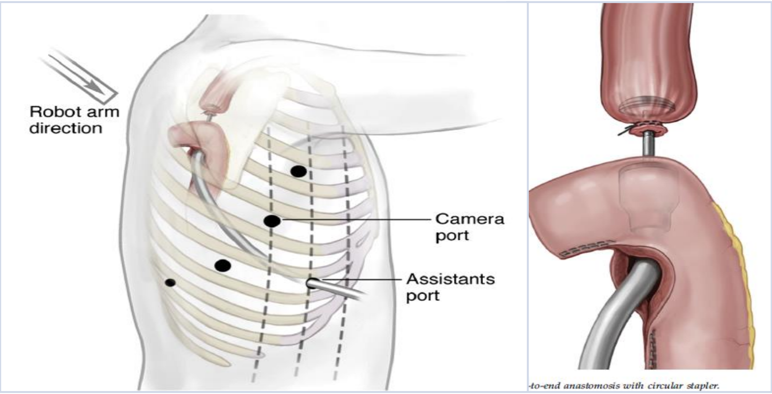
Data are n (%), median (range) and mean (±SD). Severity postoperative complications: grade 1: temporary disadvantage as a result of complication, but full recovery without reintervention; grade 2: complete recovery after reintervention; grade 3: complication caused permanent injury to the patient; grade 4: patient deceased at the consequences of complication. GA indicates general anesthesia; NA, not applicable; NS, not specified.

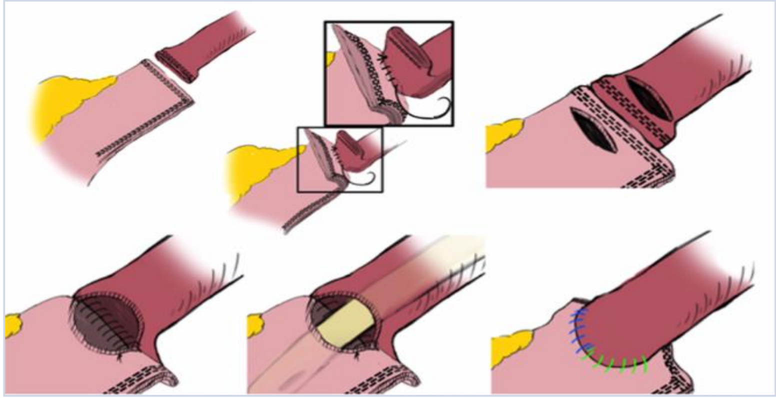
Surg Endosc (2017) 31:119–126

RAILE: anastomosis

Cervical anastomosis is preferred by most surgeon over the intrathoraic but it is associated with higher leaks (10–30 %), stenosis, recurrent nerve injuries, dysphagia. The Ivor-Lewis technique was developed later for the high technical complexity





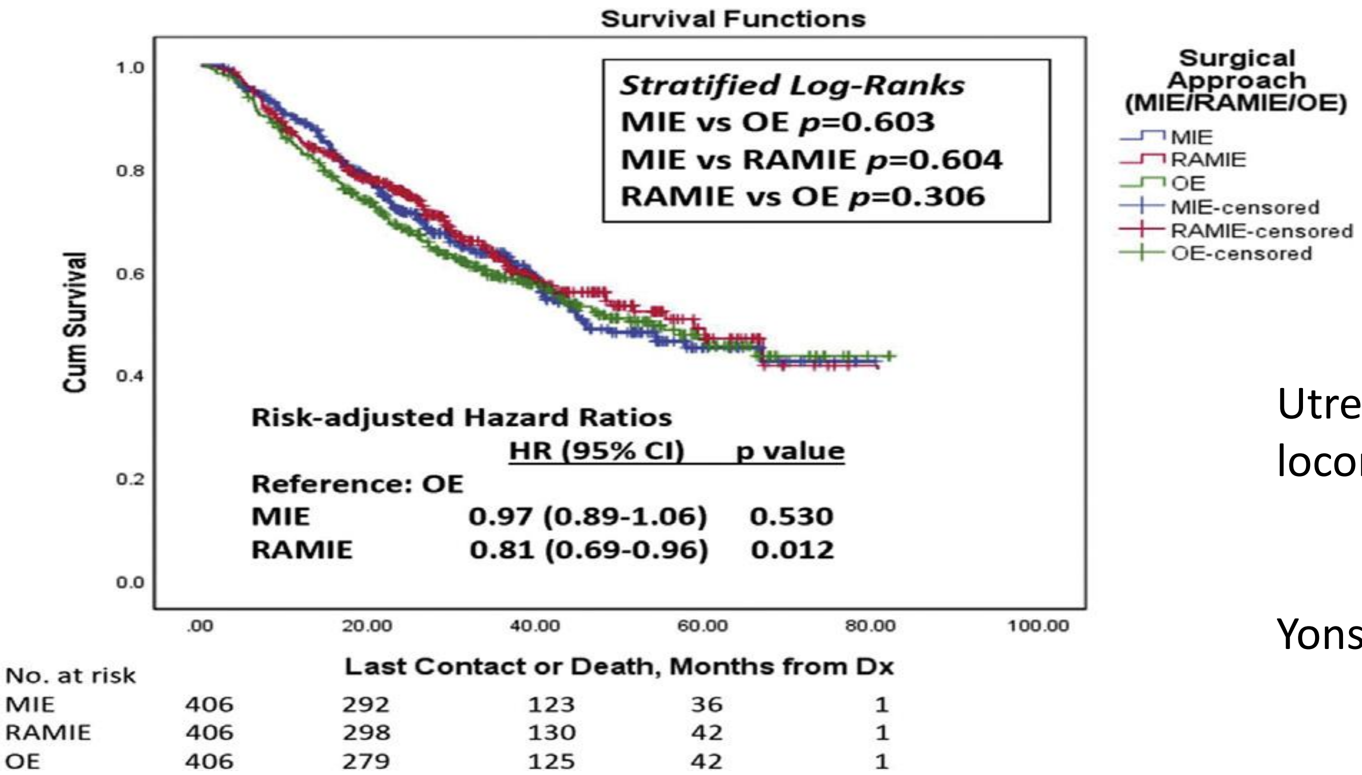


Anastomotic leckage according to ECCG (18)

–Side to side linear stapled	4/5 (80%) Grade I: 1 Grade II 3 Grade III: 1
–Circular stapled	3/18 (16.6%) Grade I: 1 Grade II: 2
–Hand sewn	5/52 (9,6%) Grade I: O Grade II: 4 Grade III: 1

Egberts et al. Dis Esoph (2017) **30**, 1–9

RAMIE: long term results



Survival curves after propensity score matching MIE, OE, RAMIE. US National center database

Wecsler et al. Ann Thorac Surg 2017;104:1138–46)

Utrecht group: R0 rate 95%, 5-year; OS 42%, and locoregional recurrence 6%.

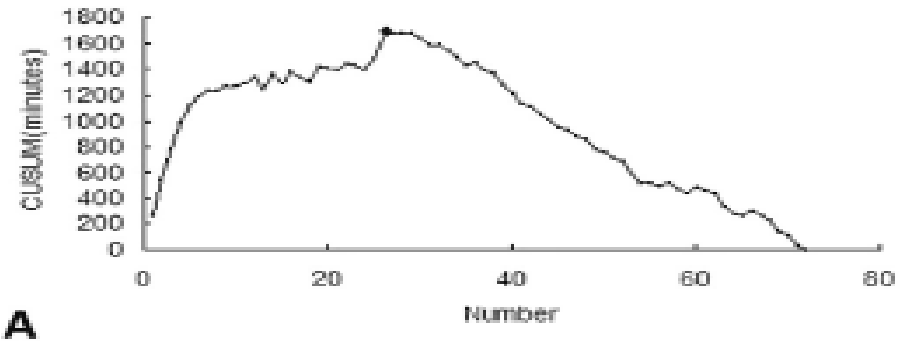
Yonsei group: R0 rate 95.7%, 3-year OS 85%.

RAMIE is oncologically effective and acceptable with a high R0 rate and adequate lymphadenectomy.

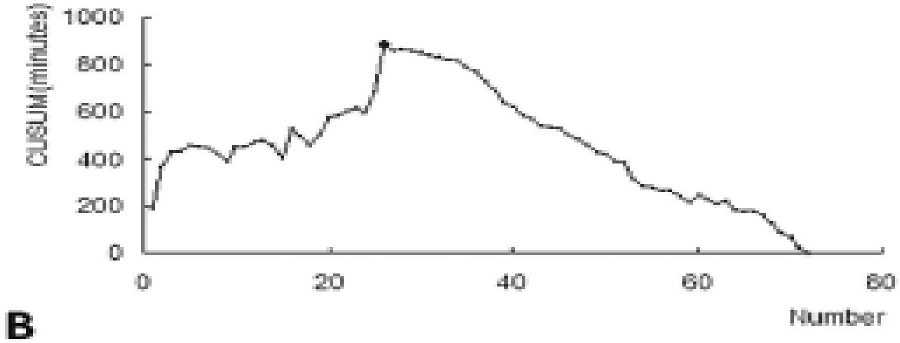
Learning curve in RAMIE

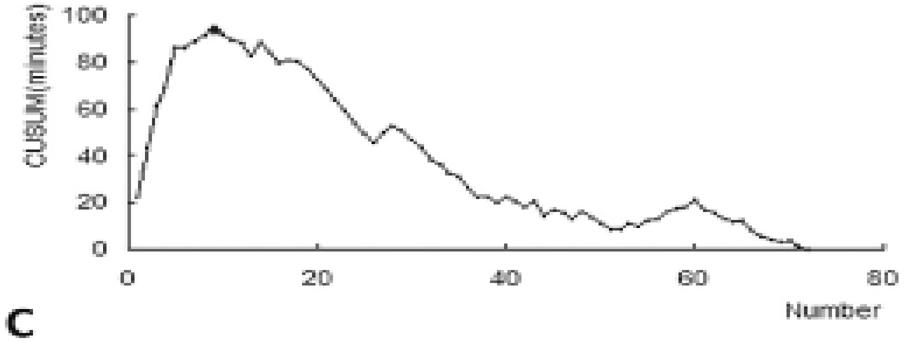
For a surgeon experienced in Open & MIE: ***26 cases for RAMIE***

Total surgical time : 26th operation

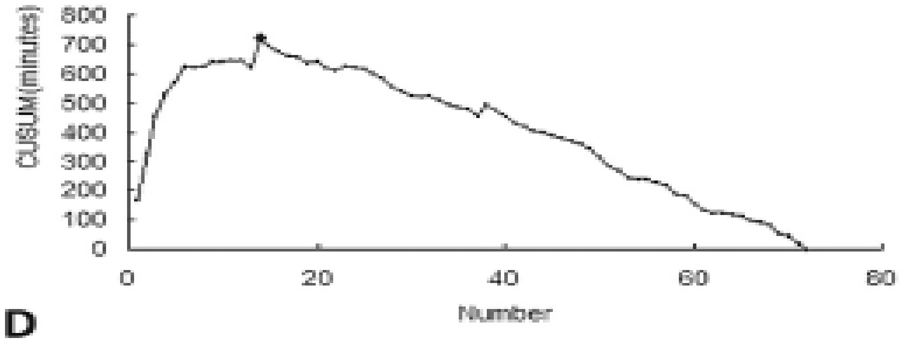


Thoracic console time : 26th operation





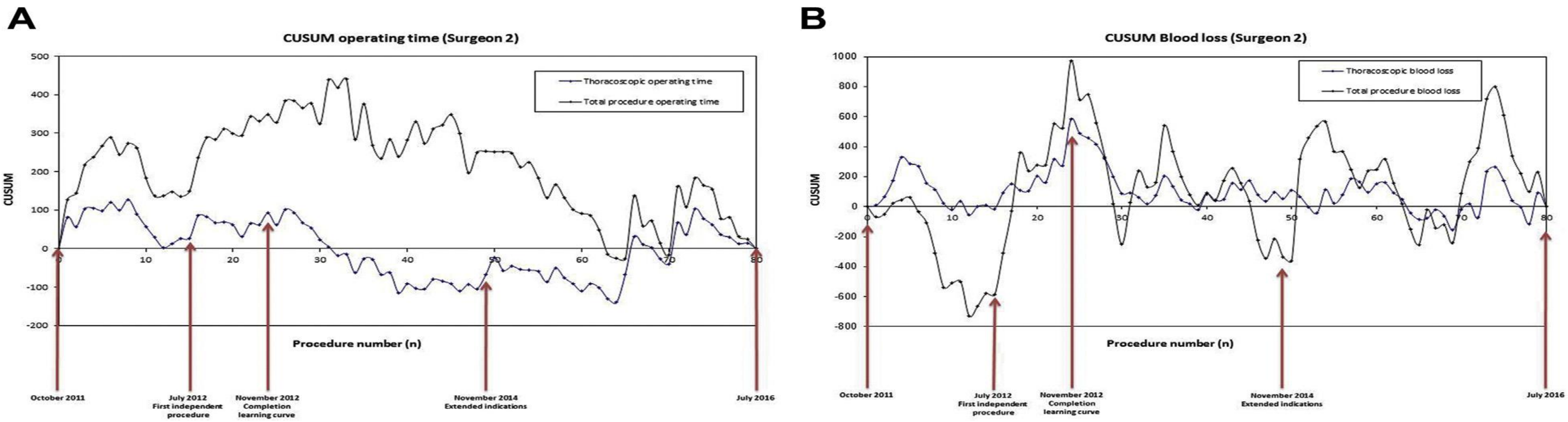
Thoracic setup & docking time: 9 procedures



Abdominal console time : 14th operation

Zhang et al. Ann Thorac Surg 2018;105:1024–30

Learning curve in RAMIE



In a structured proctoring program (20 procedures as assisting table surgeon, 5 observational & 15 supervised), the learning phase of thoracic RAMIE was completed ***within 24 cases*** (15 supervised and 9 independent cases). ***70 procedure*** for proctor!!

Van der Sluis P et al. Ann Thorac Surg 2018;106:264–71

Consideration

RAMIE allows to gain more control in anatomically challenging areas (dissection of cancer near the *upper thoracic inlet,* higher lymph node yield along the *left recurrent nerve*) and in performing h*and-sewn anastomosis* in RAILE

Conclusions

RAMIE is a safe and feasible procedure in experenced center (compared to MIE & OE) particularly for McKeown procedure. The Ivor Lewis procedure is still in the implementation phase and far from being standardised.

The currently available evidence from literature is too limited for any definite conclusions in relation to traditional techniques but RAMIE is yet another way of performing a difficult operation. It will undoubtedly become the preferred approach of certain surgeons and groups.

Multidisciplinary team: toward ERAS

Enhanced recovery pathways lead to an improvement in postoperative outcomes following esophagectomy: systematic review and pooled analysis.

Markar SR[1], Karthikesalingam A[2], Low DE[1].

Author information

1 Department of Thoracic Surgery, Virginia Mason Medical Center, Seattle, Washington, USA.

2 Department of Outcomes Research, St George's hospital, London, UK.

The aim of this systematic review and pooled analysis is to determine the effect of enhanced recovery programs (ERP) on clinical outcome measures following esophagectomy. Medline, Embase, trial registries, conference proceedings, and reference lists were searched for trials comparing clinical outcome from esophagectomy followed by a conventional pathway with esophagectomy followed by an ERP. Primary outcomes were the incidence of postoperative mortality, anastomotic leak and pulmonary complications, and secondary outcomes were length of hospital stay and the incidence of 30-day readmission. Nine studies were included comprising 1240 patients, 661 patients underwent esophagectomy followed conventional pathway, and 579 patients underwent ERP. Utilization of ERP was associated with a reduction in the incidence of anastomotic leak (12.2-8.3%; pooled odds ratios = 0.61; 95% confidence interval = 0.39 to 0.96; P = 0.03) and pulmonary complications (29.1-19.6%; pooled odds ratios = 0.52; 95% confidence interval = 0.36 to 0.77; P = 0.001) and length of hospital stay, and no significant change in postoperative mortality or readmission rate. There was significant variation in the design of enhanced recovery protocols, surgical approach, and utilization of neoadjuvant therapies between the studies that are important confounding variables to be considered. This study suggests a benefit to the utilization of ERP following esophagectomy. The pathways provide a template for all medical personnel interacting with these patients in order to provide incremental changes in all aspects of clinical care that translates into global improvements seen in postoperative outcomes.

Multidisciplinary team: toward ERAS

TABLE 1. Studies Assessing ERAS in Esophagectomy

	Year	Design	Level	Program	Findings
Cao et al[13]	2012 (published online)	Retrospective case-control (n = 112)	2−	Mixed open resections Exclusions: moderate- to high-risk patients (cardiac/respiratory disease, age >65 yr plus minor comorbidity), failure to fast track NG tube routinely avoided ICU routinely avoided Feeding jejunostomy used POD1 Removal of urinary catheter POD1 Removal of chest drain POD3 (no criteria given) Removal of TEA POD4 NBM until CS POD4 Discharge POD7	Reduction in LOS (7 d) Reduction in complications (18%) Before: mortality (5%), morbidity (47%), pulmonary (19%), leak (11%), readmission (5%), LOS (15 d) After: mortality (2%), morbidity (29%), pulmonary (11%), leak (7%), readmission (4%), LOS (8 d) Failure to fast track (27%)
Li et al[12]	2012	Retrospective case-control (n = 106)	2−	Open and minimally invasive resections with new pathway Pyloric drainage, single chest drain, no jejunostomy ICU routinely avoided Nonopioid TEA 5 d Urinary catheter 2 d NBM for 3 d, CS POD5 Chest drains removed after solid diet Discharge POD7	Reduction in LOS (2 d) Routine ICU admission unnecessary Before: mortality (0%), morbidity (59%), pulmonary (32%), leak (11%) readmissions (6%), LOS (10 d) After: mortality (2%), morbidity (62%), pulmonary (24%), leak (14%), readmissions (5%), LOS (8 d)
Munitiz et al[14]	2010	Retrospective case-control (n = 148)	2−	Open Ivor-Lewis resections Pathway introduced to formalize existing practice Prescribed reduction in postoperative FIO_2 Postoperative fluid restriction (TPN plus saline) Chest drains removed POD4 NBM until CS POD5 ICU care until POD3	Improved pulmonary morbidity, mortality, and LOS (4 d) Before: mortality (5%), morbidity (38%), pulmonary morbidity (23%), leak (8%), LOS (13 d) After: mortality (1%), morbidity (31%), pulmonary morbidity (14%), leak (7%), LOS (9 d)

Findlay JM, Gillies RS, Millo J et al (2014) Enhanced recovery for esophagectomy: a systematic review and evidence-based guidelines. Ann Surg 259:413–431

Multidisciplinary team: toward ERAS

Jiang et al[15]	2009	Retrospective observational (n = 114)	3	Unspecified esophagectomy Intraoperative fluid restriction Feeding jejunostomy used POD1 TEA and urinary catheter removed POD2 NG tube removed POD3 Chest drains removed POD4 (if <100 mL/24 h) NBM until CS POD5	Favorable morbidity and mortality Mortality (2.6%), morbidity (64%), pulmonary (11%), leak (0.8%), LOS (7 d), readmission (4%) Failure to fast track (22%); greater in age >65 yr and preoperative comorbidities
Low et al[16]	2007	Retrospective observational (n = 340)	3	Single surgeon, evolving program Intraoperative fluid restriction (not quantified) Feeding jejunostomy Chest drains removed POD2, and POD3–5 (criteria unspecified) NBM until CS POD4–5 PCEA and NG tube removed POD5 or 6 Prescribed physiotherapy regimen Discharge POD7–8	Favorable morbidity and mortality Mortality (0.3%), morbidity (45%), pulmonary (17%) leak (4%), LOS (12 d)
Cerfolio et al[17]	2004	Retrospective observational (n = 90)	3	Single-surgeon Ivor-Lewis resections Standardized computerized pathway ICU routinely avoided Feeding jejunostomy from POD1 Anterior chest drain removed POD2 Second removed POD4 if <450 mL/d TEA, urinary and NG catheters removed POD3 NBM until CS POD4–5	Favorable morbidity and mortality Mortality (4%), morbidity (26%), leak (none), readmission (4%), LOS (7 d). Routine ICU admission unnecessary High patient satisfaction Failure to fast track 22% (greater with neoadjuvant therapy)

F_{IO_2} indicates fraction of inspired oxygen; ICU, intensive care unit; NBM, nil by mouth; PCEA, patient-controlled epidural analgesia.

Findlay JM, Gillies RS, Millo J et al (2014) Enhanced recovery for esophagectomy: a systematic review and evidence-based guidelines. Ann Surg 259:413–431

Multidisciplinary team

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Donald E. Low[1] · William Allum[2] · Giovanni De Manzoni[3] · Lorenzo Ferri[4] · Arul Immanuel[5] · MadhanKumar Kuppusamy[1] · Simon Law[6] · Mats Lindblad[7] · Nick Maynard[8] · Joseph Neal[1] · C. S. Pramesh[9] · Mike Scott[10] · B. Mark Smithers[11] · Valérie Addor[12] · Olle Ljungqvist[13]

- Multimodal system
- Evidence based care protocols
- Assessing progress and compliance through continuous audit
- Procedure- specific, non- procedure specific. Operative or technical issue and peri and postoperative issues
- The ERAS study group produced a consensus statement regarding patients undergoing colonic resection in2005
- The current ERAS guidelines for esophagectomy cover all critically important standard issues associated with enhanced recovery, but also address issues unique to esophageal resection

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
SCIENTIFIC REVIEW
Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Table 1 ERAS recommendations for procedure-specific, operative and non-procedure-specific components in esophagectomies

Element	Recommendation	Level of evidence	Recommendation grade
Procedure-specific components			
Preoperative nutritional assessment and treatment	Nutritional assessment should be undertaken in all patients with a view to detecting and optimizing nutritional status before surgery	Low	Strong
Preoperative nutritional intervention	In high-risk cases enteral support is indicated preferably using the GI tract with selective use of feeding tubes	Low	Strong
Preoperative oral pharmaconutrition	Evidence in support of pharmaconutrition for patients undergoing surgery for esophageal cancer is conflicting and its routine use cannot be supported at this time	Moderate	Strong
Multidisciplinary tumor board	There is limited data to support an improvement in overall survival. MDTs should be fundamental to management planning for all patients with esophageal cancer. MDTs ensure appropriate multidisciplinary input into patient care and improve the quality of that care	Moderate	Strong
Prehabilitation programs	Evidence from small studies supports the use of prehabilitation programs for major abdominal surgery, however there is limited data for esophagectomy. Patients undergoing esophagectomy may benefit from a multimodal prehabilitation program and ongoing assessments may provide additional information to direct future recommendations	*(Extrapolated, Small Studies)*: Low	Moderate

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery
CrossMark
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Operative components			
Timing of surgery following neoadjuvant therapy	The optimum time for surgery following neoadjuvant chemotherapy is 3–6 weeks following completion of chemotherapy. The optimum time for surgery following neoadjuvant chemoradiotherapy is 6–10 weeks following the last day of radiotherapy	Moderate	Moderate
Access: minimally invasive or open	Both open and minimally invasive approach to esophagectomy can yield acceptable outcomes. Recent assessments suggest that minimally invasive access during esophagectomy is feasible and safe and seems to be associated with some beneficial outcomes such as less perioperative blood loss, reduced rate of pulmonary infections and a shorter hospital stay without any clear significant disadvantages	Moderate	Moderate
Choice of conduit	The stomach, colon and jejunum are all viable options for conduit reconstruction after an esophageal resection. There is no single option or substitute appropriate for all patients and circumstances. The decision needs to be based on an awareness of the possibilities and limitations as well as short-term and long-term advantages and disadvantages of each organ as an esophageal substitute. Due to its reliable vascularity and relative simplicity a tubulized gastric conduit is recommended as the first option	*Gastric conduit*: Low *Tubulized stomach*: Moderate	Strong Strong
Role of pyloroplasty	The evidence for pyloroplasty and other pyloric drainage procedures is limited, with no strong evidence of effect on outcome. No specific recommendation on the role of pyloroplasty can be made at this time	Low	Strong
Lymphadenectomy	Two-field lymphadenectomy is recommended for T1b-T3/4 adenocarcinoma in the middle and lower third of the esophagus. This should not include dissection of the recurrent laryngeal nerve nodes	Moderate	Strong
	Three-field lymphadenectomy is recommended in upper third SCC but there should be careful selection according to early stage disease in patients with good performance status and surgery performed in experienced centers		

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhan Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Table 1 continued

Element	Recommendation	Level of evidence	Recommendation grade
Perianastomotic drains	Avoid the use of perianastomotic drain in cervical anastomosis (no benefit shown)	Moderate	Moderate
NG tube/gastric decompression	Nasogastric tube decompression at the time of esophageal resection is currently recommended with the caveat of considering early removal (on postoperative day 2) when clinically appropriate	Moderate	Strong
Chest drain management following esophagectomy	The use (duration and number) of chest drains should be minimized. Chest drains may be removed in the absence of air and chyle leaks. A single mid-positioned drain is as effective as two drains and causes less pain; passive drainage is as good as active drainage	Weak	Moderate
Routine use of enteric feeding tubes	Early enteral feeding with target nutritional rate on day 3–6 should be strongly considered after esophagectomy. For appropriate target nutritional rate see post-operative feeding recommendations. Either feeding jejunostomy or nasojejunal/nasoduodenal tubes may be used	Moderate	Moderate
Esophagectomy: perioperative fluid management	Optimal fluid balance should be the focus with consideration of all contributory factors. Positive balance resulting in weight gain >2 kg/day is to be avoided	High	Strong
	Goal-directed fluid therapy may be indicated for higher risk patients not part of a formal ERAS program	Moderate	Weak
	Balanced crystalloids for fluid replacement is recommended	Moderate	Moderate

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery
CrossMark
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Anesthetic management	Volatile or intravenous anesthetics are equally effective for maintenance of anesthesia. Intermediate-acting NMBs, BIS monitoring, avoiding volume overload, and lung protective strategies facilitate early extubation and reduce postoperative complications. Clinical evidence supporting lung protection strategies is strong for TLV, but less well studied during OLV	Volatile or intravenous maintenance of anesthesia: Moderate	Strong
Anesthetic maintenance	Appropriately-dosed intermediate-acting muscle relaxants	High	Strong
	BIS	High	Strong
	Avoid volume overload	Moderate	Strong
Two-lung ventilation	Low V_T (6–8 mL/kg PDW)	High	Strong
	Routine PEEP >2–5 cm H_2O and recruitment maneuvers have not been fully defined	Moderate	Strong
One-lung ventilation	Avoid hyperoxia; allow mild hypercapnia	High	Moderate
	Low V_T (4–5 mL/kg PBW)	Moderate	Moderate
	PEEP (5 cm H_2O) ventilated lung	Low	Strong
	CPAP (5 cm H_2O) non-ventilated lung	Low	Moderate
Intensive care unit utilization	Postoperative management of patients after esophagectomy should be individualized and does not routinely require ICU care. The availability of PCU/HDU is a safe alternative for lower risk patients	Moderate	Strong

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery CrossMark
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Table 1 continued

Element	Recommendation	Level of evidence	Recommendation grade
Perioperative pain control for esophagectomy	*Thoracic epidural analgesia*	(*Extrapolated*): Moderate	Strong
	Should be considered as first line approach to post-operative analgesia following esophagectomy		
	Paravertebral Analgesia	(*Extrapolated*): Moderate	Strong
	Paravertebral blocks are a good alternative to TEA following esophagectomy		
	Acetaminophen	(*Extrapolated*): Moderate	Strong
	Regular acetaminophen dosing should be considered post-esophagectomy		
	NSAIDS	(*Extrapolated*): Moderate	Strong
	Commence NSAIDS on an individualized basis taking into account complexity and difficulty of surgery, age and renal function		
	Gabapentinoids	(*Extrapolated*): Low	Weak
	Gabapentinoids may be applicable for post-esophagectomy analgesia but limited evidence is currently available		
	Ketamine	(*Extrapolated*): Moderate	Weak
	Ketamine may be applicable for post-esophagectomy analgesia but additional studies are required		
	Magnesium	(*Extrapolated*): Moderate	Weak
	Magnesium may be applicable for post-esophagectomy analgesia but additional studies are required		
	Lidocaine infusions	(*Extrapolated*): Moderate	Weak
	Lidocaine infusion likely has a role in post-esophagectomy analgesia but further studies are required		

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery
CrossMark
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Postoperative early nutrition: oral vs jejunostomy	Introduction of early enteral nutrition is beneficial in patients undergoing surgery for esophageal cancer	Moderate	Strong
Early mobilization	Postoperatively, early mobilization should be encouraged as soon as possible using a standardized and structured approach with daily targets	Moderate	Strong
The role of multidisciplinary standardized clinical pathways	Evidence supports multidisciplinary care using a standardized pathway in the perioperative care of patients undergoing esophagectomy	Low	Strong
Audit	Continuous institutional audit of outcomes alongside key care processes should be part of daily practice. Audit contributing to institutional, regional, national or international datasets for benchmarking should be a targeted goal	Moderate	Strong
Non-procedure-specific components			
Preoperative counseling patient/family	Patients undergoing esophagectomy, and their family or care taker, should receive pre-operative counseling with emphasis on perioperative and postoperative targets and goals	Low	Strong
Smoking–alcohol cessation	Smoking should be stopped 4 weeks prior to surgery and regular high alcohol consumers should abstain at least 4 weeks before surgery to reduce postoperative complications	*(Extrapolated)*: Moderate	Strong

World J Surg (2019) 43:299–3
https://doi.org/10.1007/s00268-
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Table 1 continued

Element	Recommendation	Level of evidence	Recommendation grade
Cardiopulmonary assessment	CPET results have been used to assess patients undergoing major surgery, to guide preoperative optimization, to predict postoperative cardiopulmonary complications after surgery and, in some centers, to assess whether borderline patients should undergo resection. Evidence in support of the use of exercise derived parameters in risk stratification of esophageal resection patients is currently limited	Low	Moderate
Bowel preparation (taking into account issues regarding colonic reconstruction)	Mechanical bowel preparation does not reduce the incidence of postoperative complications and should not be used routinely prior to esophageal resection with gastric reconstruction. Most surgeons would still recommend MBP for planned colonic reconstruction although evidence is lacking	*(Extrapolated)*: Moderate	Strong
Preoperative fasting	Prolonged fasting should be avoided, and clear liquids, including specific preoperative high-carbohydrate drinks, should be allowed until 2 h prior to esophagectomy. Caution should be applied for patients with significant dysphagia or other obstructive symptoms	*Avoidance of preoperative fasting*: High *Preoperative carbohydrate drinks: (Extrapolated)*: Low	Strong Moderate
Preanesthetic analgesics and anxiolytics	Long-acting anxiolytics should be avoided, especially in the elderly, while short acting drugs may be used to reduce preoperative anxiety	Moderate	Weak
Postoperative nausea and vomiting	Prophylaxis in high-risk patients can reduce the incidence of PONV. The use of a combination therapy is recommended. If PONV occurs, therapy with 5-hydroxytryptamine receptor antagonists should be preferred	*(Extrapolated)*: Low	Strong

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4

SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Beta-blockade	Prophylactic beta-blockage for non-cardiac surgery reduces the incidence of postoperative myocardial infarction and supraventricular arrhythmias, but may potentially increase stroke, hypotension, bradycardia and even death. The beneficial effects seem to be cardiac-risk related, and are only seen in those with moderate to high cardiac risk. Current evidence supports continuing beta-blockers in the perioperative period in those who are chronically on beta-blockers and to prescribe beta-blockers for high-risk patients with coronary artery disease undergoing high-risk non-cardiac operations	Moderate	Strong
Prophylaxis of atrial dysrhythmia	Prophylactic amiodarone may reduce the incidence of postoperative atrial fibrillation but current evidence does not support reduction in length of stay, overall morbidity or mortality in patients undergoing esophagectomy	Moderate	Moderate
	Perioperative cardiac rhythm management strategies should be patient specific, aimed to reduce the modifiable risk factors and prompt recognition and treatment of associated or contributory complications		
Antithrombotic prophylaxis	Antithrombotic prophylaxis with LMWH, together with mechanical measures, reduce the risk of VTE. Treatment should be started 2–12 h before the operation and should continue for 4 weeks after the operation. Epidural catheters should be placed no sooner than 12 h from the last LMWH does. LMWH should not be given until at least 4 h have passed after epidural catheter removal	High	Strong

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

Element	Recommendation	Level of evidence	Recommendation grade
Hypothermia	Intraoperative hypothermia leads to adverse postoperative events. Measures to maintain normothermia, such as forced-air blankets, warming mattress or circulating-water garment systems, use of warm intravenous fluid should be recommended. Temperature monitoring with an aim of maintaining core temperature of above 36 °C or 96.8 °F is desirable	High	Strong
Postoperative glycemic control	Reducing insulin resistance and treatment of excessive hyperglycemia is strongly associated with improved outcomes. A multi modal approach to minimize the metabolic stress of surgery is recommended to reduce insulin resistance and hyperglycemia. Preoperative carbohydrate treatment, epidural anesthesia, minimally invasive surgical techniques and early enteral feeding are recommended. Blood glucose levels above 10 mmol/L (180 mg/dl) should be treated	Moderate	Strong
Bowel stimulation	A multimodal approach with epidural analgesia and near-zero fluid balance is recommended. Oral laxatives and chewing gum given postoperatively are safe and may accelerate gastrointestinal transit	Low	Weak
Foley catheter management	Expeditious removal of urinary catheters following surgery can positively impact rates of postoperative urinary tract infections. However, in patients that have had a thoracotomy and who have an epidural catheter in place, removal of the urinary catheter prior to removal of the epidural catheter carries a significant risk for urinary catheter replacement notably in males	High	Strong
	Catheter removal within 48 h has higher incidence of reinsertion for urinary retention. Early removal of urinary catheters is worthy of consideration but there needs to be strict protocols for patient bladder monitoring to assess the need for catheter reinsertion		
	Urinary infection rates are lower with the use of a suprapubic catheter if urinary drainage required for longer than 4 days	High	Moderate

World J Surg (2019) 43:299–330
https://doi.org/10.1007/s00268-018-4786-4
World Journal of Surgery
CrossMark
SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Multidisciplinary team

General and Oncologic Surgery unit
S.Croce & Carle Hospital, Cuneo Italy

- Nutritional assessment and treatment
- Preoperative fasting
- Perianastomotic drains
- Chest drain management
- NG tube/gastric decompression
- Perioperative fluid management
- Anesthesiologist management
- Hypothermia
- Glycemic control
- Use of feeding jejunostomy
- Postoperative nausea and vomiting prophylaxis
- Intensive care unit management
- Perioperative pain control
- Postoperative early nutrition
- Early mobilization
- Antithrombotic prophylaxis

⇄

SURGICAL PROCEDURE