Beth Israel Lahey Health
Lahey Hospital & Medical Center

Tufts University School of Medicine

New technology in esophageal cancer: where we are & where we're going

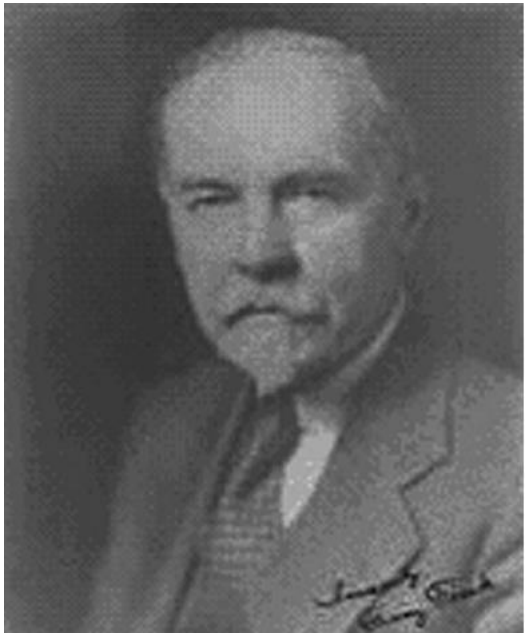
Elliot Servais, MD, FACS
Section Chief, Thoracic Surgery
Lahey Hospital & Medical Center
Tufts University School of Medicine

General Thoracic Surgical Club

Disclosure

- Consultant & proctor for Intuitive Surgical

Where we started



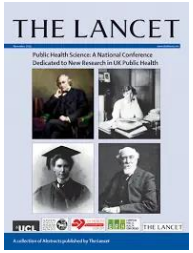
(Ann Thorac Surg 2008;85:1497–9)

Franz John A Torek - 1st esophagectomy in 1919

"There is little doubt that the successful outcome of radical curative surgery for esophageal carcinoma remains one of the great challenges of surgical practice."

-Ivor Lewis, *British Journal of Surgery* 1946[1]

Esophagectomy: MIE vs Open



Minimally invasive versus open oesophagectomy for patients with oesophageal cancer: a multicentre, open-label, randomised controlled trial

Surya S A Y Biere, Mark I van Berge Henegouwen, Kirsten W Maas, Luigi Bonavina, Camiel Rosman, Josep Roig Garcia, Suzanne S Gisbertz, Jean H G Klinkenbijl, Markus W Hollmann, Elly S M de Lange, H Jaap Bonjer, Donald L van der Peet, Miguel A Cuesta

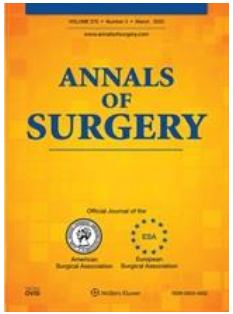
Lancet 2012; 379: 1887–92

	OO (N=56)	MIO (N=59)	p value
Pulmonary outcomes			
Pulmonary infection within 2 weeks	16 (29%)	5 (9%)	0·005
Pulmonary infection in-hospital	19 (34%)	7 (12%)	0·005
Secondary outcomes			
Hospital stay (days)*	14 (1–120)	11 (7–80)	0·044
Short-term quality of life†			
SF 36†			
Physical component summary	36 (6; 34–39)	42 (8; 39–46)	0·007
Mental component summary	45 (11; 40–50)	46 (10; 41–50)	0·806
EORTC C30†			
Global health	51 (21; 44–58)	61 (18; 56–67)	0·020
OES 18‡			
Talking	37 (39; 25–49)	18 (26; 10–26)	0·008
Pain	19 (21; 13–26)	8 (11; 5–11)	0·002
Total lymph nodes retrieved*	21 (7–47)	20 (3–44)	0·852
Resection margin§			0·080
R0	47 (84%)	54 (92%)	..
R1	5 (9%)	1 (2%)	..

	OO (N=56)	MIO (N=59)	p value
Intraoperative data			
Operative time (min)*†	299 (66–570)	329 (90–559)	0·002
Blood loss (mL)†	475 (50–3000)	200 (20–1200)	<0·001
Conversion‡	NA	8 (14%)	
Level of anastomosis§			0·970
Cervical	37 (66%)	38 (64%)	
Thoracic	15 (27%)	17 (29%)	
Postoperative data			
ICU stay (days)†	1 (0–106)	1 (0–50)	0·706
VAS (10 days)¶	3 (2)	2 (2)	0·001
Epidural failure‖	11 (20%)	10 (17%)	0·734
Other complications			
Anastomotic leakage	4 (7%)	7 (12%)	0·390
Thoracic complications without anastomotic leakage**	2 (4%)	2 (3%)	0·958
Vocal-cord paralysis††	8 (14%)	1 (2%)	0·012
Pulmonary embolism	0 (0%)	1 (2%)	0·328
Reoperations	6 (11%)	8 (14%)	0·641

"TIME" trial

Esophagectomy: MIE vs Open



Minimally Invasive Esophagectomy

Results of a Prospective Phase II Multicenter Trial—the Eastern Cooperative Oncology Group (E2202) Study

James D. Luketich, MD, Arjun Pennathur, MD,* Yoko Franchetti, PhD,† Paul J. Catalano, PhD,† Scott Swanson, MD,‡ David J. Sugarbaker, MD,‡ Alberto De Hoyos, MD,§ Michael A. Maddaus, MD,¶ Ninh T. Nguyen, MD,|| Al B. Benson, MD,§ and Hiran C. Fernando, MD***

Ann Surg 2015;261:702–707

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

A Randomized Controlled Trial

Pieter C. van der Sluis, MD, PhD, MSc, Sylvia. van der Horst, MSc,* Anne M. May, PhD,† Carlo Schippers, MSc,* Lodewijk A. A. Brosens, MD, PhD,‡ Hans C. A. Joore, MD,§ Christiaan C. Kroese, MD,¶ Nadia Haj Mohammad, MD, PhD,|| Stella Mook, MD, PhD,** Frank P. Vleggaar, MD, PhD,†† Inne H. M. Borel Rinkes, MD, PhD,* Jelle P. Ruurda, MD, PhD,* and Richard van Hillegersberg, MD, PhD**

Ann Surg 2019;269:621–630

RAMIE

The robotic, 2-stage, 3-field esophagolymphadenectomy

Kemp H. Kernstine, MD, PhD,[a] Daniel T. DeArmond, MD,[a] Mohsen Karimi, MD,[a] Timothy L. Van Natta, MD,[a] Javier C. Campos, MD,[b] Mary R. Yoder, RN,[c] and Jeffrey E. Everett, MD,[a] Iowa City, Iowa

J Thorac Cardiovasc Surg 2004;127:1847-9

- Proposed benefits:
  - Improved optics, instrument degrees of freedom, self-assistance
- FDA approved da Vinci robot for esophagectomy March 31, 2020

RAMIE

TABLE 1 Change in Procedure Case Volume in The Society of Thoracic Surgeons General Thoracic Surgery Database During the Prior 1 and 6 Years

Variable	2013	2018	2019	% Change: 2013 to 2019	% Change: 2018 to 2019
Lobectomy	9607	13,383	13,381	39	0
Thoracoscopy[a]	6034	10,402	10,959	82	5
Thoracotomy	3573	2981	2422	−32	−19
Robotic-assisted	1298	4446	5559	328	25
Pneumonectomy	698	564	491	−30	−13
Bilobectomy	468	479	451	−4	−6
Segmentectomy	1284	2167	2425	89	12
Thoracoscopy[a]	895	1818	2122	137	17
Thoracotomy	389	349	303	−22	−13
Robotic-assisted	152	862	1205	693	40
Wedge[b]	6833	8118	7509	10	−8
Thoracoscopy[a]	5436	7099	6893	27	−3
Thoracotomy	1397	1019	616	−56	−40
Robotic-assisted[c]	478	1711	2089	337	22
Esophagectomy	2093	2612	2718	30	4
Open	1412	1334	1205	−15	−10
Minimally invasive[a]	681	1278	1513	122	18
Robotic-assistance	153	454	520	240	15
Tracheal resection	151	116	119	−21	3
Hiatal hernia	3138	5844	4423	41	−24

Servais et al. *Ann Thor Surg* 2021

GTSD 2019 RAMIE data:

- 19.1% of all esophagectomies
- 34.4% of MIE
- 262% increase in RAMIE from 2013

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RAMIE vs MIE

Diseases of the Esophagus (2020) 33, 1–6
DOI: 10.1093/dote/doz060

DISEASES OF THE ESOPHAGUS

ISDE The International Society for Diseases of the Esophagus

Original Article

Robot-assisted minimally invasive esophagectomy (RAMIE) compared to conventional minimally invasive esophagectomy (MIE) for esophageal cancer: a propensity-matched analysis

E. Tagkalos,[1,*] L. Goense,[2,*] M. Hoppe-Lotichius,[1] J.P. Ruurda,[2] B. Babic,[1] E. Hadzijusufovic,[1] W. Kneist,[1] P.C. van der Sluis,[1] H. Lang,[1] R. van Hillegersberg,[2] P. P. Grimminger[1]

- Propensity-matched analysis: 50 RAMIE vs 50 MIE
- Equivalent post-op complications
- Decreased ICU LOS & increased LN harvest in RAMIE

RAMIE vs MIE

JAMA Network Open

JAMA Network Open. 2021;4(11):e2129228.

Original Investigation | Surgery

Comparison of Clinical Outcomes of Robot-Assisted, Video-Assisted, and Open Esophagectomy for Esophageal Cancer

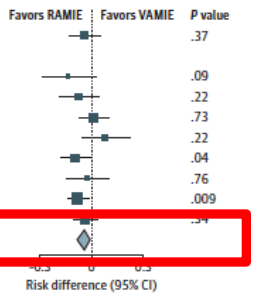
A Systematic Review and Meta-analysis

Michael A. Mederos, MD; Michael J. de Virgilio, BS; Rivfka Shenoy, MD, MS; Linda Ye, MD; Paul A. Toste, MD; Selene S. Mak, PhD; Marika S. Booth, MS; Meron M. Begashaw, MPH; Mark Wilson, MD, PhD; William Gunnar, MD; Paul G. Shekelle, MD, PhD; Melinda Maggard-Gibbons, MD; Mark D. Girgis, MD

- Review & Meta-analysis comparing RAMIE vs “VAMIE”
- 9 studies, 1 RCTs, 9355 patients

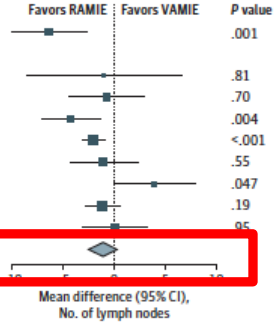
C RAMIE vs VAMIE for pulmonary complications

Study	Complications, No./total No. RAMIE	VAMIE	Risk difference (95% CI)	P value
He et al,[24] 2020	18/92	24/96	-0.05 (-0.17 to 0.06)	.37
Pooled studies				
Chao et al,[39] 2018	6/34	12/34	-0.18 (-0.38 to 0.03)	.09
Chen et al,[40] 2019	8/54	13/54	-0.09 (-0.24 to 0.06)	.22
Deng et al,[41] 2019	5/52	4/52	0.02 (-0.09 to 0.13)	.73
He et al,[45] 2018	5/27	2/27	0.11 (-0.07 to 0.29)	.22
Naffouje et al,[49] 2019	3/41	16/82	-0.12 (-0.24 to 0.00)	.04
Tagkalos et al,[53] 2020	6/40	7/40	-0.02 (-0.19 to 0.14)	.76
Yang et al,[56] 2020	71/271	99/271	-0.10 (-0.18 to -0.03)	.009
Zhang et al,[58] 2019	4/66	7/66	-0.05 (-0.14 to 0.03)	.34
Pooled random effects result: I^2 = 20.3%			-0.06 (-0.11 to -0.01)	



A RAMIE vs VAMIE for lymph node harvest

Study	Lymph nodes harvested, No. RAMIE	VAMIE	Mean difference (95% CI), No. of lymph nodes	P value
He et al,[24] 2020	92	96	-6.40 (-10.09 to -2.71)	.001
Pooled studies				
Chao et al,[39] 2018	34	34	-0.94 (-8.46 to 6.58)	.81
Chen et al,[40] 2019	54	54	-0.70 (-4.32 to 2.92)	.70
Deng et al,[41] 2019	52	52	-4.20 (-7.09 to -1.31)	.004
Espinoza-Mercado et al,[42] 2019	433	1578	-2.00 (-3.02 to -0.98)	<.001
He et al,[45] 2018	27	27	-1.00 (-4.24 to 2.24)	.55
Tagkalos et al,[53] 2020	40	40	4.00 (0.06 to 7.94)	.047
Yang et al,[56] 2020	271	271	-1.10 (-2.74 to 0.54)	.19
Zhang et al,[58] 2019	66	66	0.10 (-3.09 to 3.29)	.95
Pooled random effects result: I^2 = 51.6%			-1.10 (-2.45 to 0.25)	



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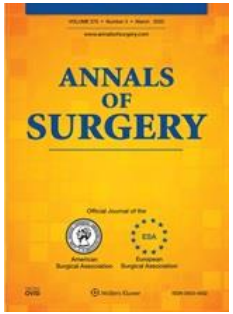
Lymph nodes matter



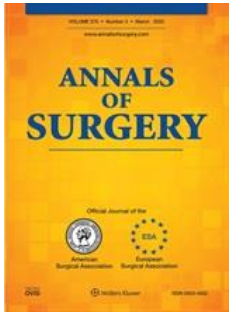
A More Extensive Lymphadenectomy Enhances Survival Following Neoadjuvant Chemoradiotherapy in Locally Advanced Esophageal Adenocarcinoma

Sihag, Smita MD*; Nobel, Tamar MD*; Hsu, Meier MS†; Tan, Kay See PhD†; Carr, Rebecca MD*; Janjigian, Yelena Y. MD‡; Tang, Laura H. MD, PhD§; Wu, Abraham J. MD¶; Bott, Matthew J. MD*; Isbell, James M. MD*; Bains, Manjit S. MD*; Jones, David R. MD*; Molena, Daniela MD*

Ann Surg. 2020 Nov 12

- Retrospective cohort study from MSKCC
- 778 EAC patients undergoing esophagectomy after induction chemo/XRT

Lymph nodes matter



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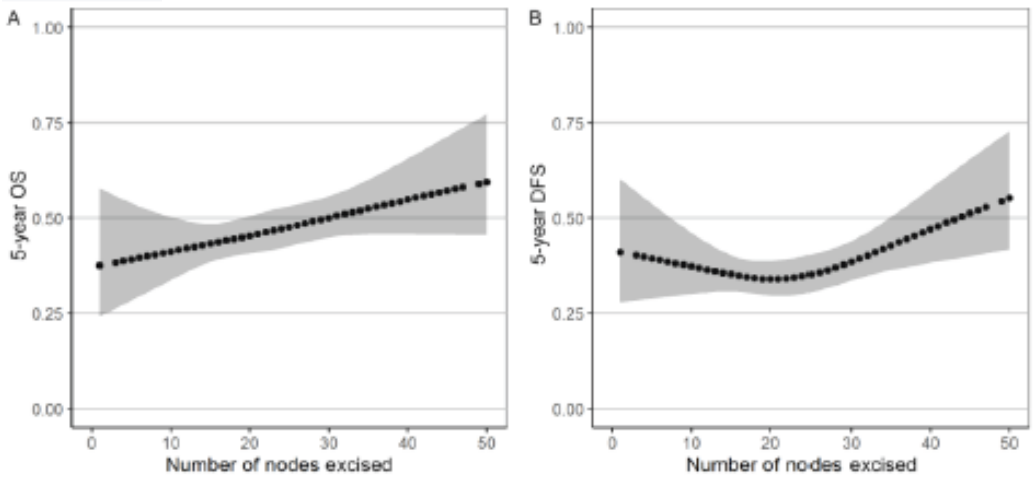
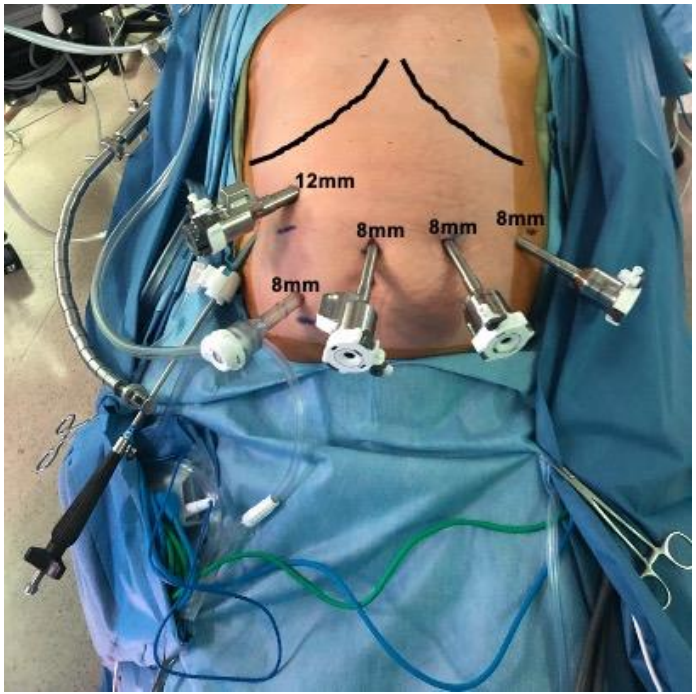
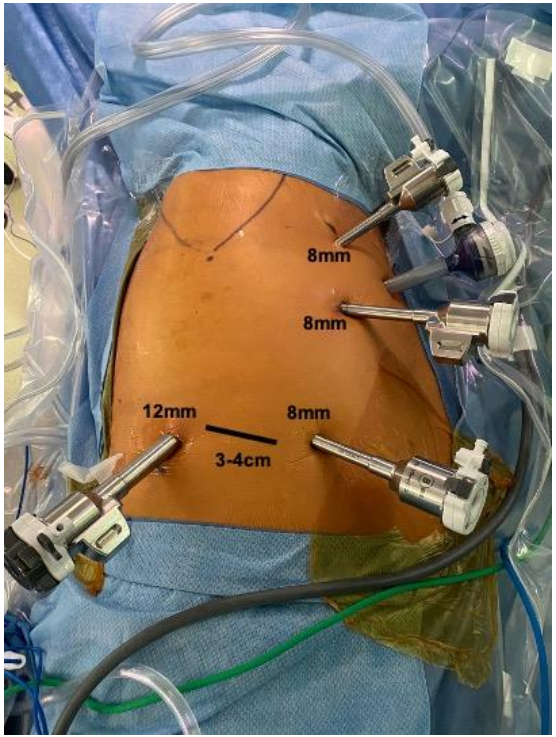
Ann Surg. 2020 Nov 12

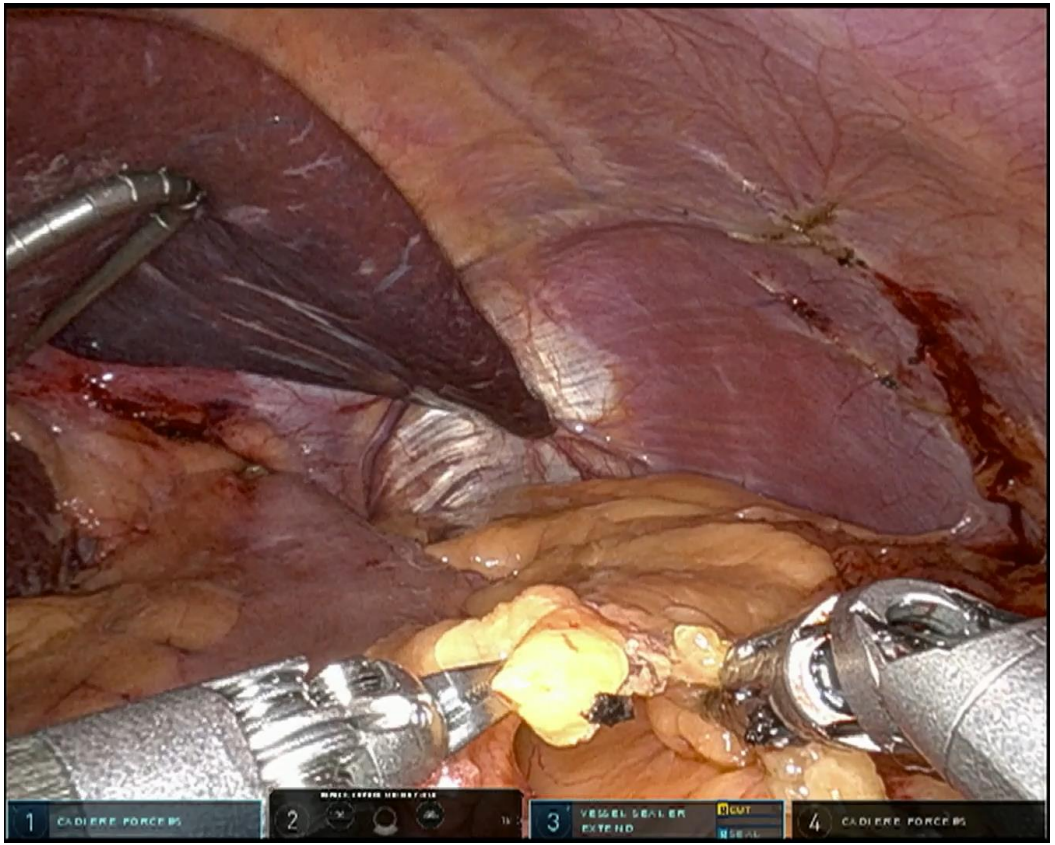


RAMIE – Ivor Lewis technique

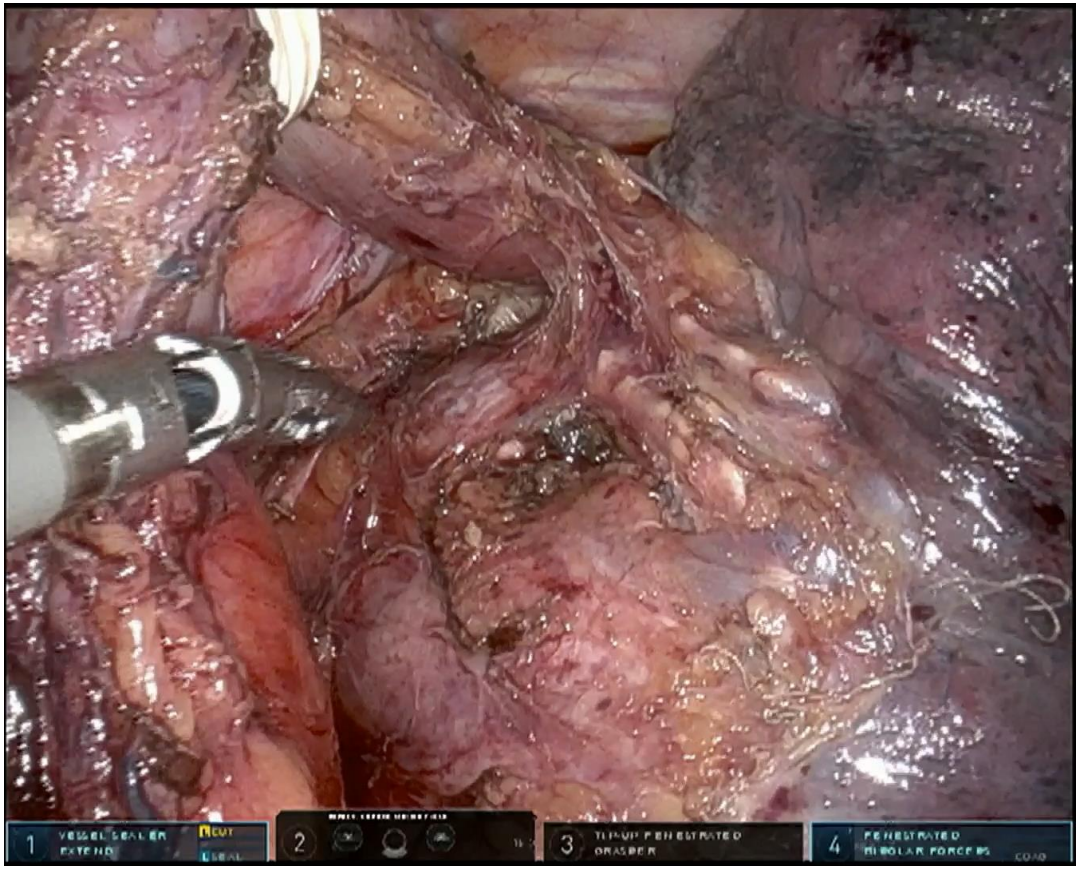




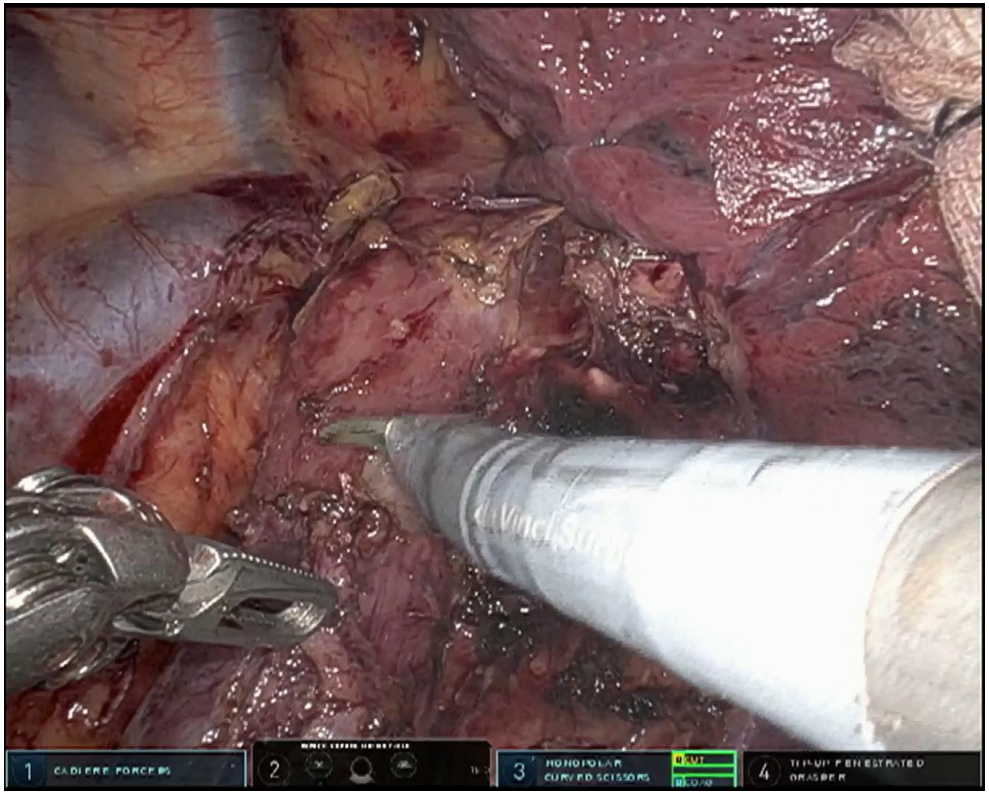
RAMIE – Conduit dissection



RAMIE – Chest dissection (3-hole)



RAMIE – Ivor Lewis anastomosis



Anastomotic perfusion & leak

Diseases of the Esophagus (2021), **00**, 1–9
https://doi.org/10.1093/dote/doab079

DISEASES OF THE ESOPHAGUS

ISDE The International Society for Diseases of the Esophagus

Original Article

Quantitative perfusion assessment of gastric conduit with indocyanine green dye to predict anastomotic leak after esophagectomy

Yoshitaka Ishikawa, Christopher Breuler,Jr. Andrew C. Chang, Jules Lin, Mark B. Orringer, William R. Lynch, Kiran H. Lagisetty, Elliot Wakeam, Rishindra M. Reddy*

Section of Thoracic Surgery, Department of Surgery, University of Michigan, Ann Arbor, MI, USA

Courtesy of Dr. Rishi Reddy

Anastomotic perfusion & leak

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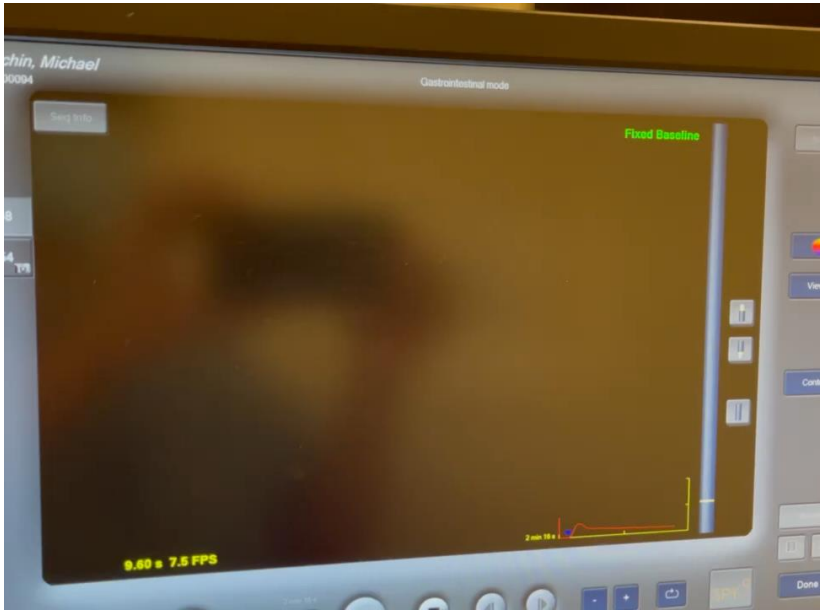

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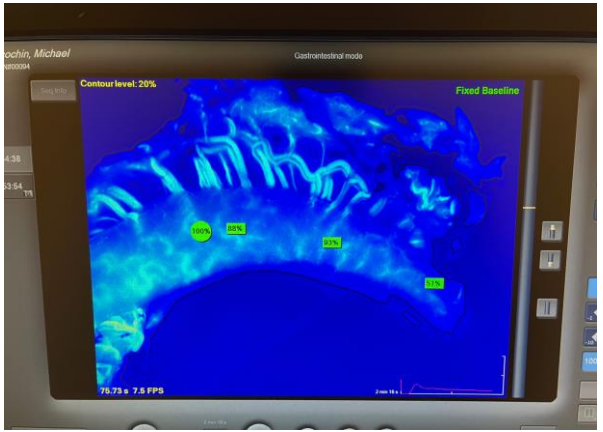

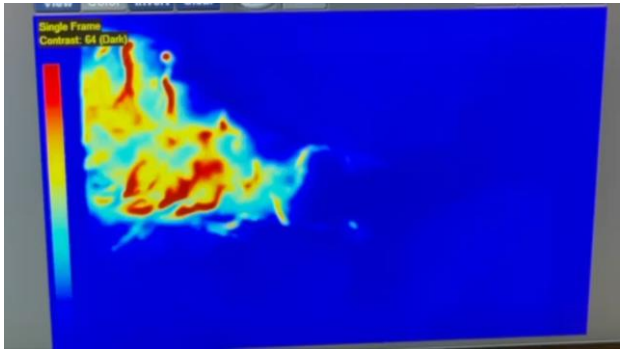

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Anastomotic perfusion & leak

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Section of Thoracic Surgery, Department of Surgery, University of Michigan, Ann Arbor, MI, USA

- 304 patients
- THE or McKeown

Table 4 Risk factors for anastomotic leak

	Univariate analysis			Multivariable analysis		
	Odds ratio	95% CI	*P*	Odds ratio	95% CI	*P*
Patient variables						
Age ≥ 65 years	1.624	0.935–2.822	0.085	1.012	0.981–1.044	0.449
Male	1.421	0.694–2.909	0.337	1.333	0.576–3.082	0.502
Diabetes mellitus	1.342	0.664–2.711	0.413	1.163	0.537–2.518	0.703
Coronary disease	1.289	0.653–2.548	0.464			
ECOG-PS = 2 or 3	1.347	0.256–7.099	0.725			
Smoker (current and former)	1.064	0.579–1.957	0.841			
Disease variables						
T3 or T4 (p, yp)	0.804	0.455–1.421	0.452			
N2 or N3 (p, yp)	0.667	0.294–1.512	0.332	0.502	0.206–1.223	0.129
Treatment variables						
Chemotherapy	1.100	0.605–1.999	0.756			
Radiation therapy	1.193	0.658–2.164	0.561			
McKeown esophagectomy	1.291	0.570–2.924	0.540			
No minimally invasive	0.791	0.460–1.362	0.398	1.369	0.730–2.565	0.327
Width of conduit <5.0 cm	1.594	0.928–2.736	0.091	1.453	0.779–2.712	0.240
SPY variables						
INI [A] < 25.8%	2.559	1.352–4.844	0.0039**			
INI [B] < 63.5%	4.284	1.637–11.21	0.0030**	5.344	1.503–15.84	0.003**
INT [B] ≥ 37.5 seconds	3.186	1.583–6.415	0.0012**			

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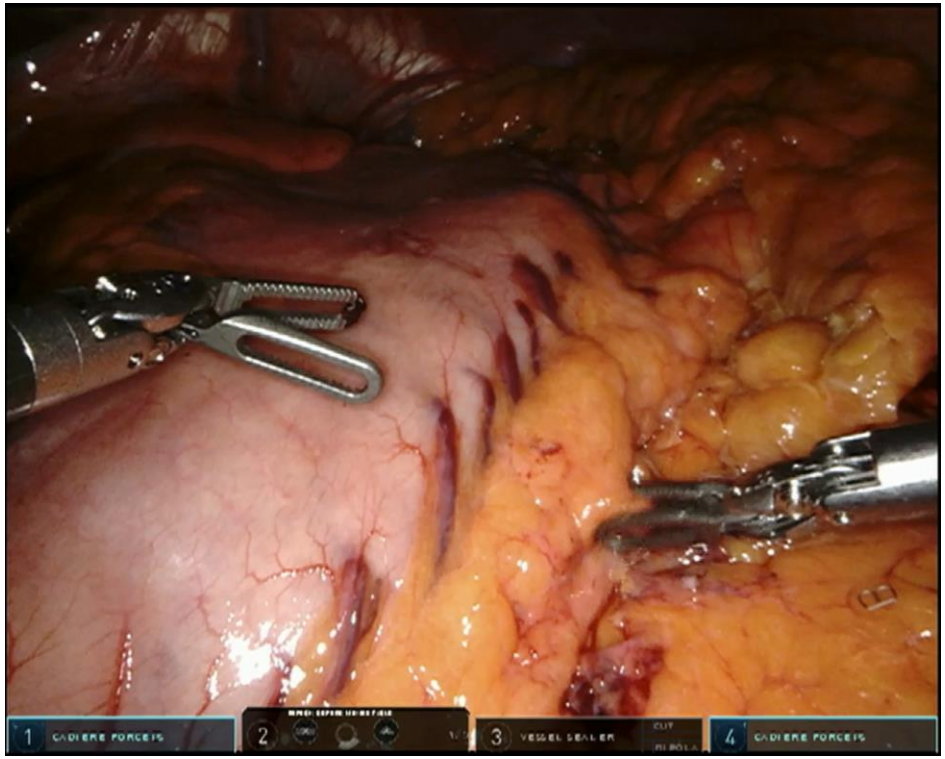
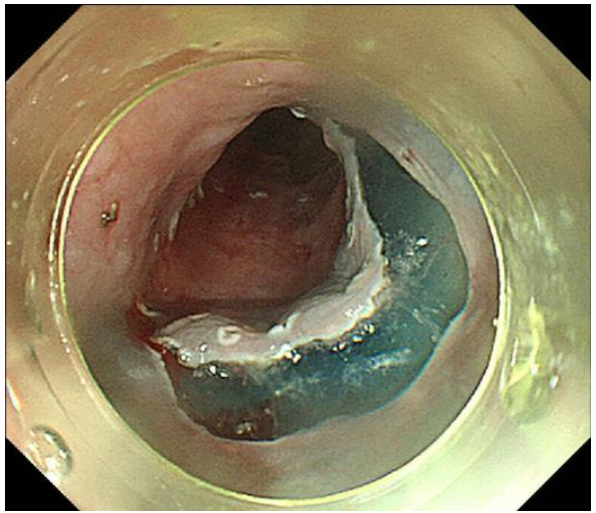
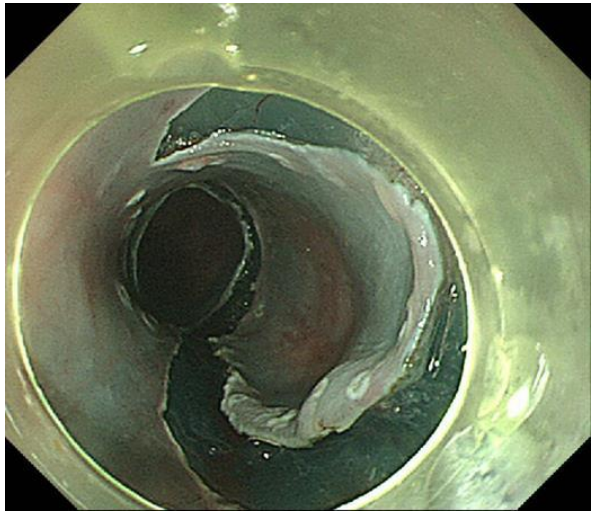
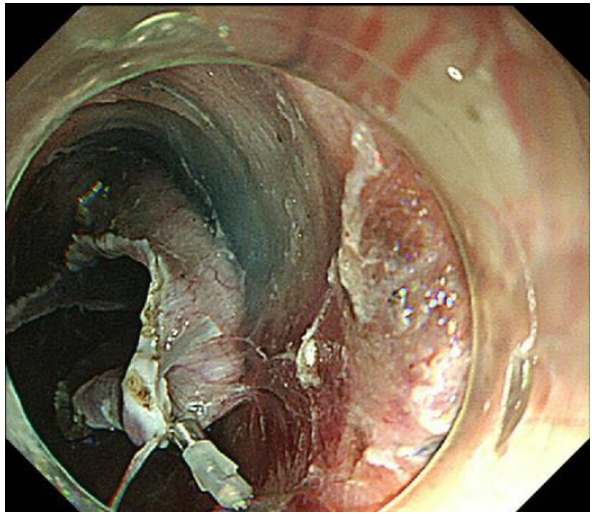
Infrared/ICG perfusion assessment



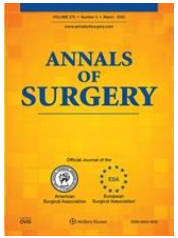
“Incision-less surgery”

“Incision-less surgery”: endoscopic resection

- Endoscopic submucosal dissection (ESD)

Endoscopic resection

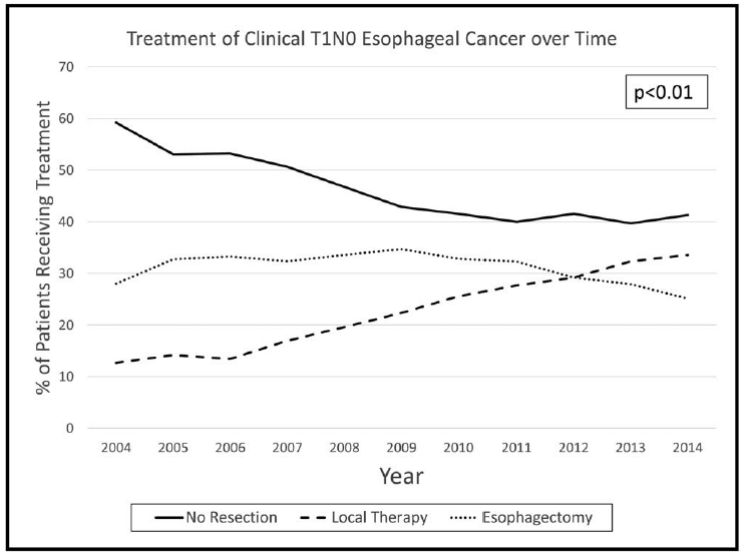


Trends in Treatment of T1N0 Esophageal Cancer

Tara R. Semenkovich, MD, MPHS, Jessica L. Hudson, MD, MPHS, Melanie Subramanian, MD, Daniel K. Mullady, MD, Bryan F. Meyers, MD, MPH, Varun Puri, MD, MSCI, and Benjamin D. Kozower, MD, MPH✉

Annals of Surgery • Volume 270, Number 3, September 2019

- NCDB 2004– 2014
- Endoscopic therapy increased from 12.7% to 33.6%



General Thoracic Surgical Club

Endoscopic resection outcomes

Long-term clinical outcomes of patients diagnosed with pT1a-muscularis mucosae with lymphovascular invasion or pT1b after endoscopic resection for cT1N0M0 esophageal squamous cell carcinoma

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Esophagus (2022) 19:153–162

- 89 patient in Taiwan following ESD for cT1N0M0 SCC
- Inclusion criteria – T1a with LVI & T1b (”non-curative resection”)

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Median f/u:
60.6 months

Table 4 Recurrence cases

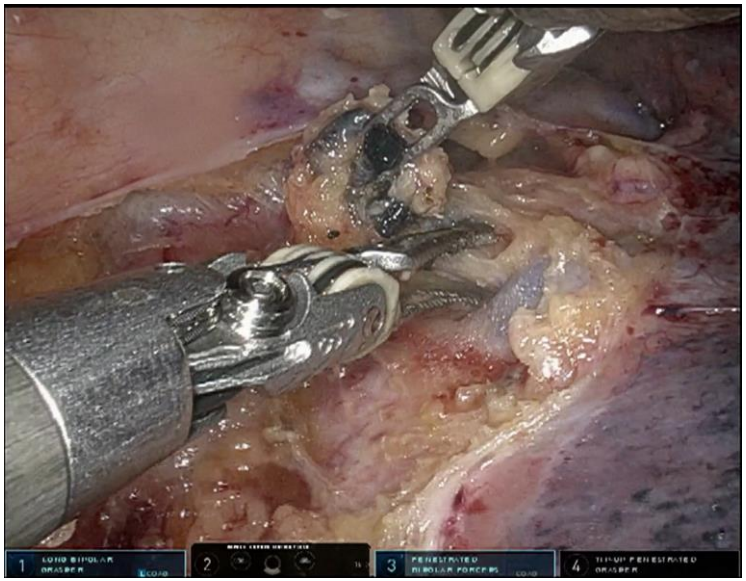
Sex, age	Location	Resection method	Size	Depth	ly/v	Additional treatment after ER	Time to recurrence (months	Site of recurrence
F, 69	Mt	ESD en bloc	8	pSM2	–/–	Obs	56	LN (#106recR)
M, 67	Lt	ESD en bloc	43	pMM	–/+	Obs	49	LN (#108)
M, 64	Mt	EMR en bloc	15	pSM2	±	Obs	26	LN (#104R)
F, 85	Mt	ESD en bloc	27	pSM2	–/–	Obs	10	LN (#106recR)
F, 83	Ae	ESD en bloc	34	pSM2	+/+	Obs	54	LN (#3)
M, 68	Mt	ESD en bloc	24	pSM1	–/+	OPE	51	LN (#107)
M, 79	Mt	ESD en bloc	22	pSM1	±	OPE	6	LN (#108, #2)
F, 46	Ut	ESD en bloc	30	pSM2	–/–	CRT	128	LN (#106recR)
M, 50	Mt	EMR en bloc	10	pSM2	–/+	CRT	66	Local

Endoscopic resection: the future?

Endoscopic resection: the future?

Robotic endoscopy

MIS lymphadenectomy



New technology in esophageal cancer surgery: conclusions & future direction

- Robotics may increase the rate of MIS for esophageal cancer
- Need further evaluation of RAMIE vs MIE outcomes
- Conduit perfusion assessment appears promising
- Endoscopic resection is here to stay for early disease
  - Robotic endoscopy
  - Expanding indications for T1b+ (with MIS lymphadenectomy)?

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Thank you!

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General Thoracic Surgical Club

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