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Use of Robotic Surgery for Mediastinal Tumor Resection

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Disclosure

- Industry-sponsored grants
  - Olympus Corp.
  - Johnson and Johnson
  - ODS Medical Inc
- Consultant
  - Olympus America Inc.
  - Medtronic
  - Johnson and Johnson
  - Astra Zeneca
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- Research Collaboration
  - Siemens
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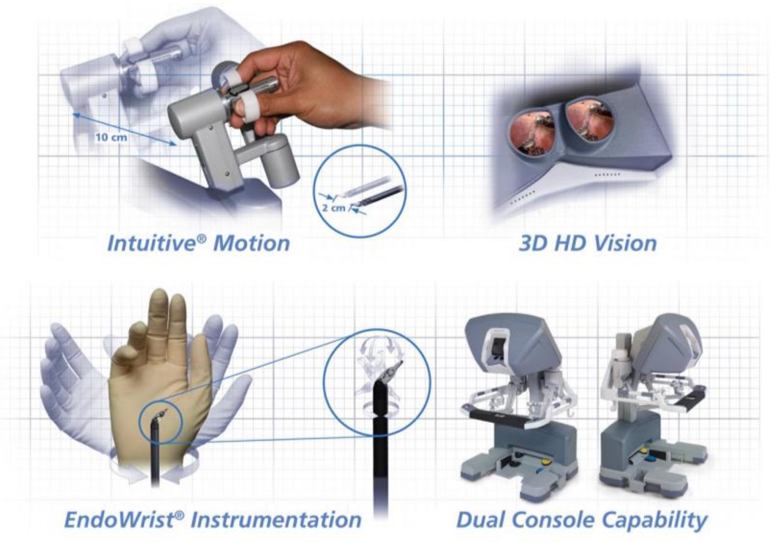
  - OKF Technology
- Advisory Board
  - Olympus America Inc
  - Medtronic
  - Johnson and Johnson

Introduction - Robotic Surgery

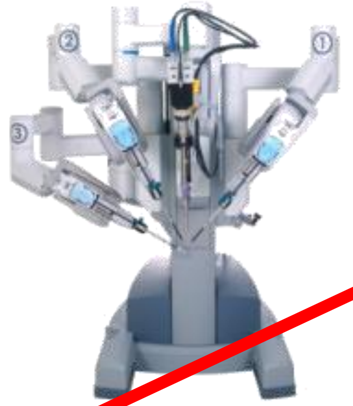
- During the past decade, the use of robotic surgical systems has rapidly increased

- Robotic Thoracic Surgery
  - Lobectomy/segmental resection
  - Mediastinal tumor resection/Thymectomy
  - Esophagectomy
  - Benign foregut surgery



Evolution of the da Vinci System

da Vinci® Xi™
- Dual Console option
- Crystal Clear HD Vision
- Multi Quadrant Access
- Position Targeting
- Built-In ESU Generator
- Advanced instruments



da Vinci®
- Eliminates lap compromises
- Introduction of 4th arm (2003)
- Simple instruments

da Vinci® S™
- 3D HD Vision (720p)
- Visual Inputs – TilePro
- Multi-quadrant access
- Streamlined set-up
- Procedure-specific and energy instruments

da Vinci® Si™
- Dual Console option
- Enhanced HD Vision (1080i)
- Superior Ergonomics
- Increased Surgeon Control
- Scalable architecture
- Advanced instruments

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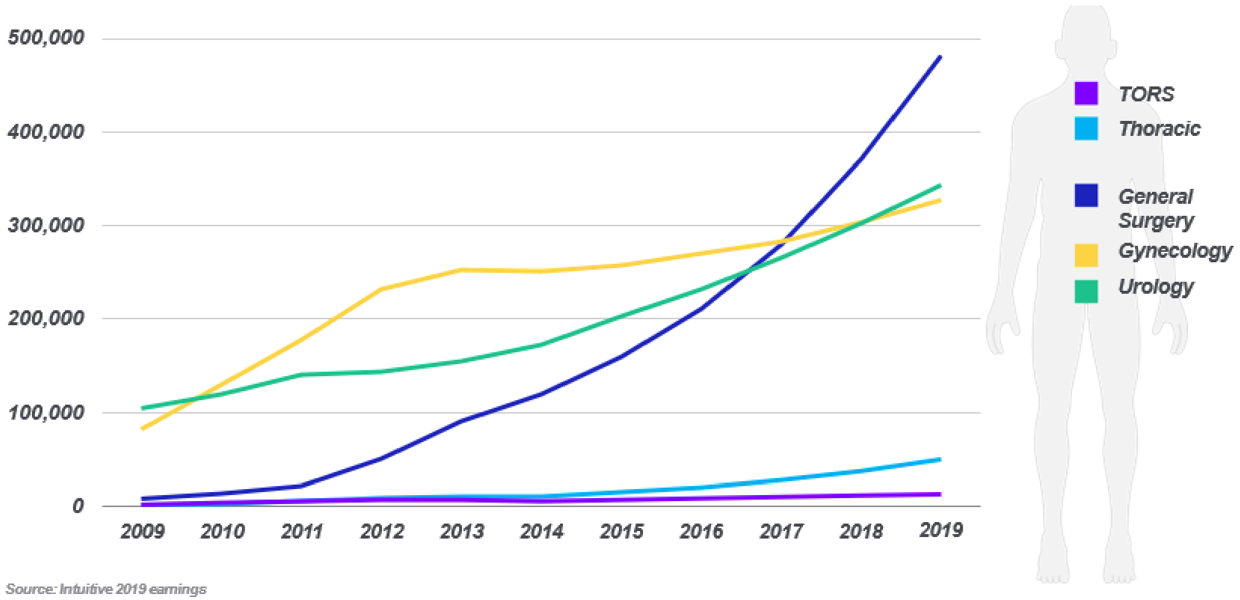
Growth in procedure categories - Global over past 10 years



Source: Intuitive 2019 earnings report

8.5M
da Vinci Procedures performed

6,000
Da Vinci Systems

Multi specialty growth of Robotic-Assisted Surgery continues to grow globally with a significant rise in General Surgery adoption over the past several years

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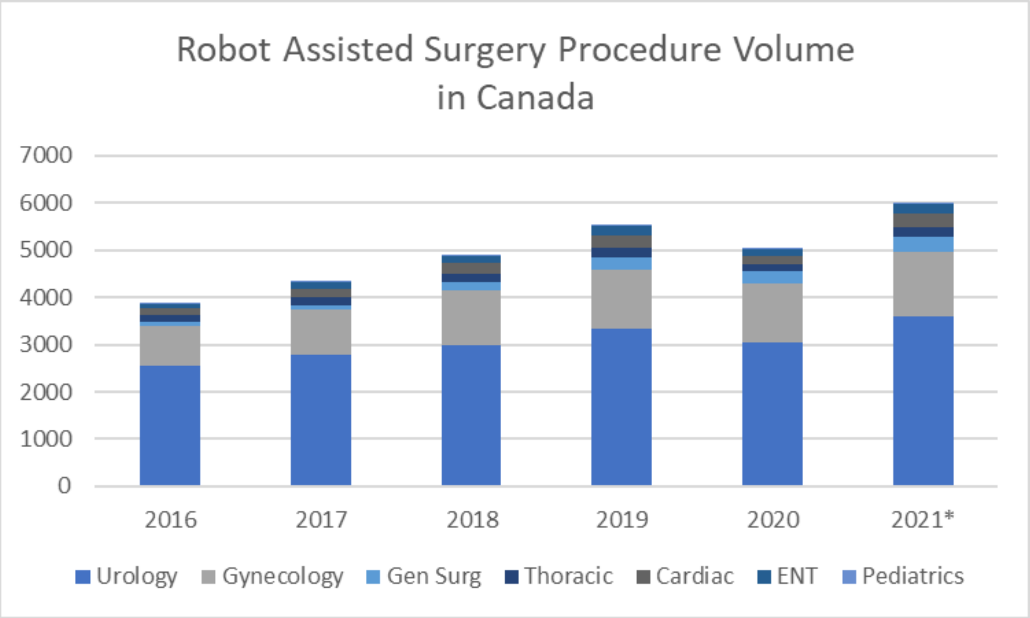
da Vinci Robotics in Canada



+44,000
da Vinci Procedures performed in Canada since 2003

32 Da Vinci Systems in **5** Provinces

Multi specialty growth of Robotic-Assisted Surgery continues to grow in Canada

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Robotic Thoracic Surgery for Mediastinal Tumors

- Multiple studies have shown that Robotic anatomical lung resection for lung cancer offer comparable radicality and safety to VATS
- Unlike lung resection, there is limited evidence comparing the outcomes of VATS vs RATS for mediastinal tumors largely due to their rarity
- Compared with VATS, the robotic platform provides less restriction of instruments and improved visualization, which may facilitate operating in narrow regions such as the mediastinum.

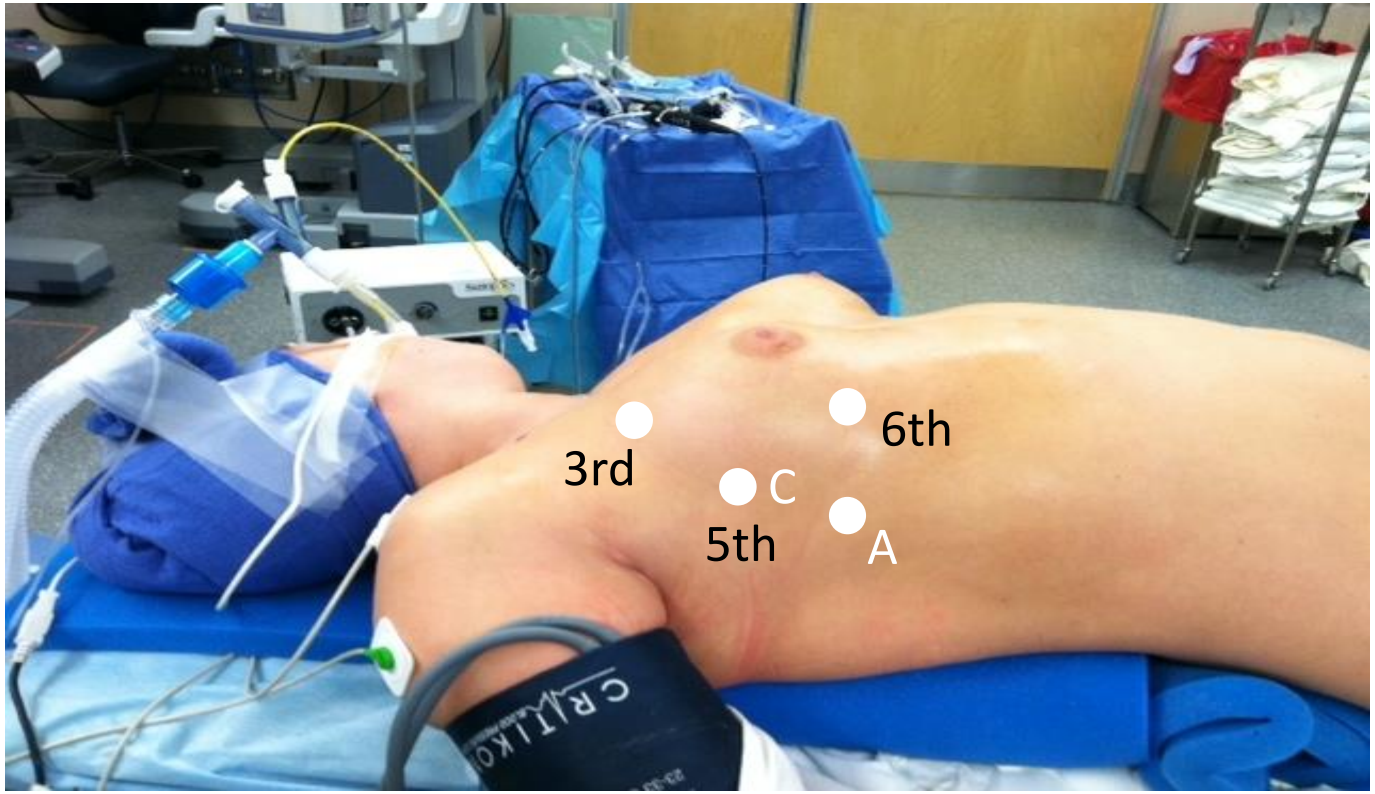
Liang H et al. Ann Surg. 2018;268: 254-259
Alvarado C et al. Ann Thorac Surg 2022;113:1853-8

RATS approach for Mediastinal Tumors

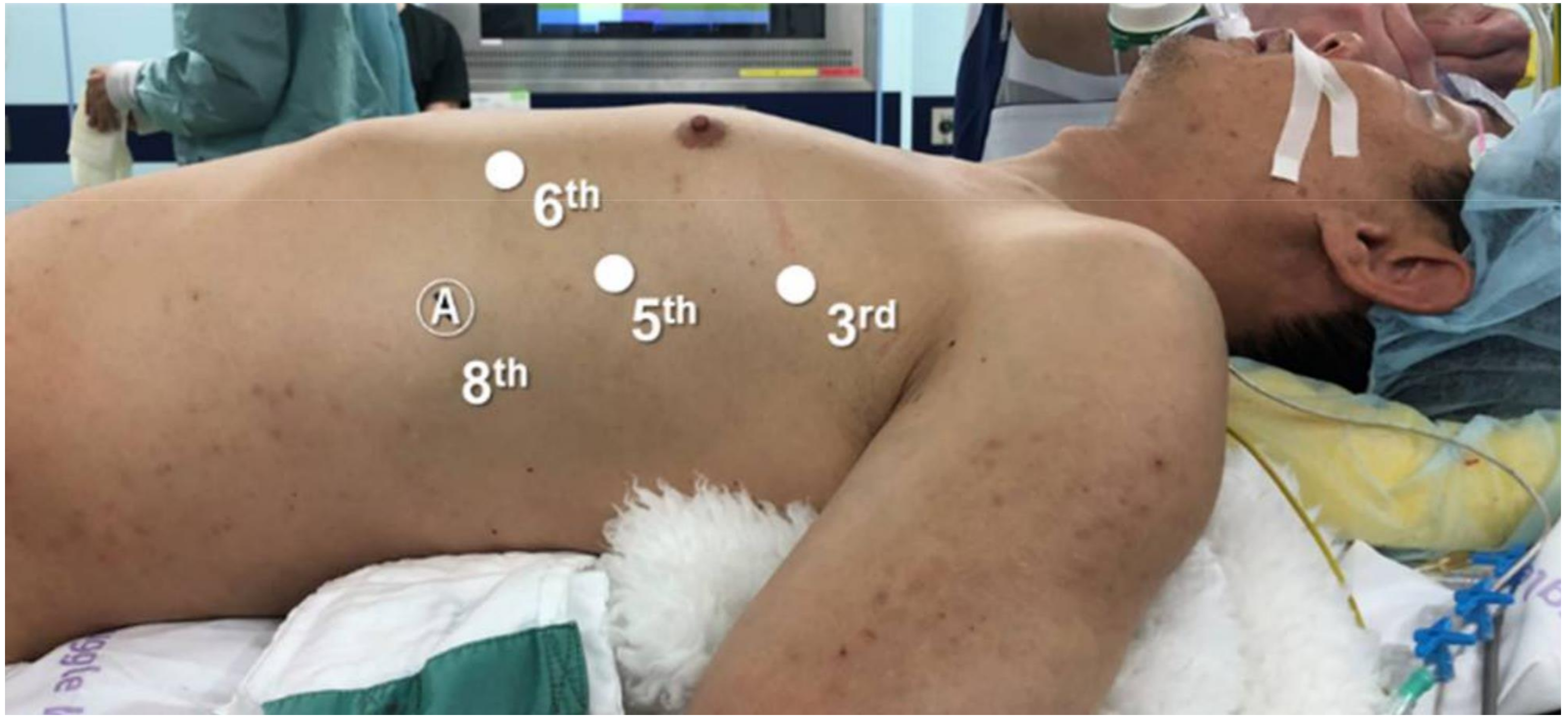
- The position and port placement should be chosen depending on the size, location, and aggressiveness of the tumor
- Anterior mediastinal tumors - tumor resection and thymectomy commonly performed in the supine position using the lateral or subxiphoid approach
- Superior, middle, and posterior mediastinal tumors - decubitus position using the lateral approach

Okazaki M et al. J. Pers. Med. 2022, 12, 1195

Robotic Thymectomy (R) – Lateral approach

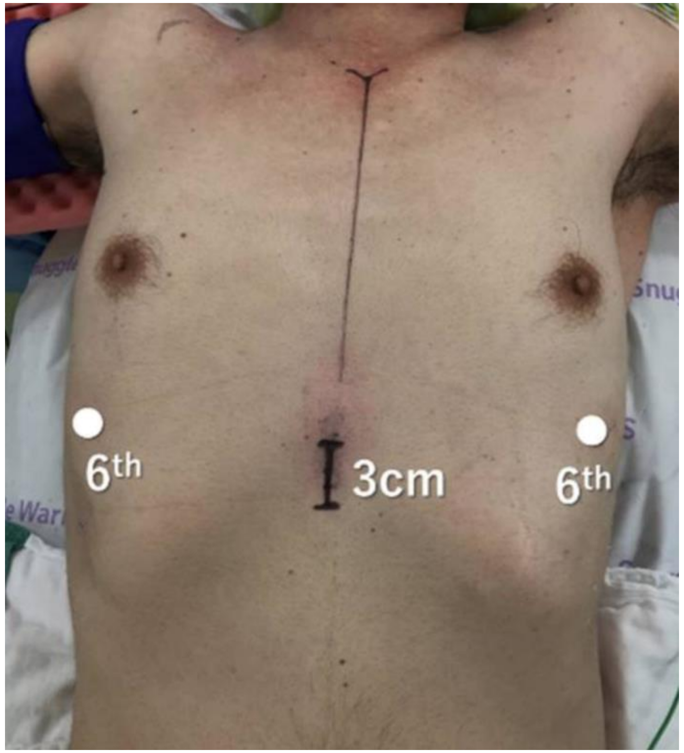


Robotic Thymectomy (L) – Lateral approach



Okazaki M et al. J. Pers. Med. 2022, 12, 1195

Robotic Thymectomy – Subxiphoid approach



Okazaki M et al. J. Pers. Med. 2022, 12, 1195

Posterior/Superior Mediastinal Tumors - Lateral Decubitis approach

Okazaki M et al. J. Pers. Med. 2022, 12, 1195

Robotic Thymectomy for Myasthenia Gravis

- Single institution experience
    - n =100, L Robotic thymectomy
    - OR time 120 (60-300) min
    - Median hospital stay 3d (range 2-14)
    - No mortality
    - Postoperative complications (6%)
    - Myasthenia Gravis Foundation of America

      class I 10%, II 35%, III 39%, IV 16%
- 5-year probability of complete stable remission 28.5%
- Overall improvement 87.5%

Marulli G et al, J Thorac Cardiovasc Surg. 2013 ; 145(3):730-5

Robotic Thymectomy for Myasthenia Gravis

- Robotic thymectomy is a safe and effective procedure
- Neurologic benefit observed in a great number of patients
- Better clinical outcome obtained in pts with early Myasthenia Gravis Foundation of America class

Marulli G et al, J Thorac Cardiovasc Surg. 2013 ; 145(3):730-5

Robotic Thymectomy for Thymoma

- Multicenter European study (n=4)
  - n=79, early-stage thymoma (Masaoka stage I or II)
  - L sided (82.4%), R sided (12.6%), bilateral (5%)
  - n=45 (57%) had associated myasthenia gravis

- Outcomes
  - OR time 155 min (range, 70-320)
  - no mortality
  - Postoperative complications (12.7%)
  - Median hospital stay 3 d (range, 2-15)

Marulli G et al, J Thorac Cardiovasc Surg. 2012 ;144(5):1125-30

Robotic Thymectomy for Thymoma

- At a median follow-up of 40 mo
  - 74 pts alive
  - 5 death (4 patients from nonthymoma-related causes and 1 from a diffuse intrathoracic recurrence)
  - 5-year survival rate of 90%

- Robotic thymectomy for early-stage thymoma is a technically sound and safe procedure with a low complication rate and a short hospital stay
- Oncologic outcome seems good, but a longer follow-up is needed to consider this as a standard approach definitively

Marulli G et al, J Thorac Cardiovasc Surg. 2012 ;144(5):1125-30

RATS vs VATS for MT Resection – National Cancer Database Analysis

- MIS MT resection database 2010-2016
- Primary Outcome of Interest - perioperative composite adverse outcomes
    - Conversion to open procedure
    - 90-day mortality
    - 30-day readmission
    - Positive pathologic margins
- Secondary Outcome
    - LOS
    - Overall Survival

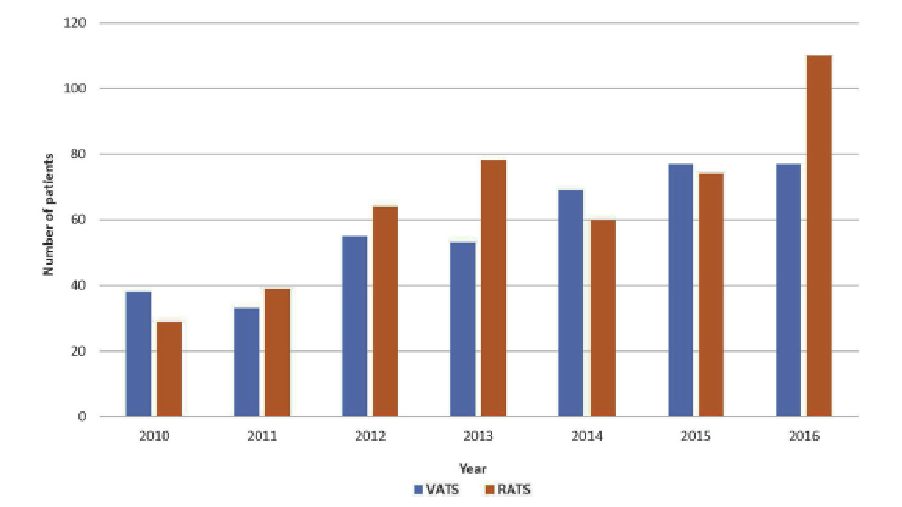


FIGURE 1 Frequency of minimally invasive surgical approach with video-assisted thoracoscopic surgery (VATS) vs robotic-assisted thoracoscopic surgery (RATS) based on year of diagnosis in the National Cancer Database from 2010 to 2016.

Alvarado C et al. Ann Thorac Surg 2022;113:1853-8

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RATS vs VATS for MT Resection

- VATS (n=402) vs RATS (n=454)
- Thymoma (85.4%) most common histology
- RATS were more likely to have a thymic tumor and tumor size smaller than 4cm
- RATS shorter LOS
- Similar long-term survival between VATS vs RATS approach (Multivariate Cox regression hazard analysis: hazard ratio, 0.89; P=0.689)

Variable	VATS (n = 402)	RATS (n = 454)	P Value
Age, y	61.5 (51-71)	62 (55-70)	.235
Male sex	196 (48.8)	223 (49.1)	.916
White race	273 (67.9)	312 (68.7)	.799
Academic program	183 (51.0)	244 (68.7)	.043
Private insurance	194 (48.3)	228 (50.2)	.567
Charlson Deyo comorbidity score			.703
0	304 (75.6)	336 (74.0)	
1	71 (17.7)	90 (19.8)	
≥2	27 (6.7)	28 (6.2)	
Histologic subtype			
Thymoma	323 (82.2)	392 (88.1)	.018
Thymic carcinoma	19 (4.8)	17 (3.8)	.475
Thymic carcinoid	16 (4.1)	17 (3.8)	.858
Germ cell	23 (5.9)	12 (2.7)	.023
Sarcoma	12 (3.1)	5 (1.1)	.049
Neoplasm, otherwise unspecified	0 (0)	2 (0.5)	.183
Tumor size, cm	5.2 (3.5-7.8)	4.5 (3.2-6.5)	.001
Tumor location			.002
Mediastinum	33 (8.2)	15 (3.3)	
Thymus	369 (91.8)	439 (96.7)	
Extent of tumor invasion			.256
Localized	176 (55.7)	197 (57.6)	
Adjacent connective tissue	72 (22.8)	88 (25.7)	
Other organs/structures involved	68 (21.5)	57 (16.7)	
Length of stay, d	3 (2-5)	3 (2-4)	.011

Alvarado C et al. Ann Thorac Surg 2022;113:1853-8

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RATS vs VATS for MT Resection – National Cancer Database Analysis

Univariate Analysis

Outcome	VATS (n = 402)	RATS (n = 454)	P Value
90-day mortality	7 (2.3)	3 (1.0)	.163
30-day unplanned readmission	8 (2.0)	10 (2.2)	.858
Positive pathologic margin	118 (31.6)	102 (24.3)	.022
Conversion to open procedure	59 (14.7)	22 (4.9)	<.001
Adverse composite outcome	162 (51.3)	126 (36.7)	<.001

Alvarado C et al. Ann Thorac Surg 2022;113:1853-8

RATS vs VATS for MT Resection – National Cancer Database Analysis

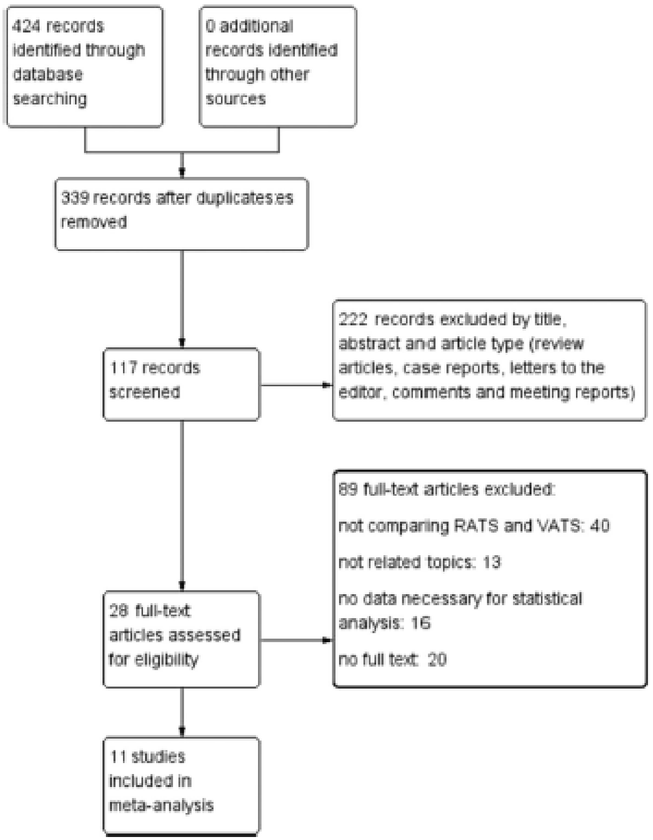
Multivariate Logistic Regression Analysis – Factors Associated with Composite Adverse Outcome

Factor	Odds Ratio	95% Confidence Interval	P Value
RATS approach	0.44	0.291-0.650	<.001
Age (years)	1	0.985-1.023	.694
Male sex (relative to female)	1.09	0.731-1.632	.665
Academic institution	0.99	0.664-1.471	.954
Size of tumor (cm)	1.02	0.972-1.071	.422
Histologic subtype			
Thymoma	1.38	0.522-3.620	.519
Thymic carcinoid	2.35	0.577-9.588	.233
Sarcoma	7.84	1.059-58.078	.044
Germ cell	1.25	0.183-8.552	.819
Extent of tumor invasion			
Adjacent connective tissue	2	1.267-3.163	.003
Organs/structures in mediastinum	6.99	4.044-12.067	<.001

Alvarado C et al. Ann Thorac Surg 2022;113:1853-8

RATS vs VATS for Thymoma – Systematic Review and Meta-analysis

- 11 studies, 1418 pts
  - RATS (n=688) VATS (n=730)
- RATS associated with
  - Less blood loss
  - Lower volume of drainage
  - Fewer postoperative pleural drainage days
  - Shorter LOS
  - Fewer postoperative complications
- No significant difference in OR time



Shen et al. Thorac Cancer. 2022;13:151–161.

Learning Curve

- Learning is more rapid with Robotic compared to VATS surgery

Number of operations required to achieve proficiency with VATS lobectomy and robotic lobectomy

Study	Ref. no.	Year	Lung operation	No. of operations required
Melfi and Mussi	[21]	2008	Robotic lobectomy	20
Gharagozloo *et al.*	[16]	2009	Robotic lobectomy	20
Veronesi *et al.*	[38▪]	2010	Robotic lobectomy	18
Louie *et al.*	[27▪▪]	2012	Robotic lobectomy	6
Lee *et al.*	[41]	2009	VATS lobectomy	30–50
Belgers *et al.*	[42]	2010	VATS lobectomy	25–30
Petersen and Hansen	[43]	2010	VATS lobectomy	50

VATS, video-assisted thoracic surgery.

Veronesi. Current Opinion in Oncology. 25(2):107-114, 2013

Summary

- Robotic technologies have significantly progressed over the past 20 years
- Intuitive movements, greater flexibility and 3D, high definition vision allow surgeons to perform surgery easier with shorter learning curve than VATS
- For patients with a mediastinal tumor who are considered appropriate candidates for minimally invasive surgery, a robotic approach is safe, efficacious, and may have improved short-term outcomes compared to VATS

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