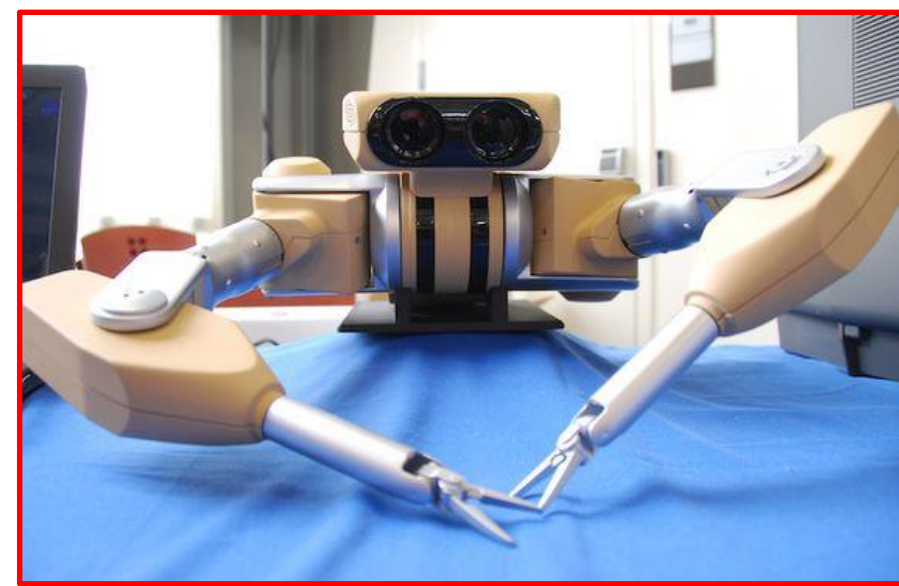


RATS

Robotic Assisted Thoracoscopic Surgery



When to use ?

JEROEN MH HENDRIKS

DPT OF THORACIC AND VASCULAR SURGERY, ANTWERP UNIVERSITY HOSPITAL

P VAN SCHIL, J HENDRIKS, P LAUWERS, CH VANDENBROECK, K YOGESWARAN, A BOUHOUCHE, L FIAS, S DELALIEUX, C TOELEN

VATS indications

- Oncology
 - Lymphnodes: excision / biopsy
 - Lung: wedge / segment / lobe / lung
 - Pleura: biopsies / decortication
 - Mediastinal tumors [thymic; neurogenic]
- Non-oncologic
 - Pneumothorax [bleb; bullae; pleurectomie; LVRS]
 - Lung [benign; infection; congenital]
 - Pleura: empyema
 - Pectus
 - Plication of diaphragm
 - Sympatectomy

RATS indications [including new]

- Oncology
 - **Lymphnodes:** **excision** / biopsy
 - **Lung:** wedge / **segment / lobe / lung** ←
 - Pleura: biopsies / decortication
 - **Mediastinal tumors** [thymic; neurogenic]
- Non-oncologic
 - Pneumothorax [bleb; bullae; pleurectomie; **pleural tent**; LVRS]
 - **Lung** [benign; infection; congenital]: wedge / **segment / lobe**
 - Pleura: empyema
 - Pectus
 - **Plication of diaphragm**
 - **Sympatectomy** selective postganglionic
 - **First rib** [TOS]

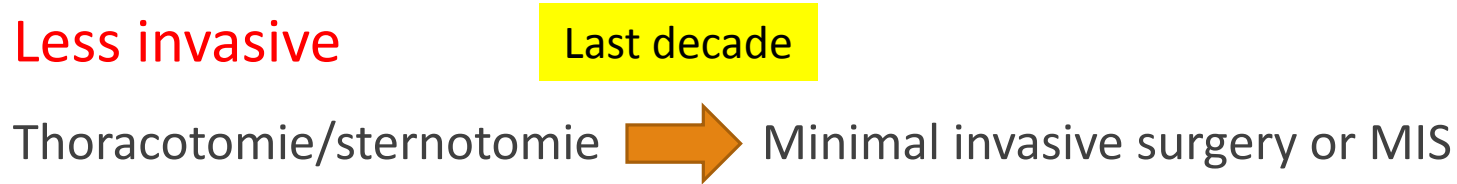
Overall trend over time for stage I NSCLC

Lesser resection



Blasberg JD, Pass HI, Donington JS. Sublobar resection: a movement from the Lung Cancer Study Group. *J Thorac Oncol* 2010; 5: 1583–1593.
Nakamura K, Saji H, Nakajima R et al. A phase III randomized trial of lobectomy versus limited resection for for small-sized peripheral non-small cell lung cancer (JCOG0802/WJOG4607L). *Jpn J Clin Oncol* 2010; 40: 271–274.

Less invasive



VATS Video-Assisted Thoracoscopic Surgery
Uni-portal VATS
RATS Robotic-Assisted Thoracoscopic Surgery

█. Surgical resection is usually acceptable if the predicted postoperative FEV₁ and DLCO values are > 40%.

Video-assisted thoracoscopic surgery versus open lobectomy for lung cancer: time for a randomized trial†

Morten Bendixen and Peter Bjørn Licht*

Department of Cardiothoracic Surgery, Odense University Hospital, Odense, Denmark

Received 28 January 2017; accepted 4 March 2017

Keywords: NSCLC • VATS • Thoracoscopy • Thoracotomy • Surgical technique
• Pain • Quality of life

We read with interest the editorial comment on video-assisted thoracoscopic surgery (VATS) versus open lobectomy by Dr Allen [1]. We agree that all published studies that used either retrospective institutional data or large national databases to compare VATS with open lobectomy may suffer from hidden biases, which may affect the outcome. Dr Allen therefore suggests it is time for a randomized trial to determine whether VATS is better than thoracotomy. Without this type of a trial, the 'VATS sceptics will never be convinced'.

We would like to add to the debate that such a trial was recently performed in Denmark [2]. In a patient and observer blinded study, we randomized 206 patients with stage I non-small-cell lung cancer (NSCLC) and found that VATS was associated with less postoperative pain and better quality of life than anterolateral thoracotomy during the first year after surgery. We concluded that VATS should be the preferred surgical approach for lobectomy in patients fit for surgery with stage I NSCLC. In our trial, surgical techniques were standardized and the number of procedures performed by each of 4 surgeons were balanced. We used a slightly modified version of the 4-port VATS technique described by McKenna *et al.* [3]. However, during the study period VATS techniques continued to evolve and most VATS lobectomies are currently performed with fewer ports. We therefore also recommend future trials to compare VATS with thoracotomy, in particular larger trials and multi-centre trials that should include both high-volume and low-volume centres. We believe that it is relevant to investigate whether the benefits of VATS improve further when VATS is performed with fewer portholes, and eventually we must investigate the effect of VATS on survival.

Fortunately, 2 multi-centre trials are recruiting patients in the UK and China, respectively. These initiatives must be commented. The general thoracic community, however, still needs to discuss how we can improve research collaborations across geographical borders and particularly across political barriers so that one day we may recruit patients into the same trials.

REFERENCES

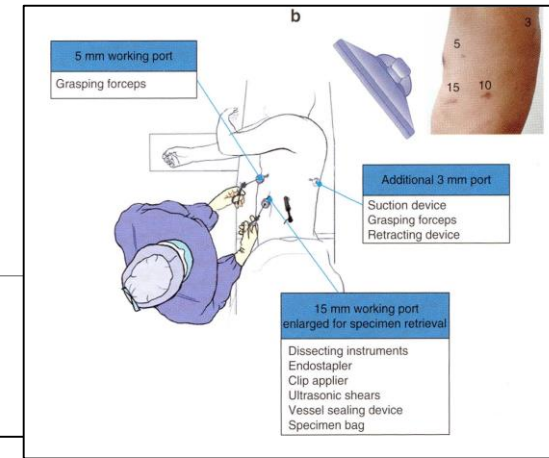
- [1] Allen MS. Video-assisted thoracoscopic surgery versus open lobectomy for lung cancer: time for a randomized trial. *Eur J Cardiothorac Surg* 2017;51:175.
- [2] Bendixen M, Jørgensen OD, Kronborg C, Andersen C, Licht PB. Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial. *Lancet Oncol* 2016;17:836–44.
- [3] McKenna RJ Jr, Houck W, Fuller CB. Video-assisted thoracic surgery lobectomy: experience with 1,100 cases. *Ann Thorac Surg* 2006;81:421–5.



CLINICAL PRACTICE GUIDELINES

Early and locally advanced non-small-cell lung cancer (NSCLC): ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up[†]

P. E. Postmus¹, K. M. Kerr², M. Oudkerk³, S. Senan⁴, D. A. Waller⁵, J. Vansteenkiste⁶, C. Escriu¹ & S. Peters⁷
on behalf of the ESMO Guidelines Committee*



Recommendations:

- Surgery should be offered to all patients with stage I and II NSCLC as the preferred treatment to all who are willing to accept procedure-related risks [III, A].
- For patients with a non-centrally located resectable tumour and absence of nodal metastasis on both CT and PET images, surgical resection is recommended [I, A].
- Anatomical resection is preferred over wedge resection [I, A].
- Anatomical segmentectomy is generally considered acceptable for pure GGO lesions or adenocarcinomas in situ or with minimal invasion [III, B].
- Lobectomy is still considered the standard surgical treatment of tumours ≥ 2 cm in size that have a solid appearance on CT [II, B].
- Lymph node dissection should conform to IASLC specifications for staging [III, A].
- Either open thoracotomy or VATS access can be carried out as appropriate to the expertise of the surgeon [III, A].
- VATS should be the approach of choice in stage I tumours [V, C].
- For patients with multifocal lung cancer, complete resection is recommended whenever possible. All patients with multifocal lung cancer should be discussed in a multidisciplinary tumour board [III, B].

Table 2. Staging and stage grouping UICC TNM 8 [30]

Occult carcinoma	TX	NO	MO
Stage 0	Tis	NO	MO
Stage IA1	T1a(mi)	NO	MO
Stage IA2	T1a	NO	MO
Stage IA3	T1b	NO	MO
Stage IB	T1c	NO	MO
	T2a	NO	MO

Lobectomy

VATS

CLINICAL PRACTICE GUIDELINES

Early and locally advanced non-small-cell lung cancer (NSCLC): ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up[†]

P. E. Postmus¹, K. M. Kerr², M. Oudkerk³, S. Senan⁴, D. A. Waller⁵, J. Vansteenkiste⁶, C. Escriu¹ & S. Peters⁷, on behalf of the ESMO Guidelines Committee*

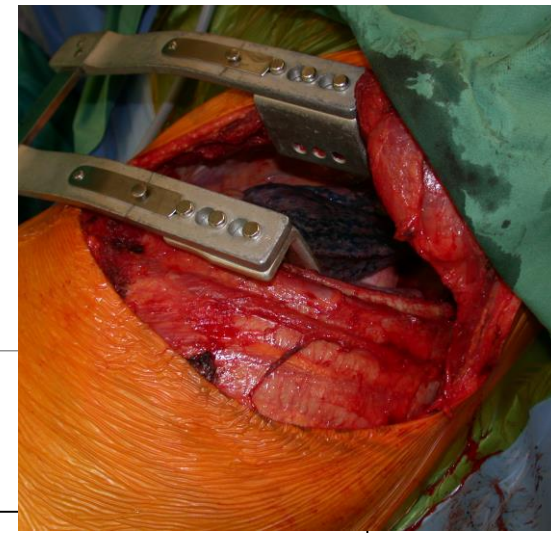


Table 2. Staging and stage grouping UICC TNM 8 [30]

Occult carcinoma	TX	NO	MO
Stage 0	Tis	N0	M0
Stage IA1	T1a(mi)	N0	M0
	T1a	N0	M0
Stage IA2	T1b	N0	M0
Stage IA3	T1c	N0	M0
Stage IB	T2a	N0	M0
Stage IIA	T2b	N0	M0
Stage IIB	T1a-c	N1	M0
	T2a-b	N1	M0
	T3	N0	M0
Stage IIIA	T1a-c	N2	M0
	T2a-b	N2	M0
	T3	N1	M0
	T4	N0	M0
	T4	N1	M0

resection ←

← access

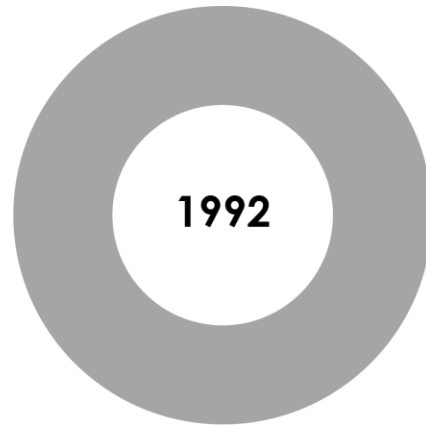
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However, ... adoption of “anatomical resection” by VATS is slow

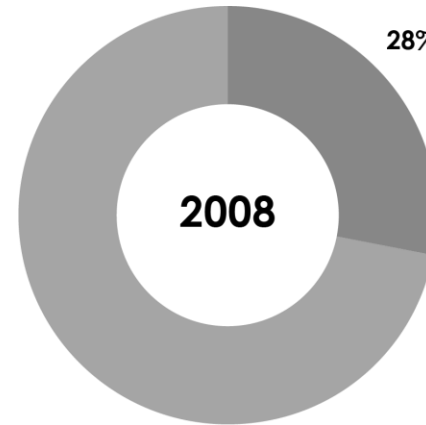
- VATS
- OPEN

100%



1992

72%



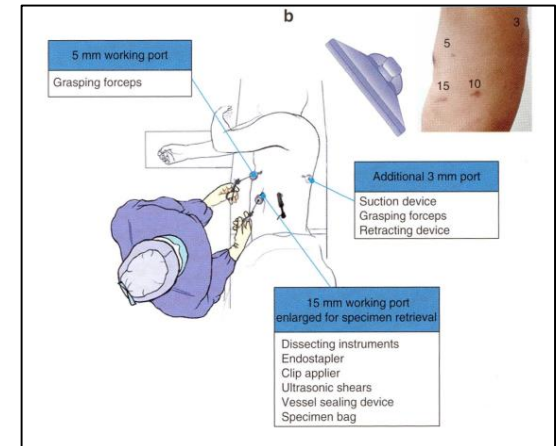
2008

28%

2012 = 33%



¹AHRQ HCUPnet database



Why slow adoption? Because VATS is difficult to reproduce



- 2D visualization
- Bad ergonomics
- Rigid instrumentation
- Stability is an issue
- Counterintuitive orientation

Solution for drawbacks of VATS = robotics

Example: da Vinci surgical robot



Solution for drawbacks of VATS: robotics

Improved vision, handling, control



3D High Definition
Camera control by surgeon

~~2D Vision~~



EndoWrist® Instrumentation
Filtered tremors

~~Rigid Instrumentation~~
~~Instability; tremors~~

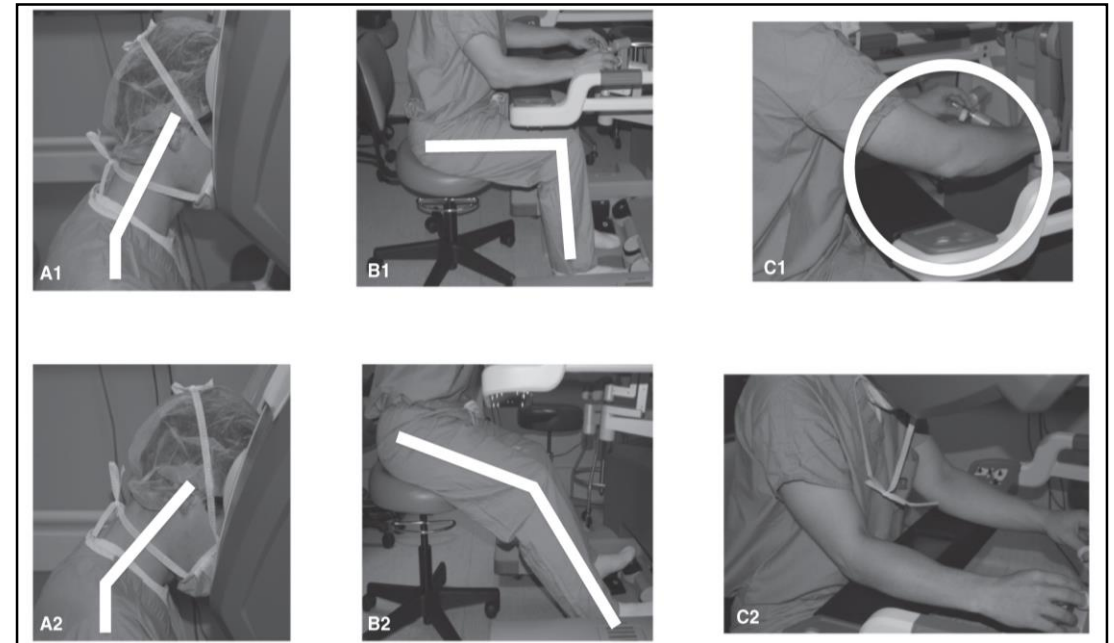
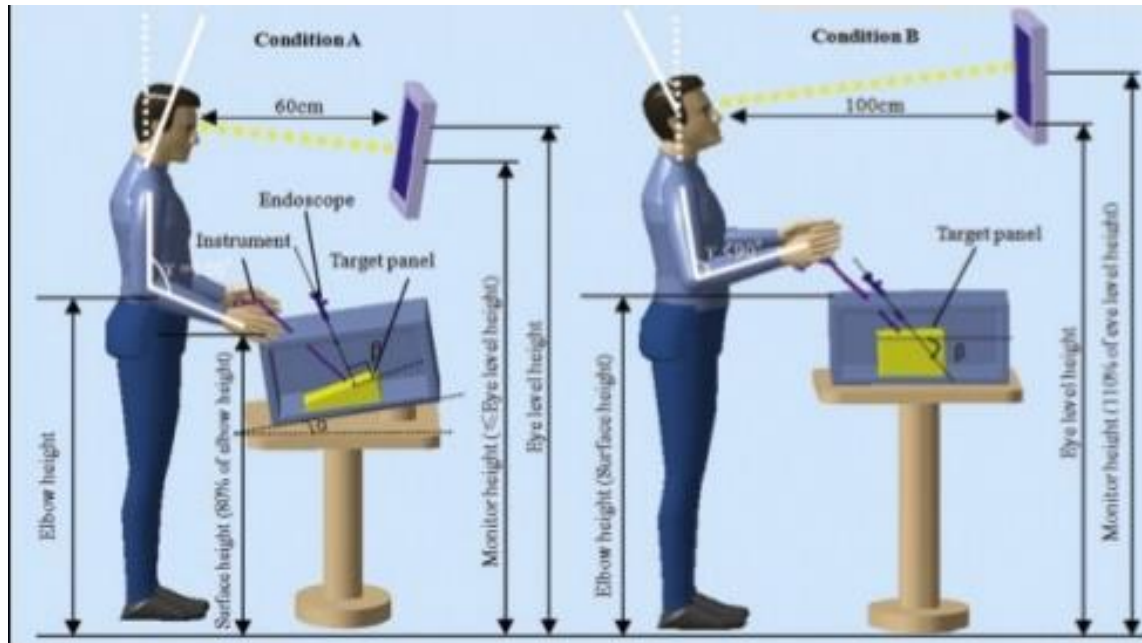


Intuitive Control

~~Counter-intuitive orientation~~

Solution for drawbacks of VATS: robotics

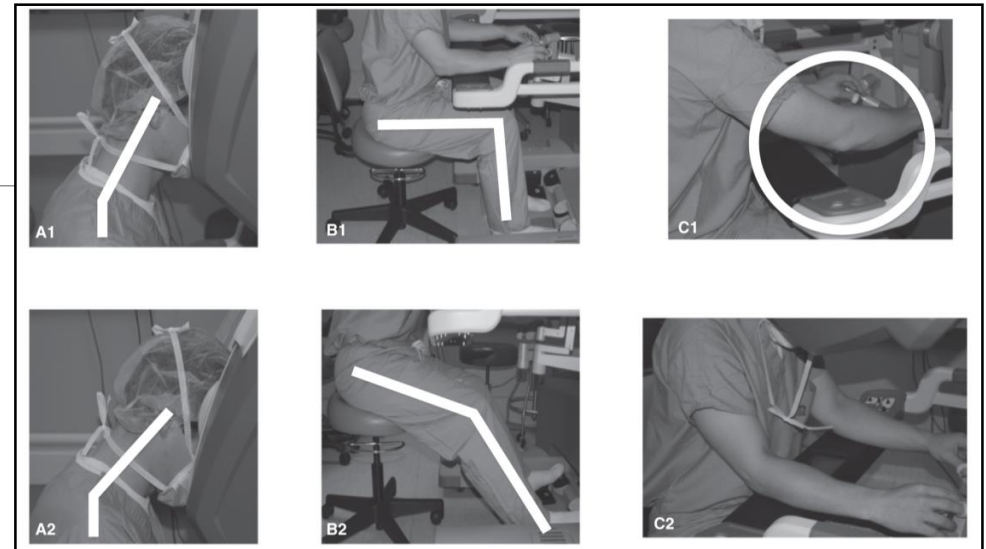
Improved / realistic ergonomics





Solution for drawbacks of VATS: robotics Improved Ergonomics

Surgical Endoscopy 2016 Jun 20
Musculoskeletal pain among surgeons performing minimally invasive surgery: a systematic review.
DISCUSSION: ... **robotic-assisted laparoscopy is less strenuous compared with conventional laparoscopy.**



Surgical Endoscopy 2016 Aug 5
Intraoperative workload in robotic surgery assessed by wearable motion tracking sensors and questionnaires.
Postures were more ergonomic during console tasks [console surgeon] than when assisting by the table [table surgeon]; ...

The International Journal of **Medical Robotics** and **Computer Assisted Surgery**
THE INTERNATIONAL JOURNAL OF MEDICAL ROBOTICS AND COMPUTER ASSISTED SURGERY
Int J Med Robotics Comput Assist Surg 2013; 9: 142–147. **ORIGINAL ARTICLE**
Published online 26 March 2013 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rcs.1489

Ergonomic assessment of the surgeon's physical workload during standard and robotic assisted laparoscopic procedures

Conclusions Robot-assisted laparoscopy is a less physically stressful surgical technique than standard laparoscopy. Copyright © 2013 John Wiley & Sons, Ltd.

Ergonomics in Laparoscopic Surgery

Francisco M. Sánchez-Margallo and
Juan A. Sánchez-Margallo

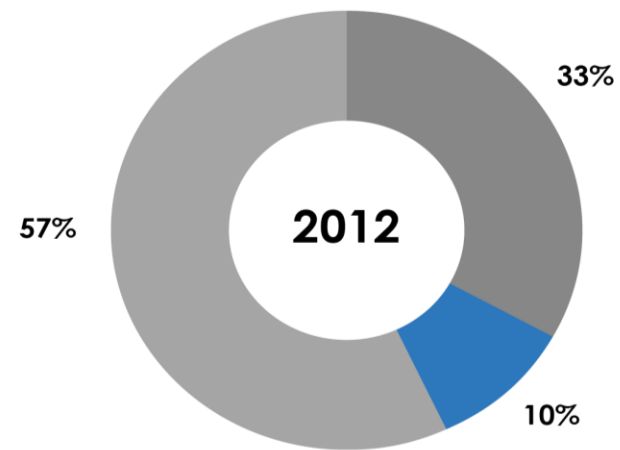
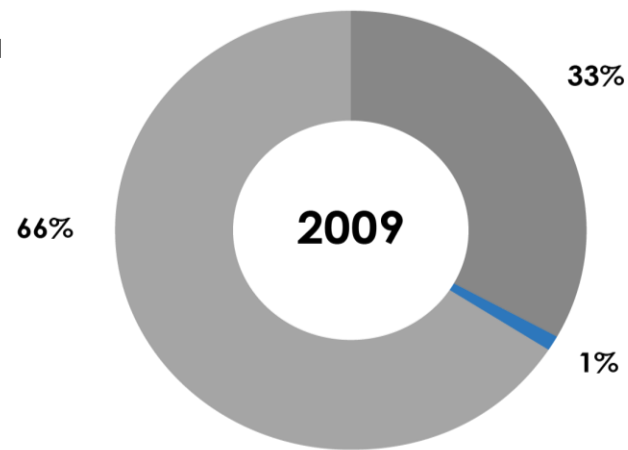
Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/66170>

position compared with traditional laparoscopy. Physical and cognitive ergonomics with robotic assistance were significantly less challenging when compared to conventional laparoscopic surgery.

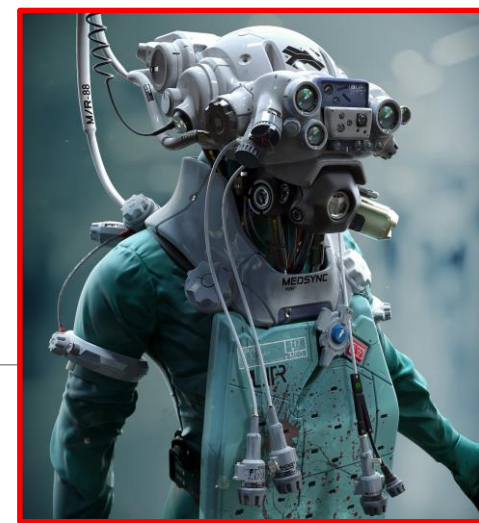
Robot induced rapid introduction of MIS for anatomical resection

- DA VINCI
- VATS
- OPEN



¹AHRQ HCUPnet database

Learning Curve of da Vinci Xi Robotics



The International Journal of **Medical Robotics** and **Computer Assisted Surgery**



THE INTERNATIONAL JOURNAL OF MEDICAL ROBOTICS AND COMPUTER ASSISTED SURGERY

Int J Med Robotics Comput Assist Surg 2012; 8: 448–452.

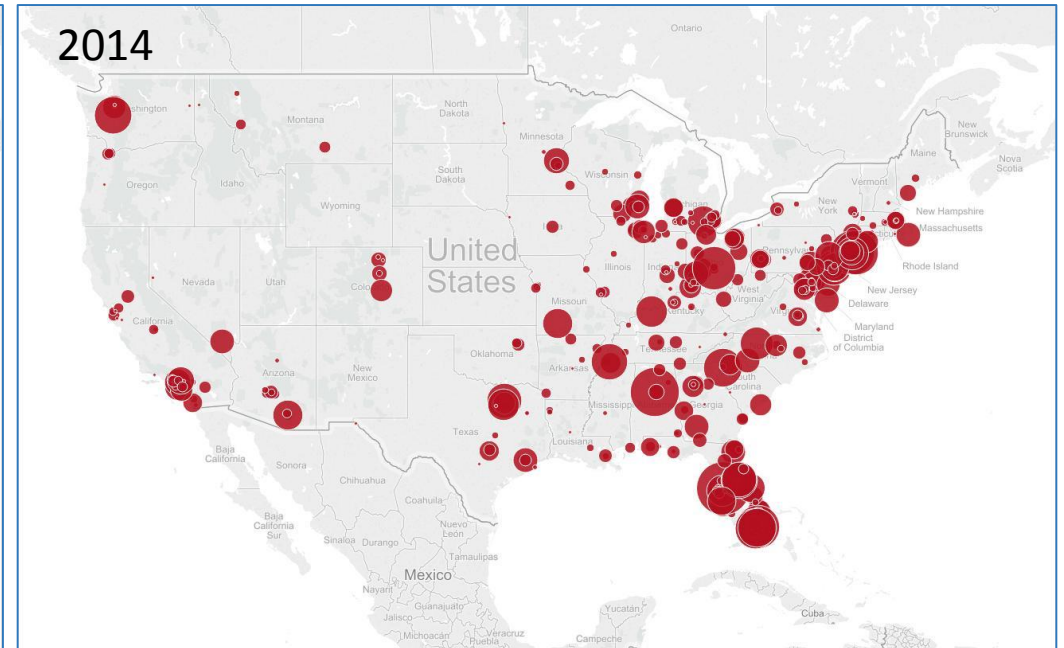
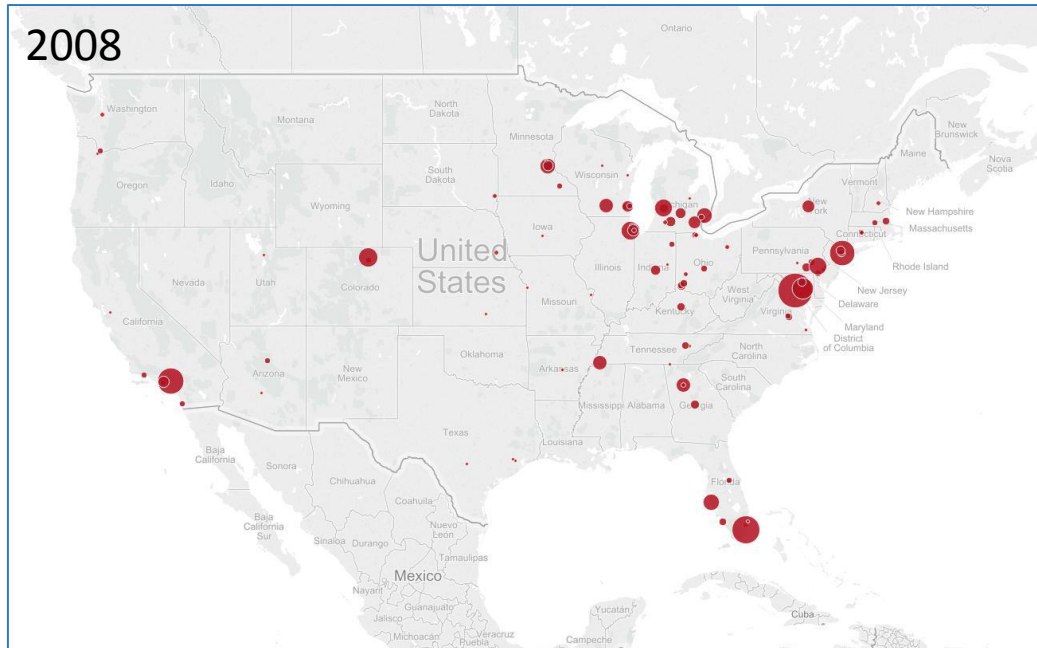
Published online 18 September 2012 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rcs.1455

ORIGINAL ARTICLE

The learning curve of robotic lobectomy

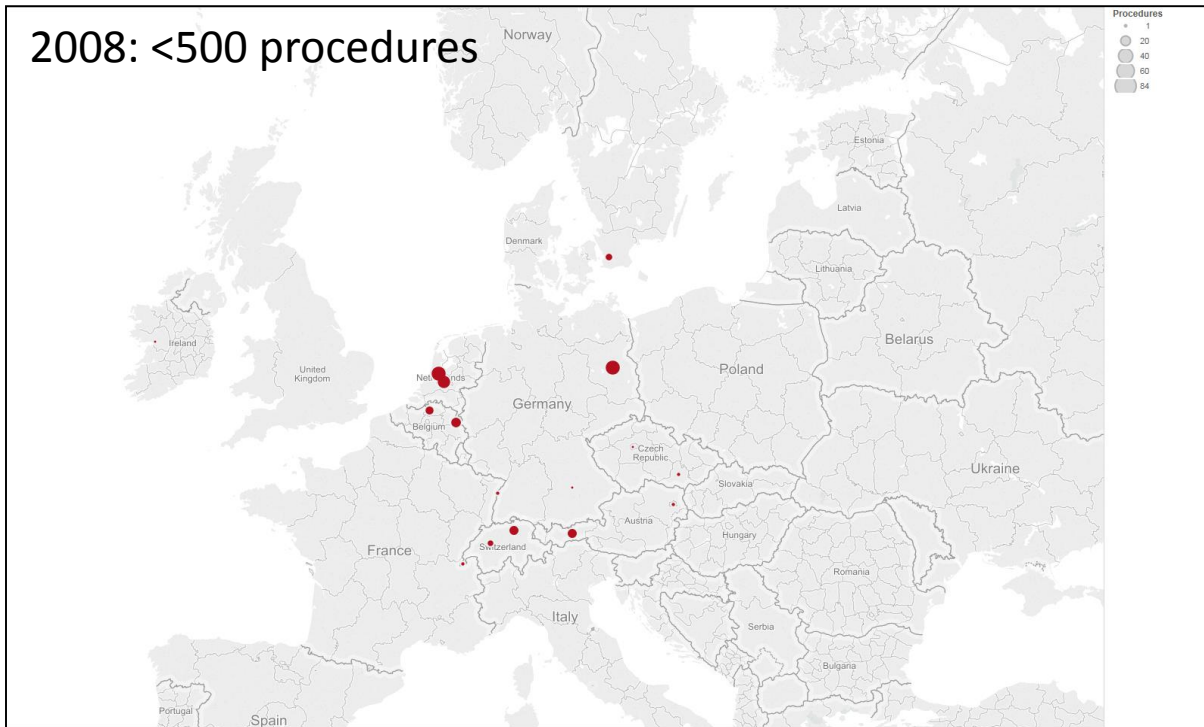
The learning curve was 18 ± 3 cases for a surgeon with VATS experience

Adoption of da Vinci “Thoracic Surgery” [US]

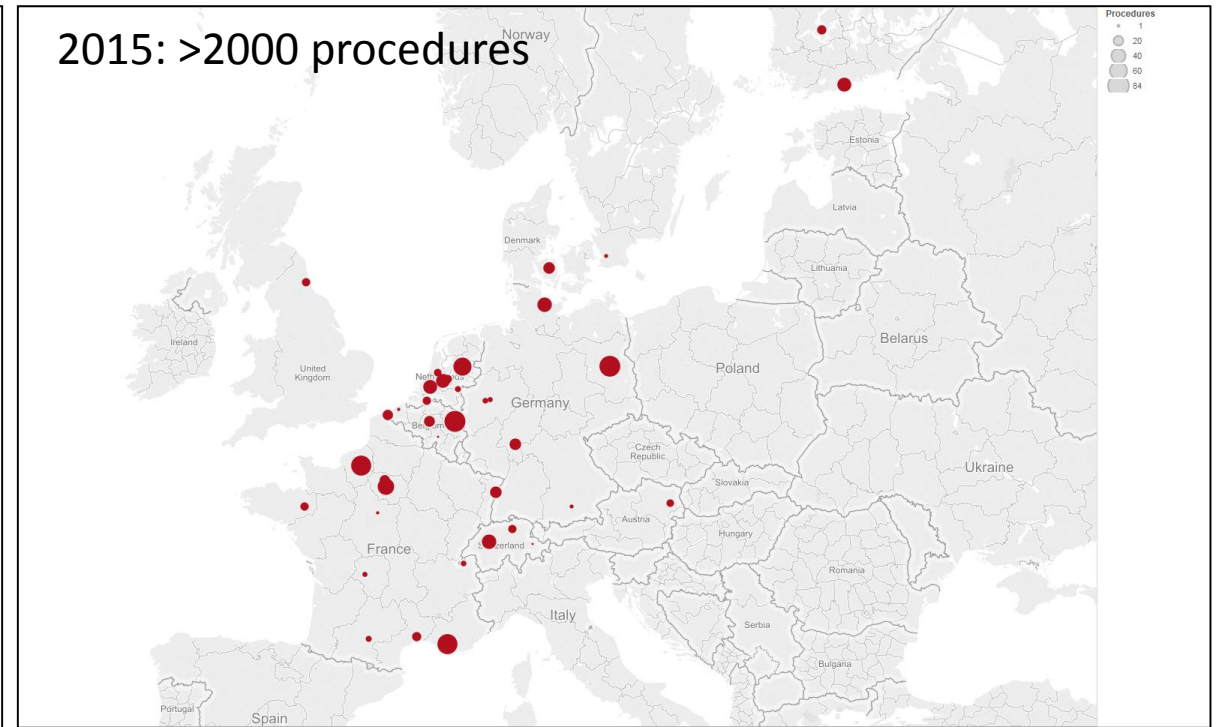


Adoption of da Vinci “Thoracic Surgery” [Europe]

2008: <500 procedures



2015: >2000 procedures



da Vinci Has Proven its Ability to Advance MIS Across Multiple Procedures



Emergence

Adoption

Standard of Care

Colorectal Surgery

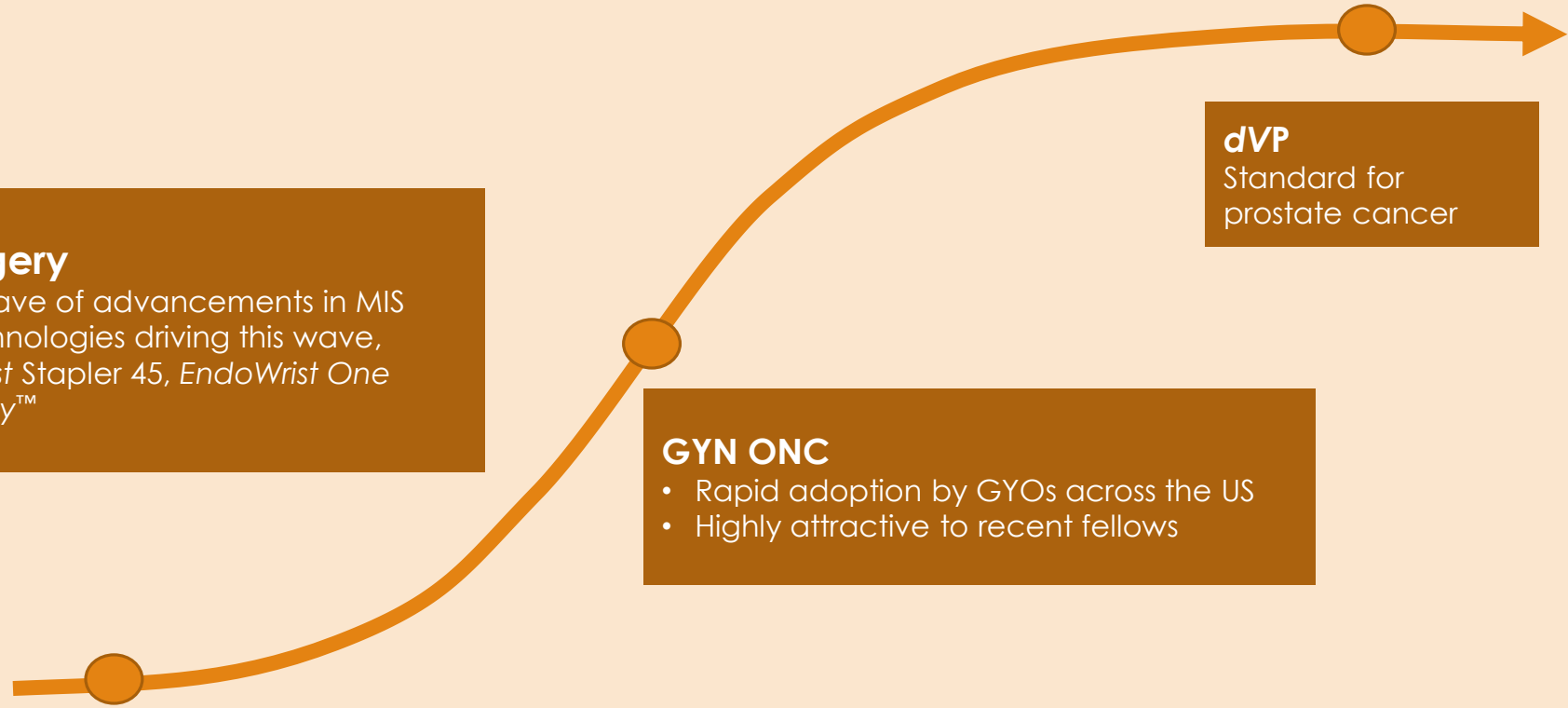
- Driving the next wave of advancements in MIS
- New platform technologies driving this wave, including *EndoWrist Stapler 45*, *EndoWrist One Vessel Sealer*, *Firefly™*

GYN ONC

- Rapid adoption by GYOs across the US
- Highly attractive to recent fellows

dVP

Standard for prostate cancer



Introduction of robotics in surgery in UZA

Since 2003: da Vinci 3-arm S

Excellent tool for resection of mediastinal tumors

Insufficient for anatomical lung resection

VATS as MIS for anatomical lung resection [lobectomy / segmentectomy]

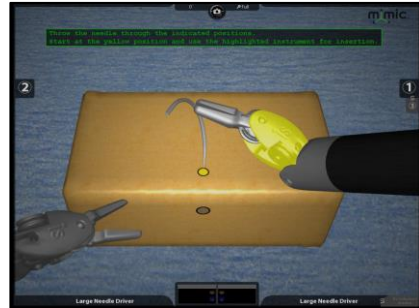
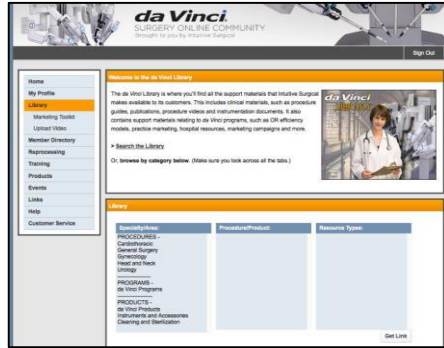
Since 2016: 4-arm da Vinci Xi

02-2016: First RATS lobectomy

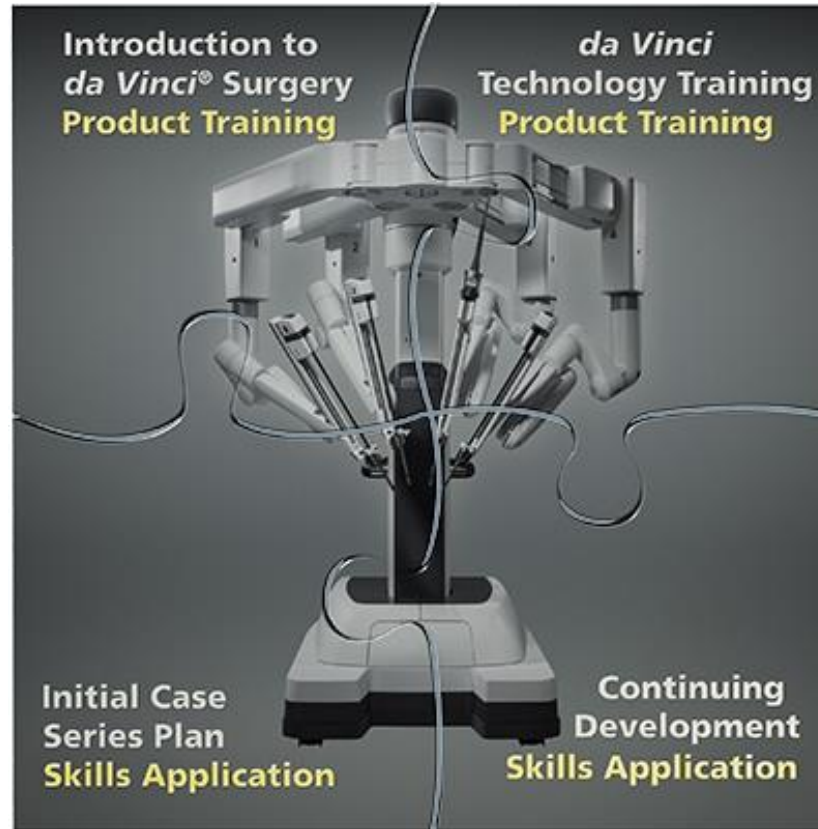
Actual: > 60 cases (lobectomy / segmentectomy)

Prospect: \geq 40 cases annually

Training RATS – pathway



Individual training: webinar, video, bibliography

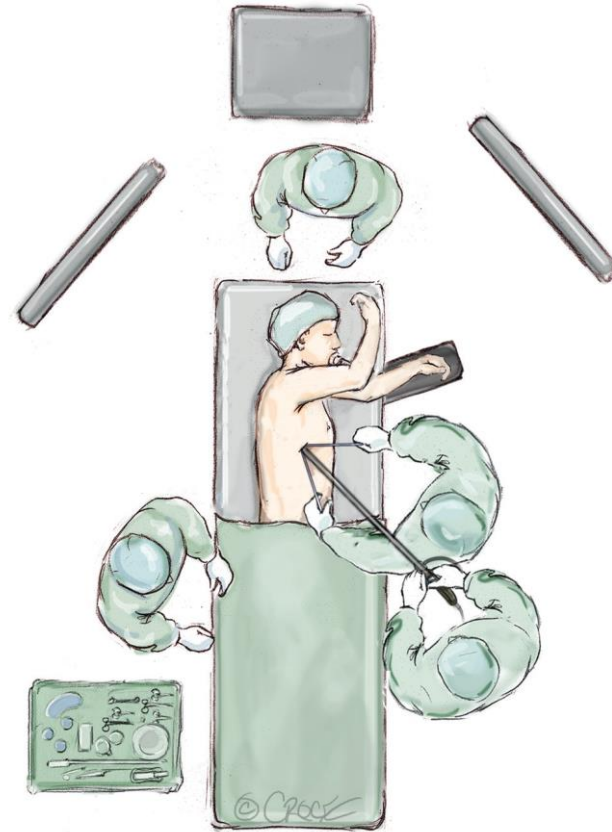
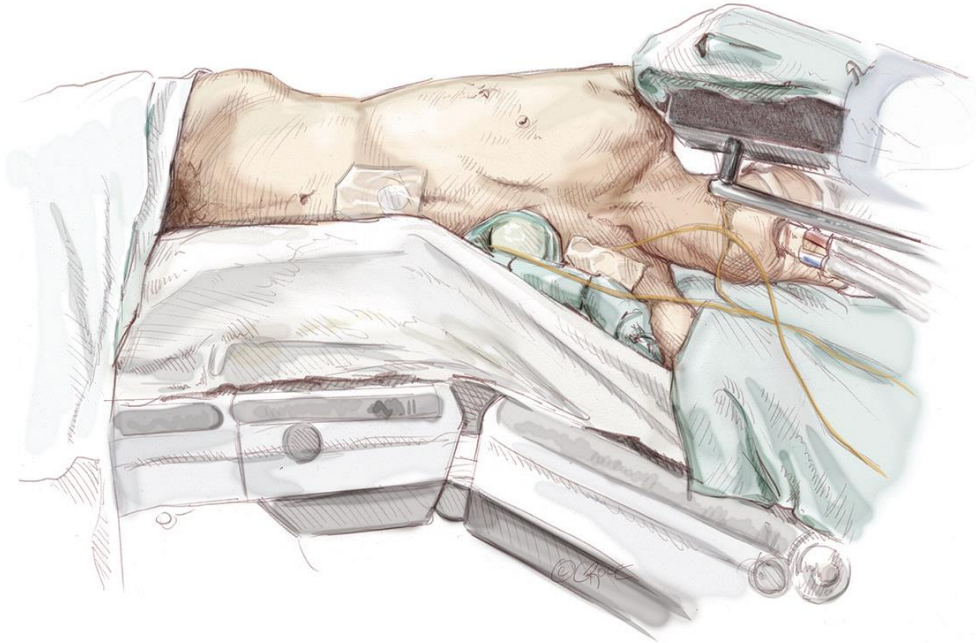


Simulation: animals / human cadaver

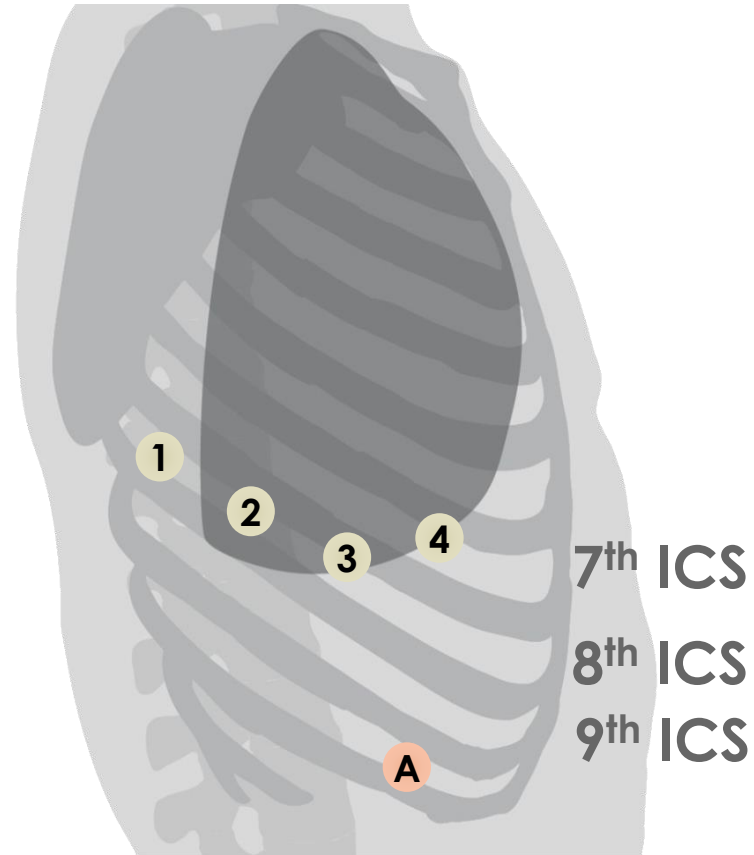


RATS

Installation comparable to VATS



2016 dV 4-arm Xi vs 2003 3-arm S



Camera

- Smaller
- Lighter
- Plug & start
- Any port

Faster sterile prep of the robot (10min)

Improved inferior reach of the arms

4 arms (real advantage)

Only 6cm between ports

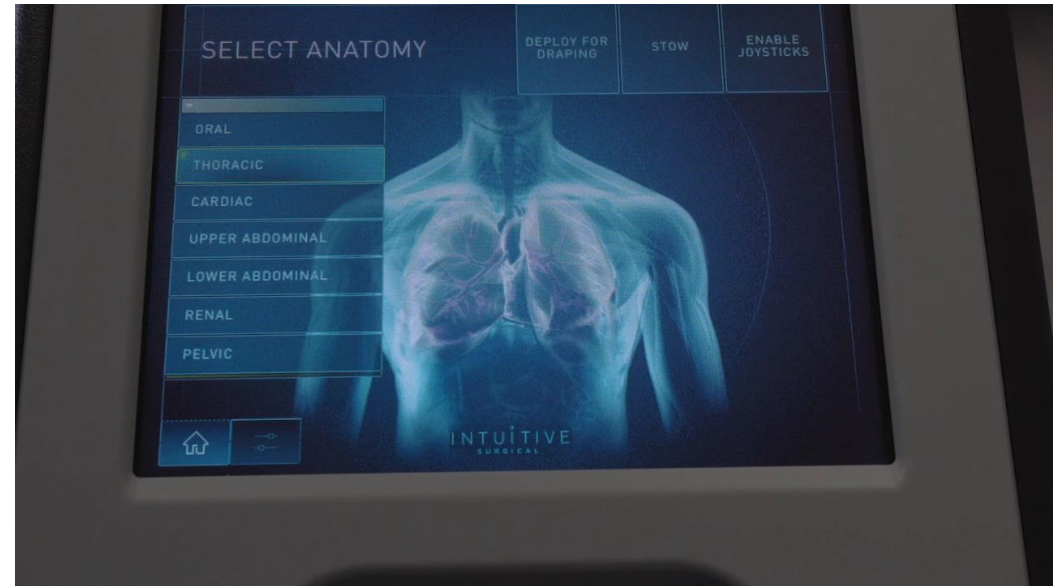
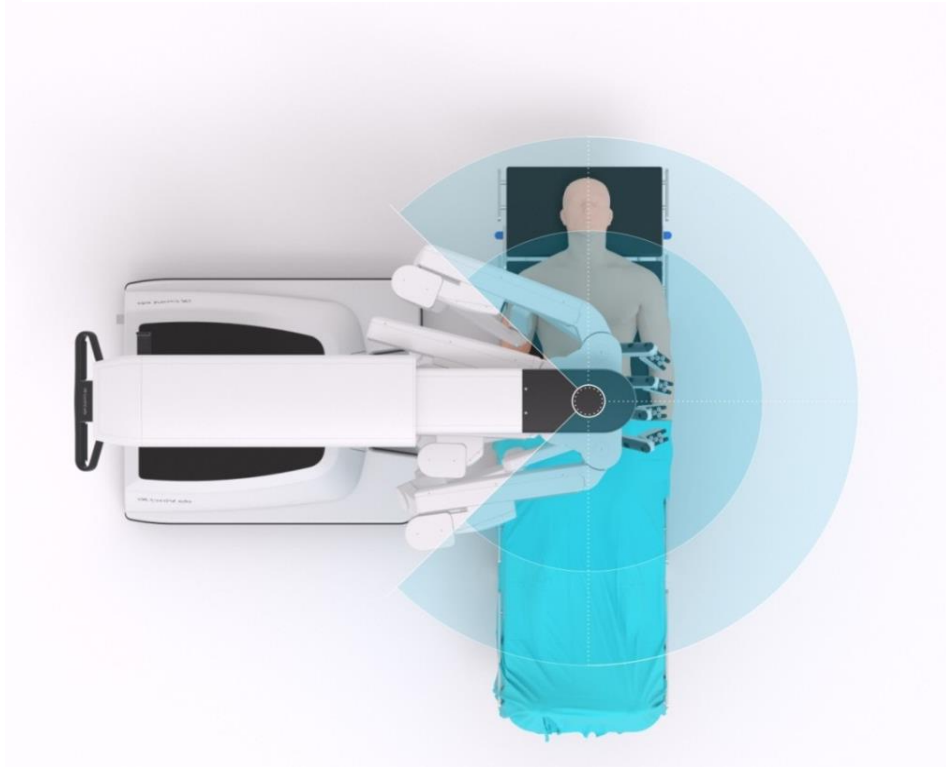
Staplers !

- 2016: tip-curved 30mm staplers / clips / hemolocks



2016 dV 4-arm Xi vs 2003 3-arm S

270° patient access



Comparative data for lobectomy [US studies]

Study (n)	Comparator	LOS, days (p value vs. robotic)	Chest tube duration, days (p value vs. robotic)	Overall Complications % (p value vs. robotic)	30 day Mortality % (p value vs. robotic)
Kent 2013¹					
Open (1,233)	SID (national database)	8.2 (<.0001)	NA	54.1 (.003)	2.0 (.016)
VATS (1,233)		6.3 (NS)	NA	45.3 (NS)	1.1 (NS)
Robotic (411)		5.9	NA	43.8	0.2
Farivar 2014²					
Open (4,612)	STS database	7.3 (<.0001)	4.8 (<.0001)	NA	2.0 (<.0001)
VATS (5,913)		5.3 (<.0001)	3.7 (.0005)	NA	0.9 (<.0001)
Robotic (181)	2 centers	3.2	2.9	NA	0
Cerfolio 2011³					
Open (318)	Single center	4.0 (.02)	3.0 (<.001)	38.0 (.05)	3.0 (NS)
Robotic (106)		2.0	1.5	27.0	0

¹Kent M, Wang T, et al.; Open, Video-Assisted Thoracic Surgery, and Robotic Lobectomy: Review of a National Database. *The Society of Thoracic Surgeons*. 2013; 97(1):236-244; ²Farivar, AS, Cerfolio, RJ, et al.; Comparing Robotic Lung Resection With Thoracotomy and Video-Assisted Thoracoscopic Surgery Cases Entered Into The Society of Thoracic Surgeons Database. *Innovations*.2014; 9(1):1-6. ³Cerfolio, RJ; Bryant, AS, et al.; Initial consecutive experience of completely portal robotic pulmonary resection with 4 arms. *The Journal of Thoracic and Cardiovascular Surgery*.2011;142(4)740-746.

REVIEW

Open Access



Feasibility and safety of robot-assisted thoracic surgery for lung lobectomy in patients with non-small cell lung cancer: a systematic review and meta-analysis

In conclusion, the current systematic and meta-analysis demonstrates that RATS lobectomy is a feasible and safe technique for selected patients and can achieve an equivalent short-term surgical efficacy when compared with VATS procedure. However, longer operative time and cost effectiveness of RATS should be taken into consideration, and long-term oncological efficacy of the RATS approach remains to be seen.

Nodal upstaging / Stage migration

VATS: Less compared to Open; RATS: equal ctO

Study	n	Hilar upstaging % (p value vs. VATS)	Mediastinal upstaging % (p value vs. VATS)	Overall upstaging % (p value vs. VATS)
Boffa 2012¹				
Open	7,137	9.3 (<.001)	5.0 (NS)	14.3 (<.001)
VATS	4,394	6.7	4.9	11.6
Licht 2013²				
Open	796	13.1 (<.001)	11.5 (<.001)	24.6 (<.001)
VATS	717	8.1	3.8	11.9
Merritt 2013³				
Open	69	17.4 (NS)	7.2 (NS)	24.6 (.05)
VATS	60	8.3	1.8	10
Park 2012⁴				
Robotic	325	NR	NR	24.0 (N/A)

Zhang et al. World Journal of Surgical Oncology (2016) 14:290
DOI 10.1186/s12957-016-1038-7

World Journal of
Surgical Oncology

RESEARCH

Open Access



Thoracotomy is better than thoracoscopic lobectomy in the lymph node dissection of lung cancer: a systematic review and meta-analysis

Wenxiong Zhang, Yiping Wei, Han Jiang, Jianjun Xu and Dongliang Yu*

Abstract

Background: The aim of this study was to investigate which surgical method is better in lymph node (LN) dissection of lung cancer.

Methods: A comprehensive search of PubMed, Ovid MEDLINE, EMBASE, Web of Science, ScienceDirect, the Cochrane Library, Scopus, and Google Scholar was performed to identify studies comparing thoracoscopic lobectomy (video-assisted thoracic surgery (VATS) group) and thoracotomy (open group) in LN dissection.

Results: Twenty-nine articles met the inclusion criteria and involved 2763 patients in the VATS group and 3484 patients in the open group. The meta-analysis showed that fewer total LNs (95% confidence interval [CI] -1.52 to -0.73, $p < 0.0001$) and N2 LNs (95% CI -1.25 to -0.10, $p = 0.02$) were dissected in the VATS group. A similar number of total LN stations, N2 LN stations, and N1 LNs were harvested in both groups. Only one study reported that fewer N1 LN stations were dissected in the VATS group (1.4 ± 0.5 vs. 1.6 ± 0.6 , $p = 0.04$).

Conclusions: Open lobectomy could achieve better LN dissection efficacy than thoracoscopic lobectomy in the treatment of lung cancer, especially in the N2 LNs dissection. These findings require validation by high-quality, large-scale randomized controlled trials.

Keywords: Video-assisted thoracic surgery, Thoracotomy, Meta-analysis, Lung cancer, Lymph node dissection

Numbers or stations ?

Numbers or Stations: From Systematic Sampling to Individualized Lymph Node Dissection in Non–Small-Cell Lung Cancer

Wen-Zhao Zhong, Si-Yang Liu, and Yi-Long Wu, *Guangdong General Hospital and Guangdong Academy of Medical Sciences, Guangzhou, People's Republic of China*

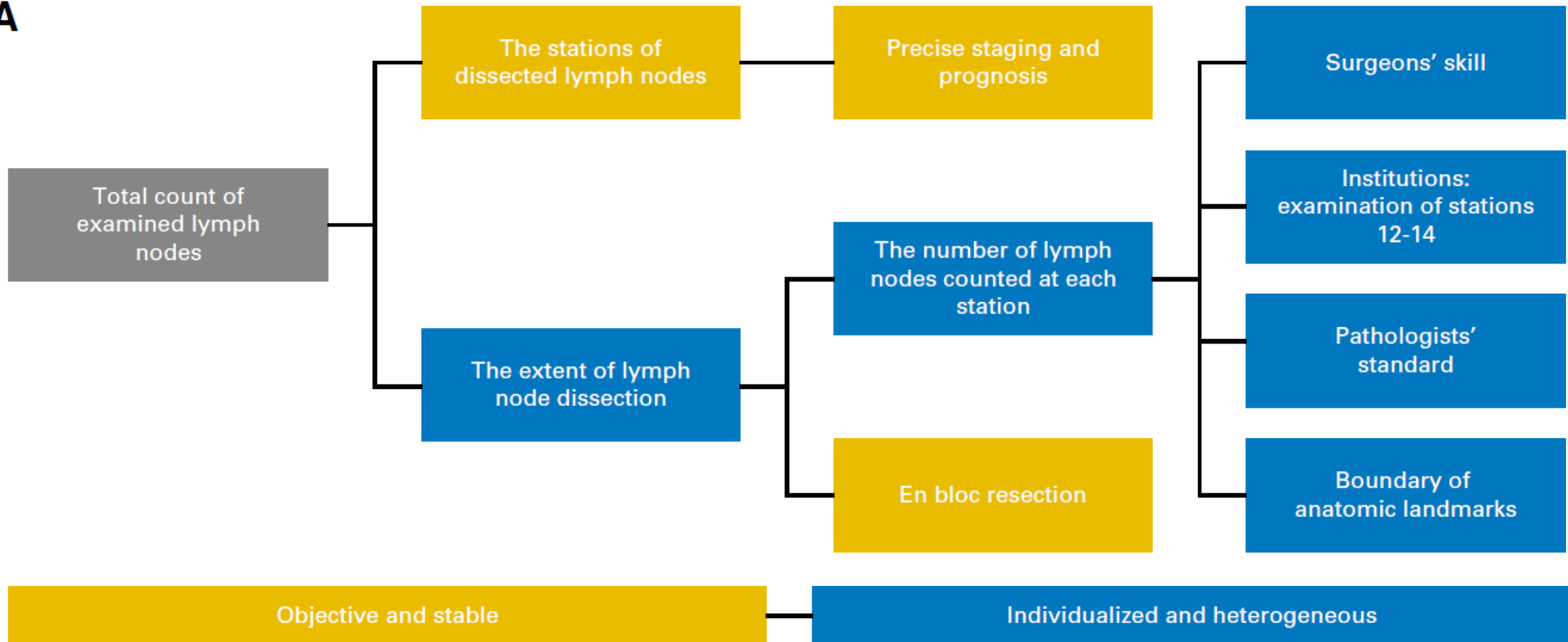
The views expressed in this article are original and are those of the authors.
See accompanying article doi:[10.1200/JCO.2016.67.5140](https://doi.org/10.1200/JCO.2016.67.5140)

~~geons, and LN maps.~~⁹ To resolve this issue, the current International Association for the Study of Lung Cancer (IASLC) Staging Project has recommended that physicians prospectively record both the number of examined LNs and their locations using the IASLC nodal map and anatomic definitions for future analysis.⁹

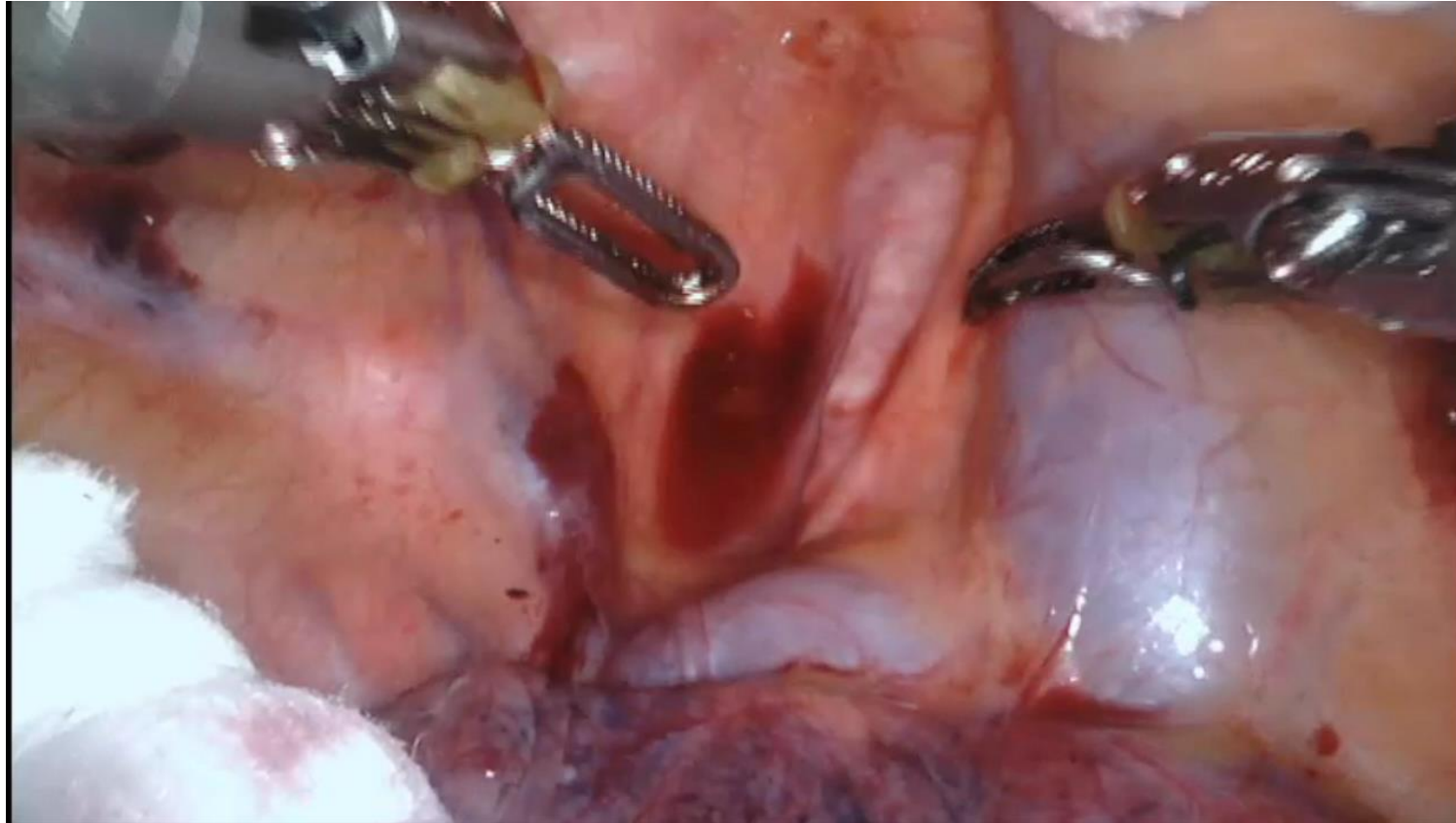
En bloc LN resection is defined as isolation and systematic removal of all surrounding fat containing lymph tissue within the boundaries of anatomic landmarks without dragging.¹⁰ ~~Osar~~

Factors leading to heterogeneity in the count of ELNs

A



LN dissection en-bloc



Unknown so far regarding MIS

Indications

- MIS: segmentectomy standard ? larger tumor size [T1c and higher]; post-induction treatment

Cost

- RATS:
 - Higher direct cost
 - Total cost ? Break-even point according to Veronesi et al [JTCVS 2010; 140:19-25] at **254** da Vinci procedures annually
 - Less as soon as competition (Robot by J&J,)

Ergonomics for long procedures

- RATS:
 - Improved ergonomics when daily surgery
 - More symptoms/discomfort (neck/fingers) for urology

Is Google Preparing Surgical Strike On Intuitive's Da Vinci?

MATTHEW GALGANI | 10/07/2016

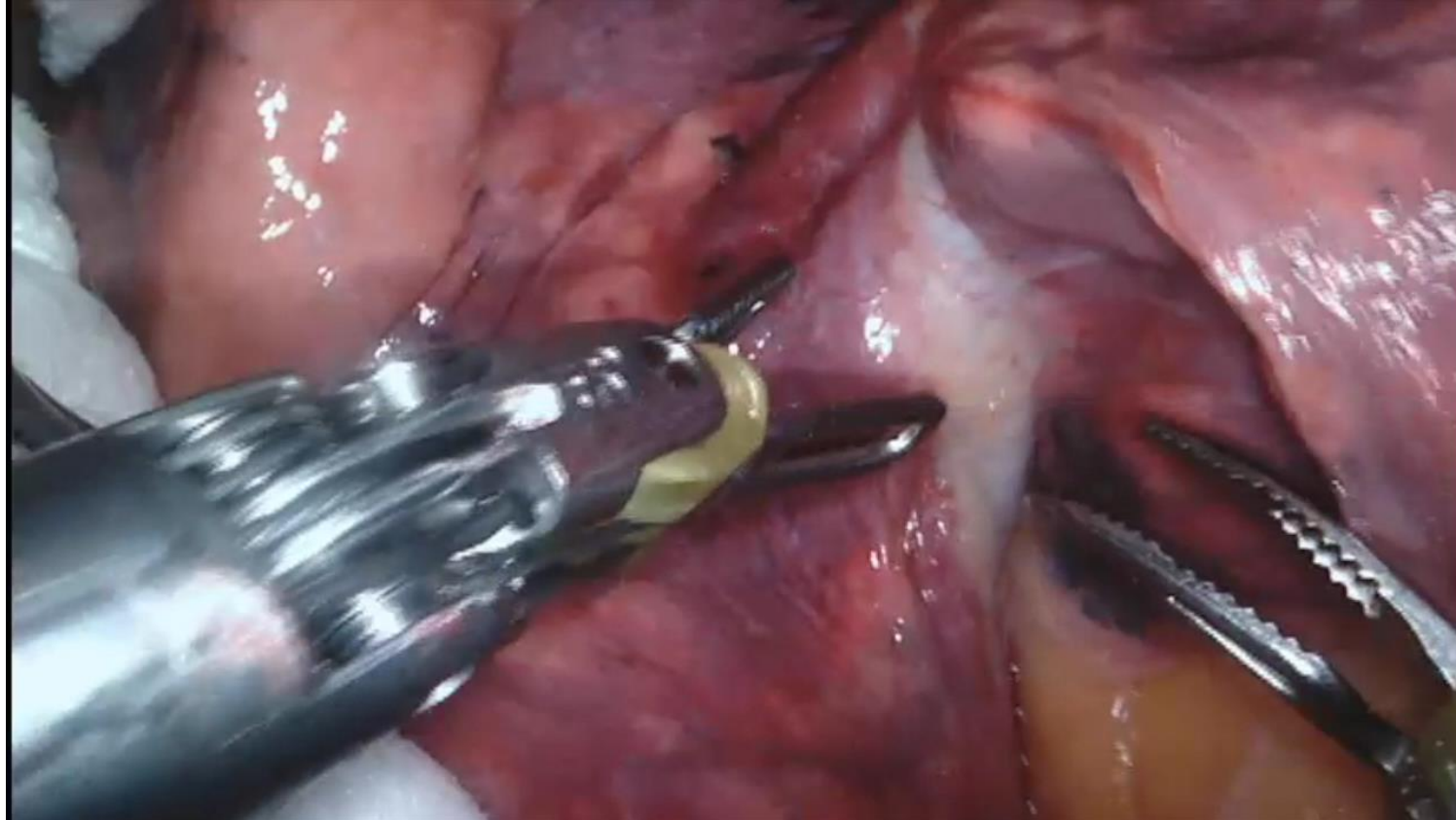


While Google-parent Alphabet (GOOGL) vows to create "the future of surgery" through its Verb Surgical joint venture with Johnson & Johnson (JNJ), Intuitive Surgical (ISRG), with its da Vinci system, remains the clear leader in robotic-assisted, minimally-invasive operations.

As FierceBiotech reported last month, Verb Surgical is aiming to develop a next-generation system that "incorporates robotics, advanced visualization, machine learning, data analytics and connectivity." But Verb's platform isn't expected to hit the market until 2020.

Meanwhile, Intuitive Surgical's da Vinci is used in over 3,660 hospitals in 64 countries, with a new da Vinci surgery beginning every 60 seconds.

Stapling





Conclusion

- MIS is accepted as a better alternative to open thoracotomy for anatomical resection regarding pain, hospitalisation and recovery BUT still no randomised trials
- Ergonomic studies in laparoscopy and thoracoscopy showed that 87% of surgeons experience severe musculoskeletal symptoms.
- VATS is an excellent tool for thoracic procedures but is only slowly adopted for anatomical resection over the last 2 decades (centres, surgeons, number of pts treated)
- Robotics in surgery is a superior step forward with the ability to improve VATS as a MIS technique for (complex) pulmonary anatomical resections
 - Advantages: superior 3Dview; far better handling; better instruments; better ergonomics; lesser conversion rate; nodal upstaging comparable to open; more complex procedures are possible
 - Disadvantage: cost [will decrease as soon as competition is present]; no tactile feedback (in development)
 - Unknown: Parameters of selection other than tumorsize ? Predictors of conversion? Other indications for anatomical resection such as infection / resection in children

Is Google Preparing Surgical Strike On Intuitive's Da Vinci?

MATTHEW GALGANI | 10/07/2016



While Google-parent Alphabet (GOOGL) vows to create "the future of surgery" through its Verb Surgical joint venture with Johnson & Johnson (JNJ), Intuitive Surgical (ISRG), with its da Vinci system, remains the clear leader in robotic-assisted, minimally-invasive operations.

As FierceBiotech reported last month, Verb Surgical is aiming to develop a next-generation system that "incorporates robotics, advanced visualization, machine learning, data analytics and connectivity." But Verb's platform isn't expected to hit the market until 2020.

Meanwhile, Intuitive Surgical's da Vinci is used in over 3,660 hospitals in 64 countries, with a new da Vinci surgery beginning every 60 seconds.