# What’s New in Surgical Robotics

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# Disclosures

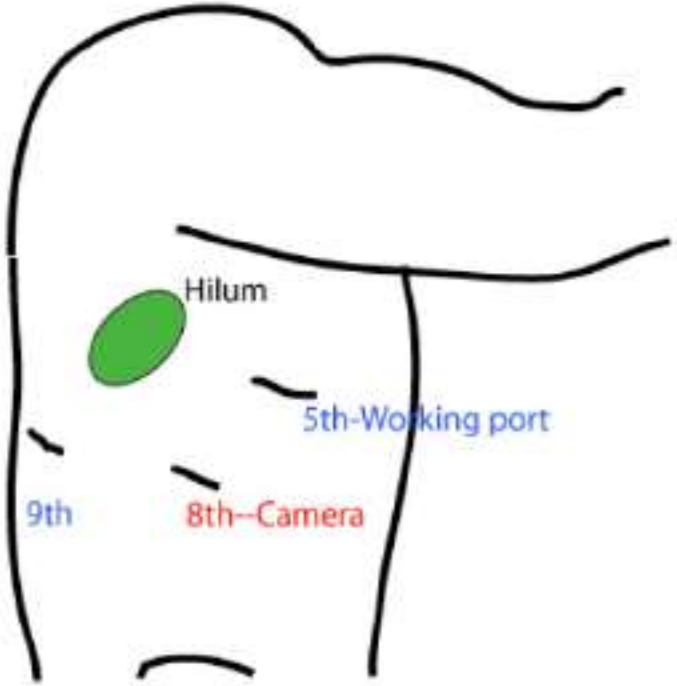
Consultant for Intuitive Surgical and Medtronic

# Outline

- Quick review of short/medium-term robotic series & trends
- Overview of new technology
  - New applications for existing systems
  - New tools for existing robots
  - SP robot
  - Robotic navigational bronchoscopy
  - New surgical systems

# VATS Pro/Con

- VATS Strengths
  - Flexibility
  - Proximity of surgeon to patient
  - Possibly (probably) cheaper
- VATS Weaknesses
  - Reliance on help
  - 2D camera/monitors
  - Difficulty of LN dissection?



# Robot Pro/Con

- Robot Strengths
  - 3D camera with 10x magnification
  - Wristed instruments
- Robotic Weaknesses
  - Inflexibility
  - No haptic feedback
  - Reliance on help

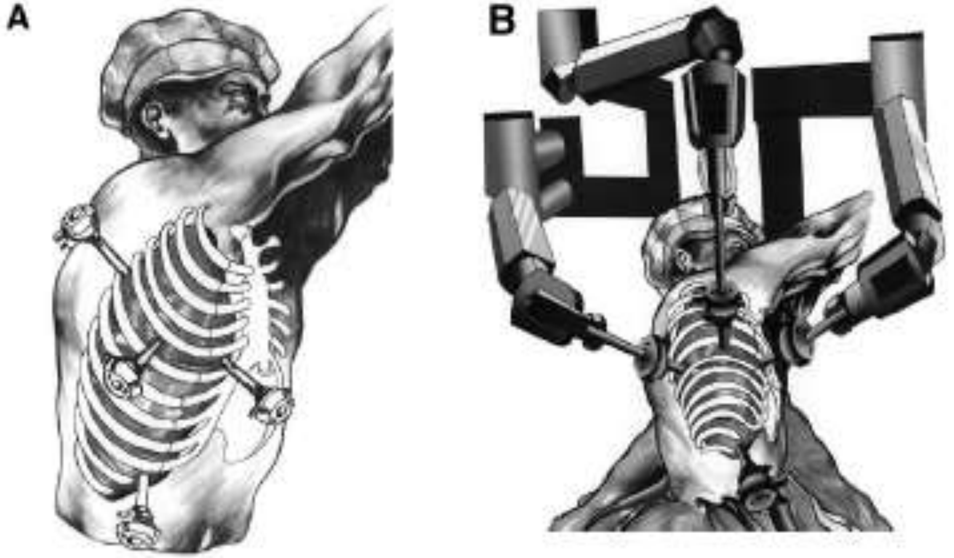
# Dylewski et al. *Semin Thoracic Surg* 2011. 23:36-42.

- 200 consecutive resections
- Median operative time 90 minutes
- 3 conversions
- Median LOS 3d

2 bilobectomies and 35 segmentectomies

**Pulmonary Resection Using a Total Endoscopic Robotic Video-Assisted Approach**

*Mark R. Dylewski, MD,[*,†] Adaeze C. Ohaeto, ARNP,[*] and Jorge F. Pereira[*]*

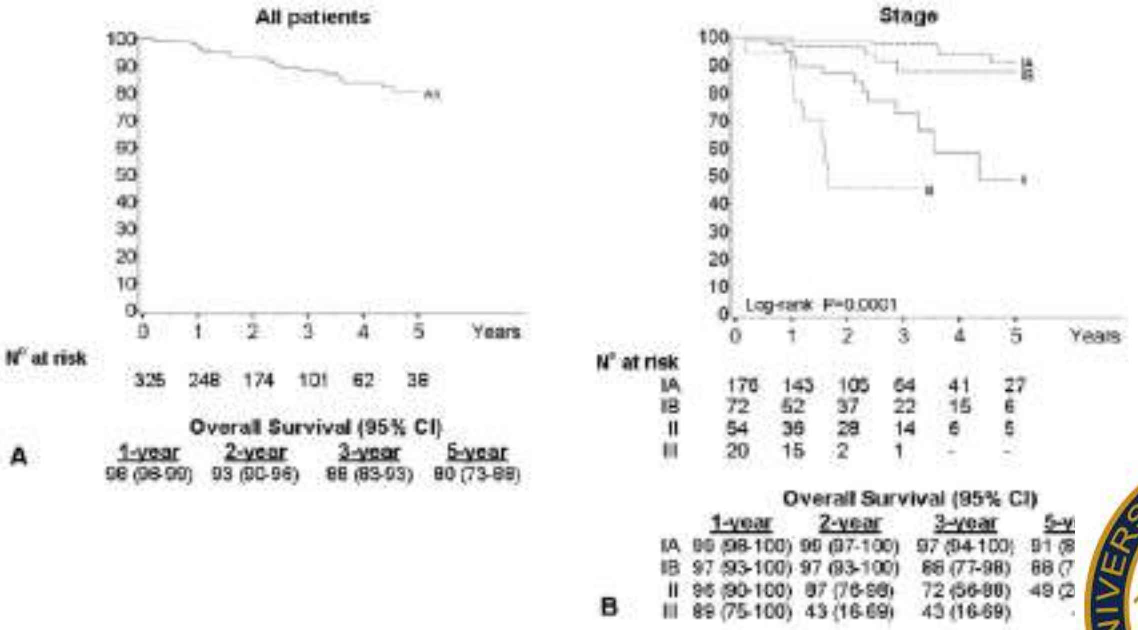


# Park et al. *JTCVS* 2012. 143:383-9.

- 325 lobectomies at 3 institutions with 8 conversions
- Median chest tube duration 3d [1,23]
- 1 perioperative mortality (0.3%)

**Robotic lobectomy for non–small cell lung cancer (NSCLC): Long-term oncologic results**

Bernard J. Park, MD,[a] Franca Melfi, MD,[b] Alfredo Mussi, MD,[b] Patrick Maisonneuve, DipEng,[c] Lorenzo Spaggiari, MD,[d] Ruy Kuenzer Caetano Da Silva, MD,[c] and Giulia Veronesi, MD[e]

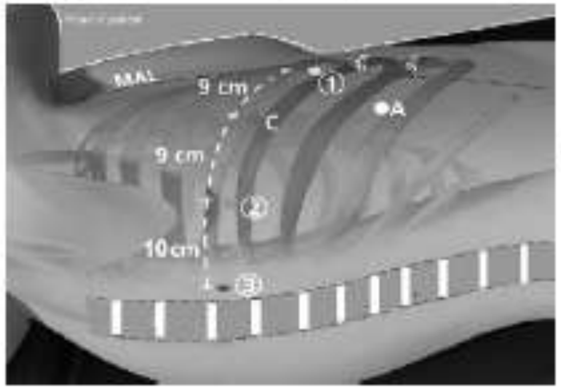


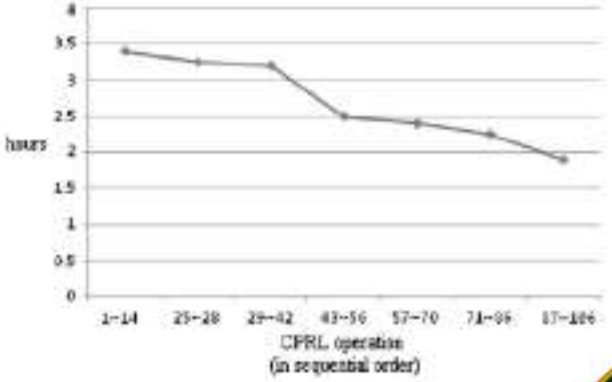
# Cerfolio et al. *JTCVS* 2012. 143:383-9.

- 168 consecutive attempted robotic cases (106 successful 4-arm lobectomies)
- Median chest tube duration 1.5d [1,6]
- Median hospital stay 2d [1,7]
- Median no. of N1 nodes resected (5 (4 in 3:1 matched thoracotomy group))
- 13 conversions (1 in last 106)

**Initial consecutive experience of completely portal robotic pulmonary resection with 4 arms**

Robert J. Cerfolio, MD, FACS, FCCP, Ayesha S. Bryant, MD, MSPH, Loki Skylizard, MD, and Douglas James Minnich, MD, FACS



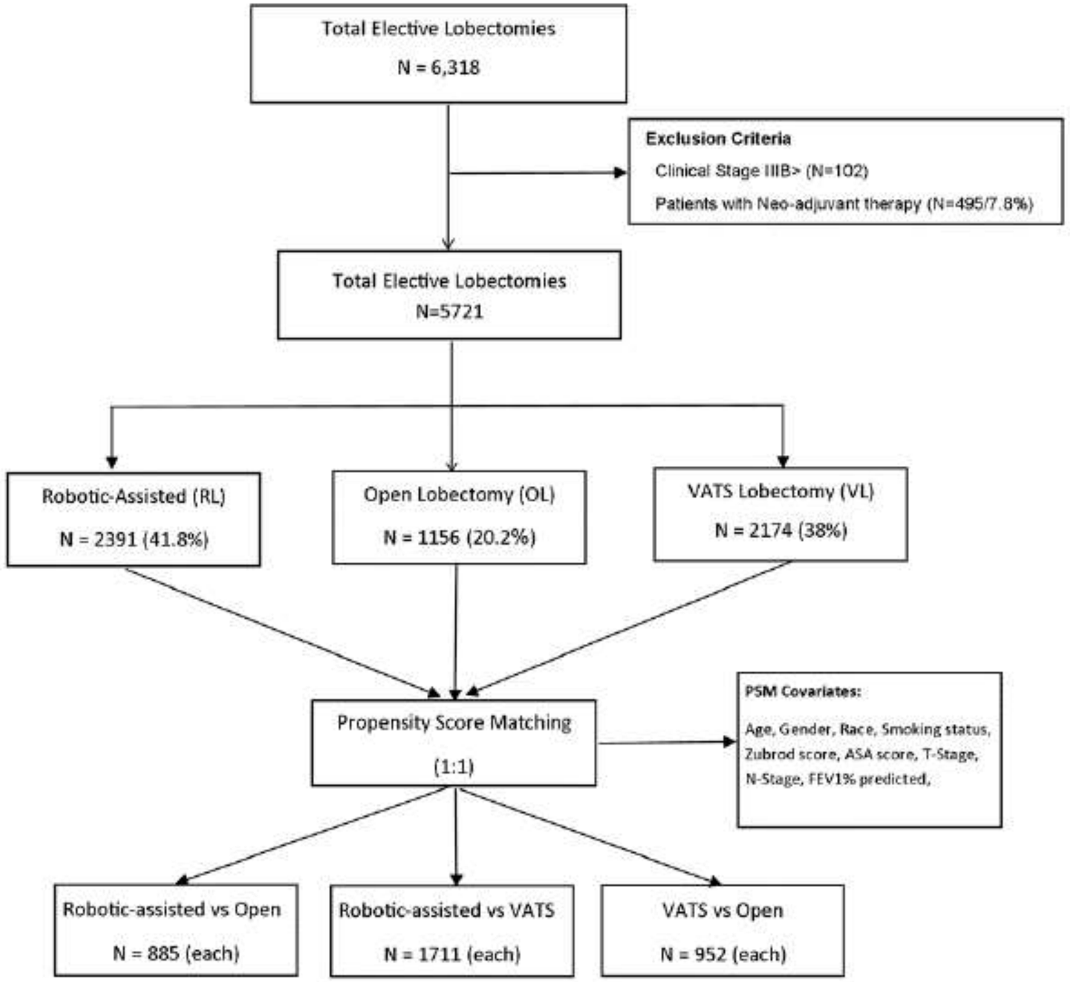




106 lobectomies, 26 wedges, 16 segmentectomies

# PORTAL Study

## Study Design

- Retrospective multi-center cohort study
- Robotic, VATS, and open lobectomies
- 2013-2019
- Propensity score matching for 9 variables
- **Matched for T and N stage**
- **Every conversion reviewed**
- **Every center contributed all lobectomies**



# PORTAL Study

## Even in experts' hands, robotic lobectomy patients had improved outcomes compared to VATS

| | | RL<br>N=1,711 | VL<br>N=1,711 | p value |
|---|---|---|---|---|
| Operative time (without concomitant procedures) | Mean ± SD (n) | 164.5 ± 75.3 (n=954) | 181.3 ± 73.6 (n=749) | <0.0001 |
| Conversion rate | n (%) | 68 (4.0%) | 173 (10.1%) | <0.0001 |
| Intra-op blood transfusion | n (%) | 15 (0.9%) | 26 (1.5%) | 0.08 |
| Post-op blood transfusion | n (%) | 22 (1.3%) | 42 (2.5%) | 0.01 |
| Length of hospital stay | Median and IQR | 3.0 (2.0,5.0) | 4.0 (3.0,6.0) | <0.0001 |
| Post-operative complications | n (%) | 463 (27.1%) | 511 (29.9%) | 0.08 |

# Comparison of Video-Assisted Thoracoscopic Surgery and Robotic Approaches for Clinical Stage I and Stage II Non-Small Cell Lung Cancer Using The Society of Thoracic Surgeons Database

Brian E. Louie, MD, Jennifer L. Wilson, MD, Sunghee Kim, PhD, Robert J. Cerfolio, MD, Bernard J. Park, MD, Alexander S. Farivar, MD, Eric Vallières, MD, Ralph W. Aye, MD, William R. Burfeind, Jr, MD, and Mark I. Block, MD

(Ann Thorac Surg 2016;102:917–24)

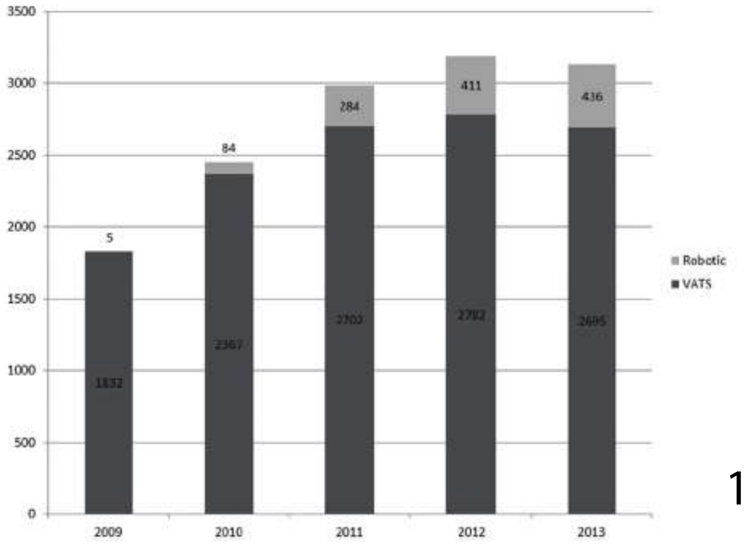



*Fig 1. Case volume by surgical approach. (VATS = video-assisted thoracoscopic surgery.)*

*Table 4. Pathologic Nodal Upstaging Overall and Stratified by Clinical Staging*

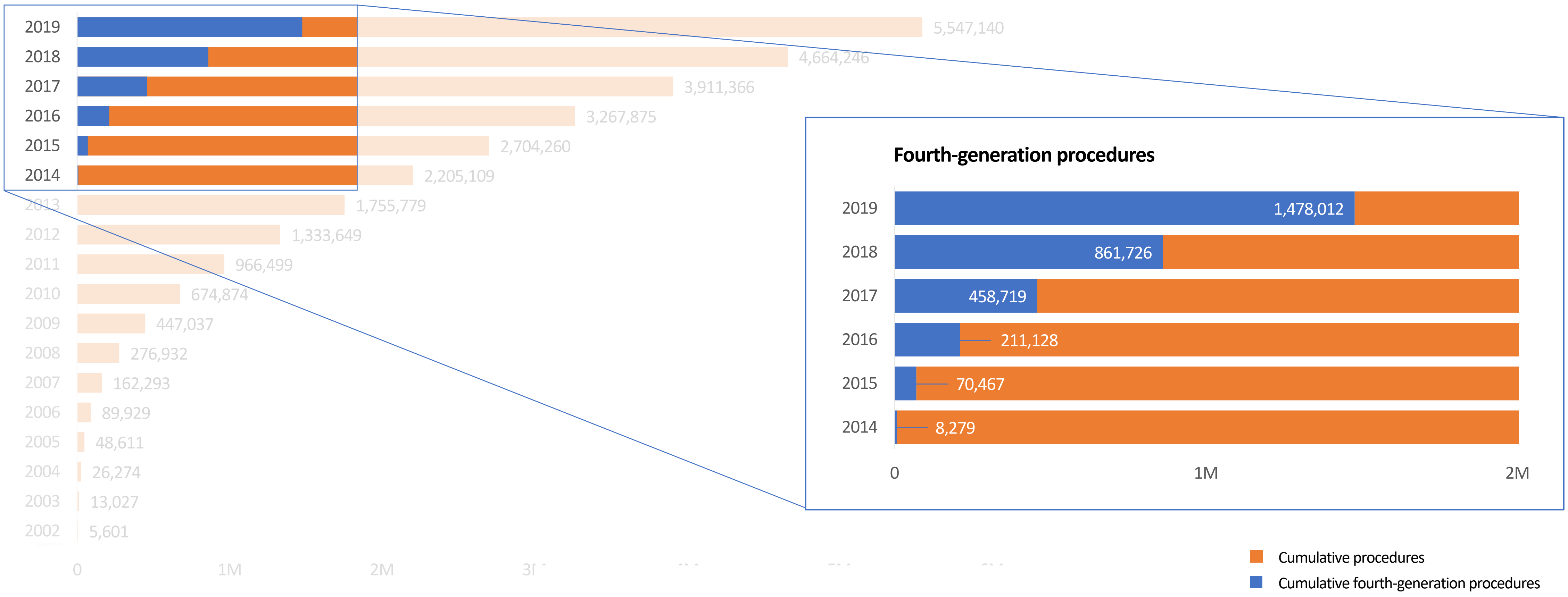
| | Proportion of Cases Upstaged to pN1 (Number Upstaged/Total Cases [%]) | | | |
|---|---|---|---|---|
| Clinical Stage | Overall | Robotic Treatment | VATS | p Value |
| cT1aN0 | 322/5,412 (5.95) | 29/471 (6.16) | 293/4,941 (5.93) | 0.8422 |
| cT1bN0 | 257/3,008 (8.54) | 19/293 (6.48) | 238/2,715 (8.77) | 0.1844 |
| cT2aN0 | 254/2,307 (11.01) | 34/244 (13.93) | 220/2,063 (10.66) | 0.1228 |
| cT2bN0 | 69/546 (12.64) | 7/47 (14.89) | 62/499 (12.42) | 0.6263 |
| Total | 902/11,273 (8.00) | 89/1,055 (8.44) | 813/10,218 (7.96) | 0.5847 |

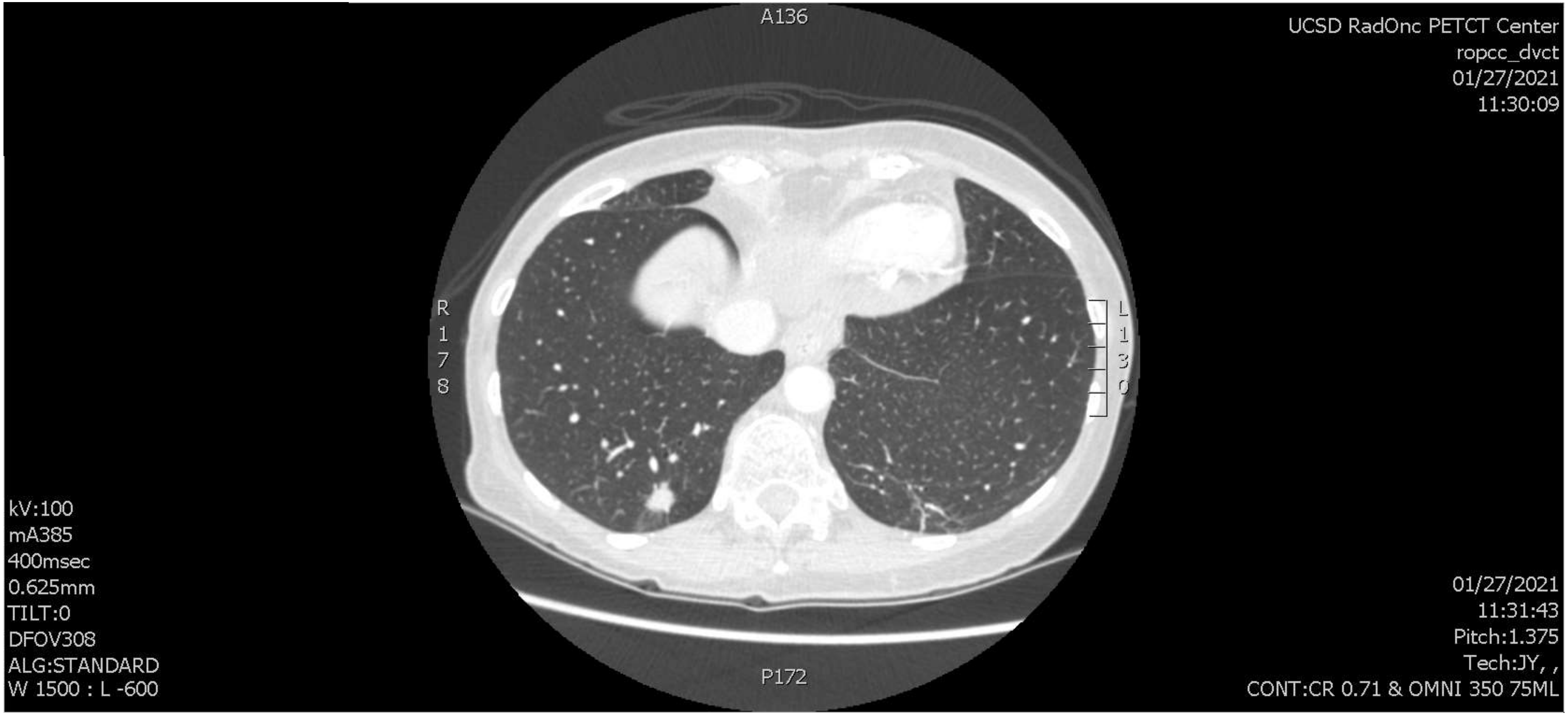
VATS = video-assisted thoracoscopic surgery.

13,598 patients: No differences in morbidity/mortality
Robotic lobes had significantly longer OR time.

# U.S. robotic-assisted surgery procedures performed with the da Vinci system to date

**U.S. cumulative procedures***

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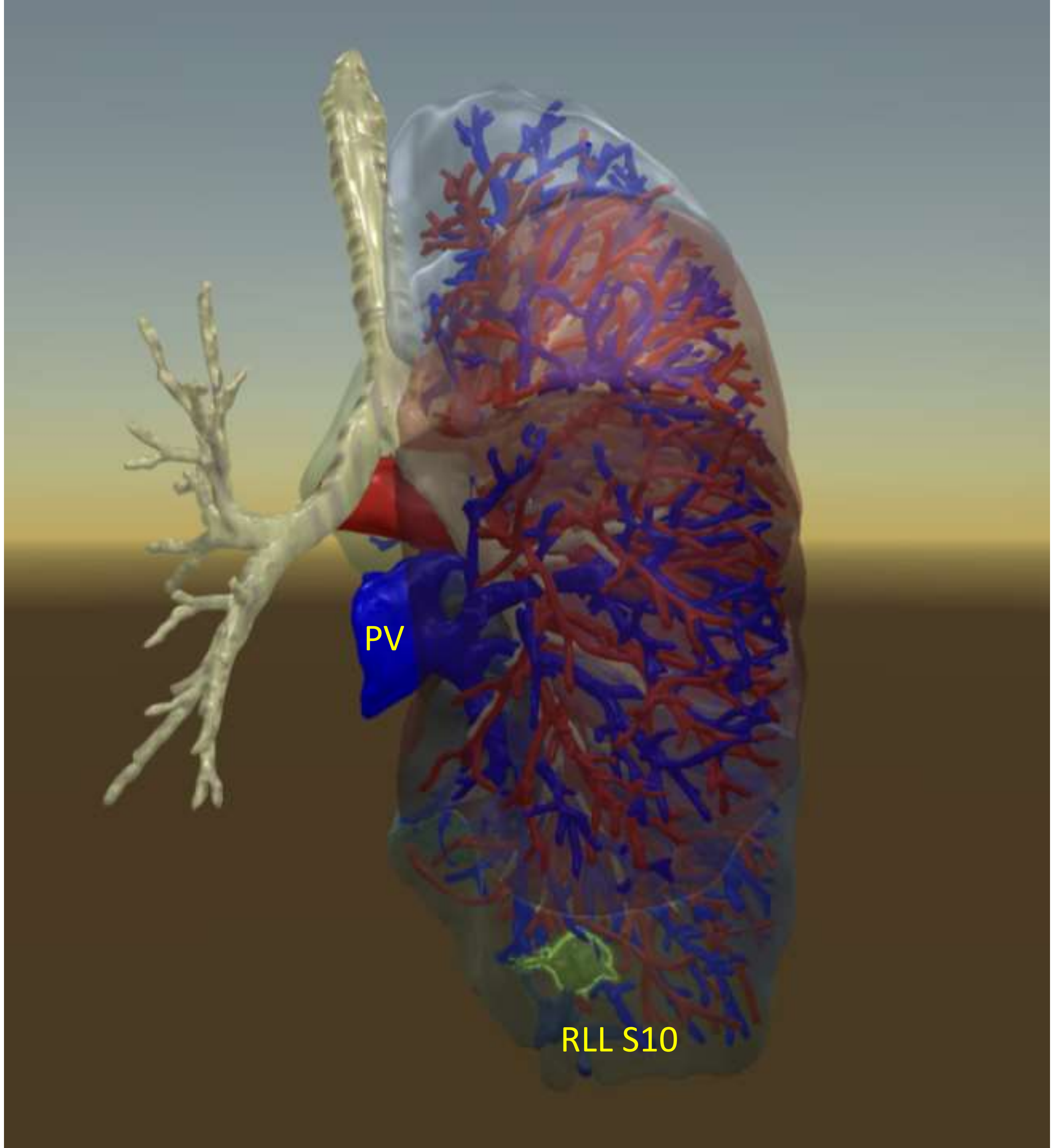
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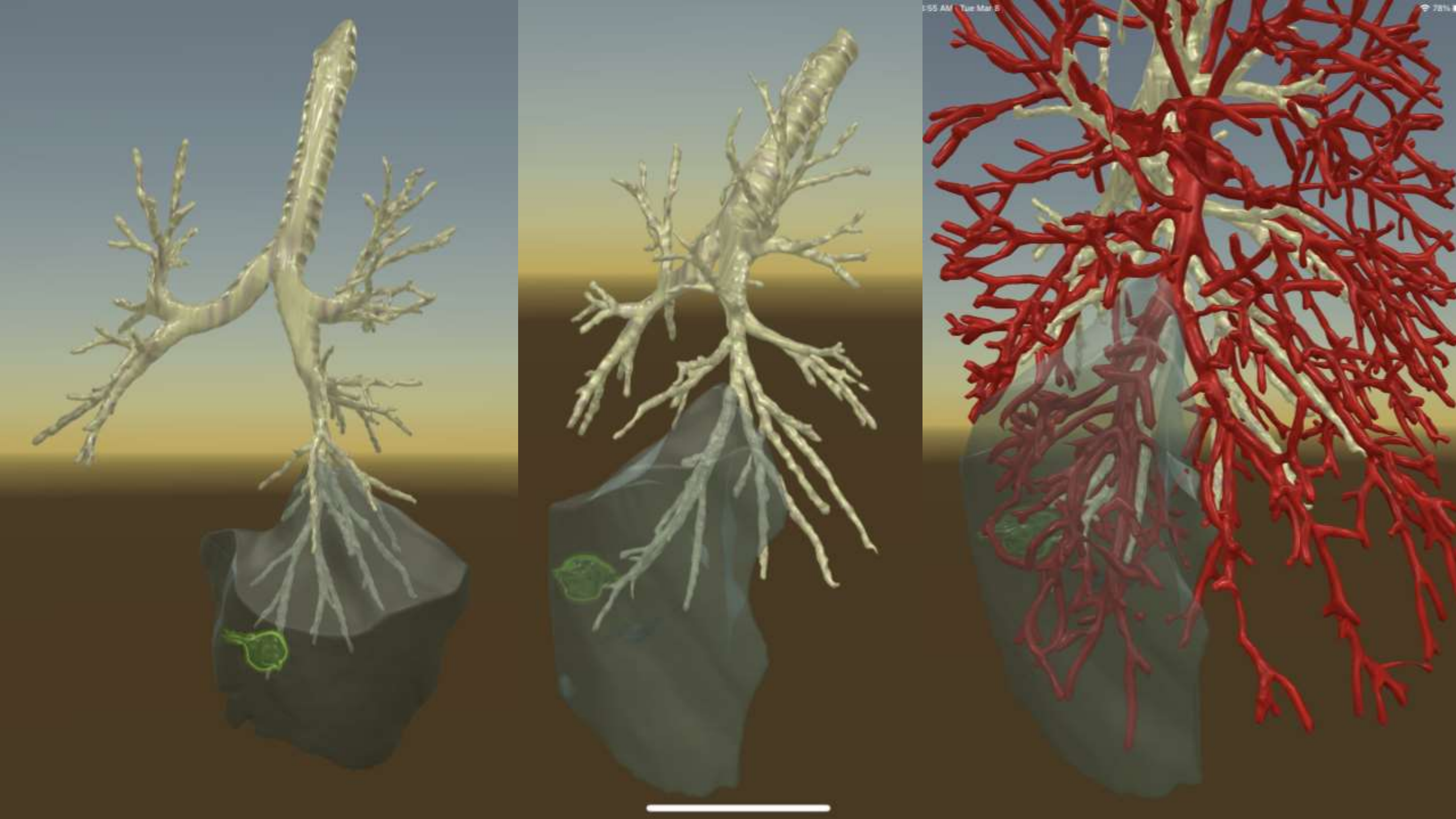
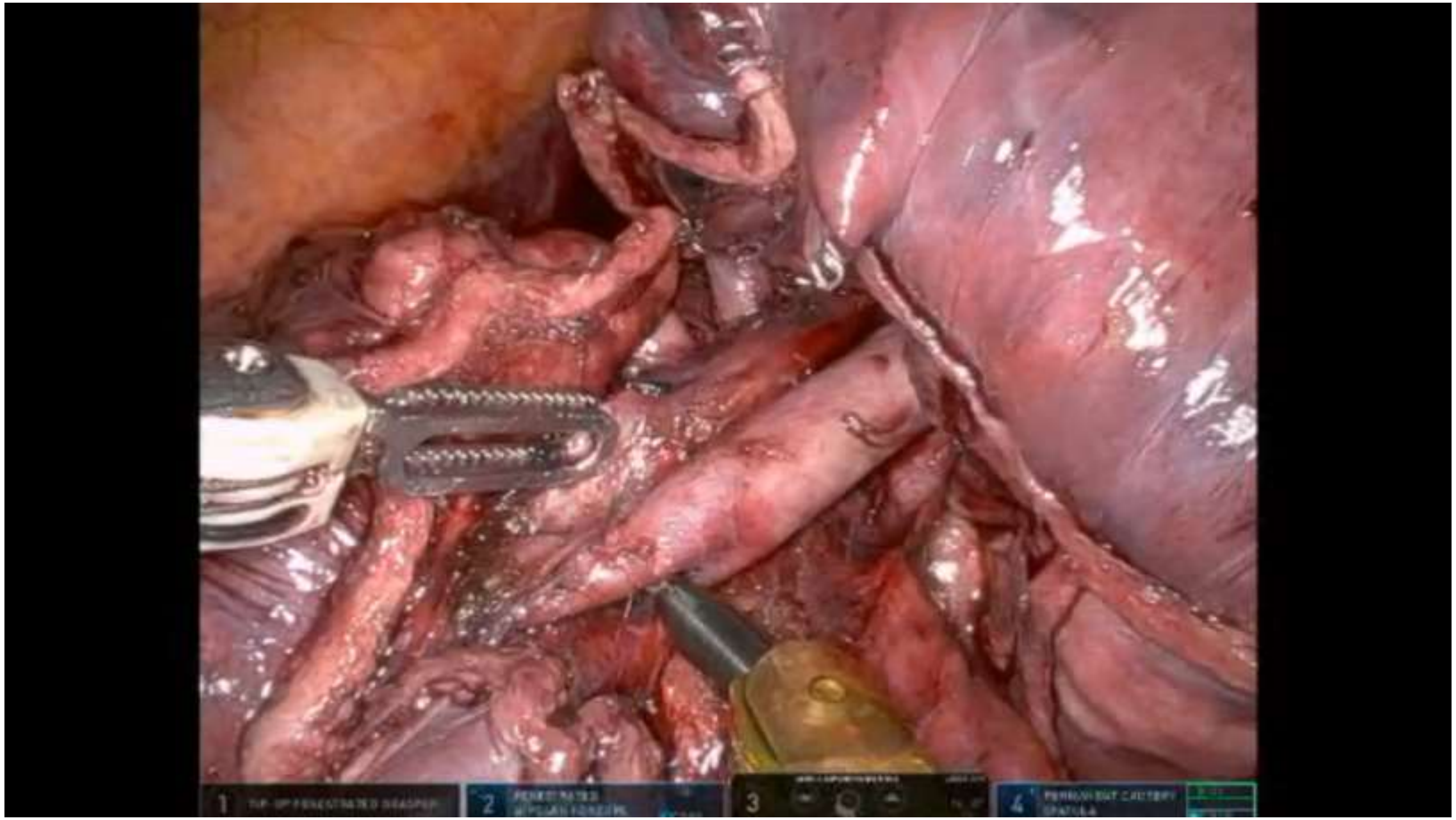


# Atypical Segmentectomy



# Locally-advanced lung cancer

- N2 disease s/p induction chemotherapy +/- radiation
- Node-positive disease
- T3 tumors
- Central tumors requiring sleeve resection

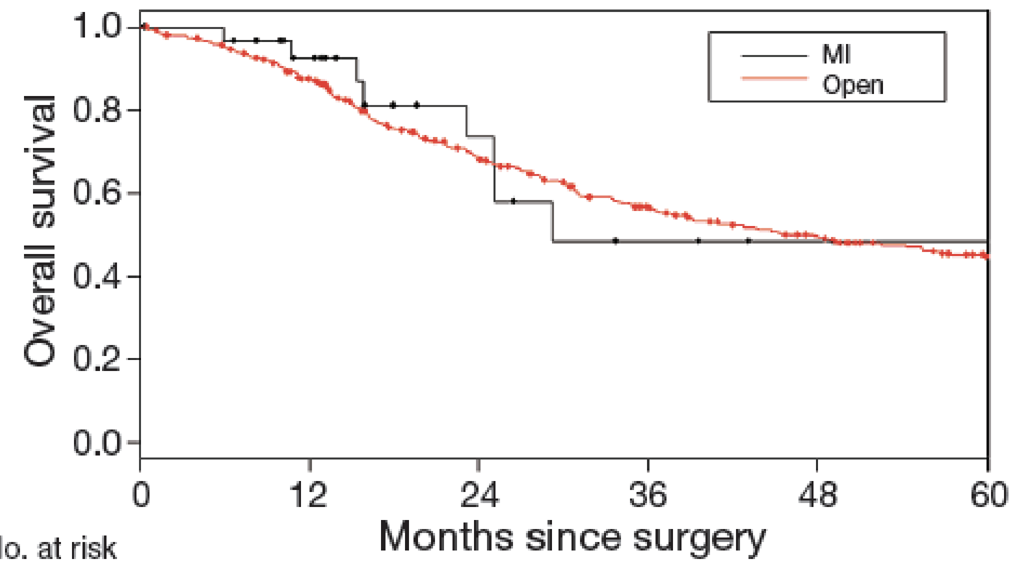
Original Article

## Minimally invasive (robotic assisted thoracic surgery and video-assisted thoracic surgery) lobectomy for the treatment of locally advanced non-small cell lung cancer

Bernard J. Park[1,2], Hao-Xian Yang[1,3], Kaitlin M. Woo[4], Camelia S. Sima[4]

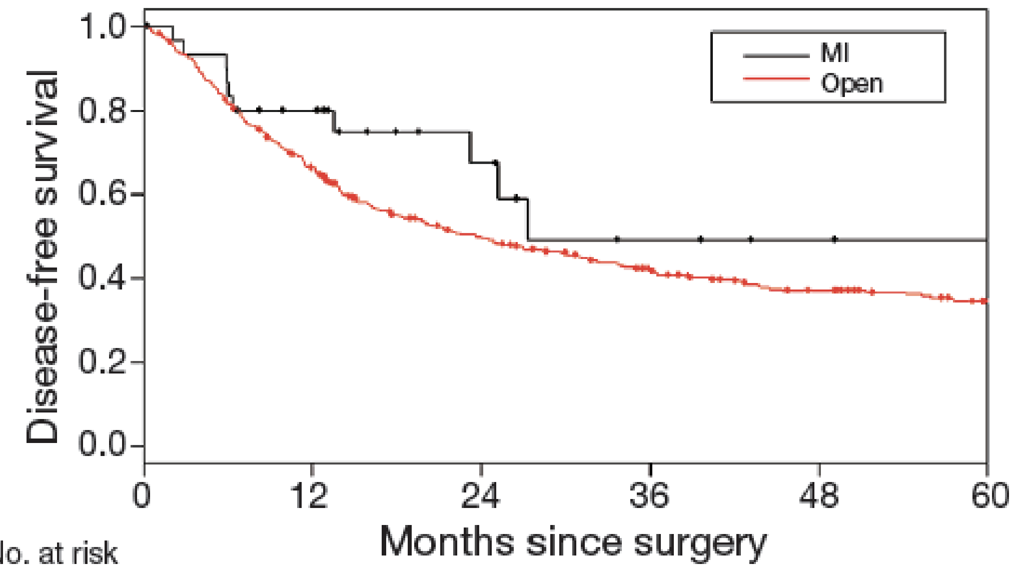
*J Thorac Dis* 2016;8(Suppl 4):S406-S413

- 428 patients at MSKCC with stage II or IIIA NSCLC undergoing induction therapy
  - 397 thoracotomy and 31 MIS for resection
    - MIS: 17 robotic and 14 VATS resections
  - 26% conversion rate in MIS group
  - Survival not different




| No. at risk | | | | | | |
|---|---|---|---|---|---|---|
| MI | 31 | 22 | 11 | 5 | 3 | 2 |
| Open | 397 | 329 | 227 | 170 | 135 | 105 |

**Figure 1** Kaplan-Meier curve for overall survival (P=0.84).




| No. at risk | | | | | | |
|---|---|---|---|---|---|---|
| MI | 31 | 20 | 10 | 5 | 3 | 2 |
| Open | 397 | 250 | 165 | 125 | 97 | 77 |

**Figure 2** Kaplan-Meier curve for disease-free survival (P=0.19).

LOS less in MIS group (4 vs 5 days)
More induction radiation in thoracotomy group

# New Indications?



## First series of minimally invasive, robot-assisted tracheobronchoplasty with mesh for severe tracheobronchomalacia



Richard Lazzaro, MD,[a] Byron Patton, MD,[a] Paul Lee, MD,[b] Jason Karp, MD,[c] Efstathia Mihelis, PA-C,[a] Sohrab Vatsia, MS,[a] and Samuel Jacob Scheinerman, MD[a]

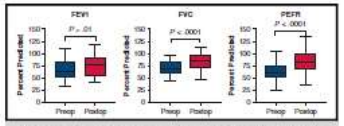
### ABSTRACT

**Objective:** Tracheobronchomalacia is a progressive, debilitating disease with limited treatment options. Open tracheobronchoplasty (TBP) is an accepted surgical option for management of severe tracheobronchomalacia. This study examined the outcomes of the first reported series of robot-assisted TBP (R-TBP).

**Methods:** We retrospectively reviewed the records of patients with clinical suspicion for tracheobronchomalacia who had dynamic computed tomography scan and subsequent R-TBP from May 2016 to December 2017.

**Results:** Four hundred thirty-five patients underwent dynamic computed tomography scan for suspicion of tracheobronchomalacia. Of this group, 42 patients underwent R-TBP. In the surgery group, the median age was 66 years (interquartile range, 39-72 years) and there were 30 women (71%). Respiratory comorbidities included asthma (88%) and chronic obstructive pulmonary disease (52%). The median operative time was 249 minutes (interquartile range, 266-277 minutes). Median hospital length of stay was 3 days (interquartile range, 2-4.75 days), and there were 19 postoperative complications (11 minor and 8 major). There were no mortalities at 90 days. Comparison of preoperative and postoperative pulmonary function testing demonstrated improvement in forced expiratory volume at 1 second by 13.5% ($P = .01$), forced vital capacity by 14.5% ($P < .0001$), and peak expiratory flow rate by 21.0% ($P < .0001$). Quality of life questionnaires also showed improvement with 82% reporting overall satisfaction with the procedure.

**Conclusions:** R-TBP can be performed with low morbidity and mortality. Early follow-up reveals significant improvement in pulmonary function testing and high patient satisfaction when compared with preoperative baseline. Long-term follow-up is needed to demonstrate the durability of R-TBP and substantiate its role in the management of patients with symptomatic, severe tracheobronchomalacia. (J Thorac Cardiovasc Surg 2019;157:791-800)




Improvement of pulmonary function tests following robot-assisted tracheobronchoplasty.

**Central Message**

Robotic tracheobronchoplasty for adult tracheobronchomalacia is safe; associated with significant improvement in FEV1, FVC, and PEFR; and can further the benefits of open tracheobronchoplasty.

**Perspective**

Robotic tracheobronchoplasty is safe and associated with early improvement in FEV1, FVC, and PEFR. The robot-assisted platform is ideal for the minimally invasive surgical approach to tracheobronchomalacia. The surgical procedure requires a standard approach to dissection that can be taught and learned by a wide breadth of thoracic surgeons. The robotic platform is ideal to further the adoption of surgical treatment of tracheobronchomalacia in adults.

See Editorial Commentary page 801.

Note: da Vinci surgery is not currently FDA cleared for tracheobronchoplasty at this time.

# New Indications?

Surgical Technique

## Subxiphoid or subcostal uniportal robotic-assisted surgery: early experimental experience

**Diego Gonzalez-Rivas**[1,2,3], **Mahmoud Ismail**[3]

[1]Department of Thoracic Surgery, Shanghai Pulmonary Hospital, Tongji University School of Medicine, Shanghai 200433, China; [2]Department of Thoracic Surgery, Coruña University Hospital and Minimally Invasive Thoracic Surgery Unit (UCTMI), Coruña, Spain; [3]Department of Thoracic Surgery, Klinikum Ernst von Bergmann Potsdam, Academic Hospital of the Charité – Universitätsmedizin Humboldt University Berlin, Berlin, Germany

*Correspondence to:* Diego Gonzalez-Rivas. Department of Thoracic Surgery, Coruña University Hospital and Minimally Invasive Thoracic Surgery Unit (UCTMI), Coruña, Spain. Email: diego.gonzalez.rivas@sergas.es.

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doi: 10.21037/jtd.2018.12.94
**View this article at:** http://dx.doi.org/10.21037/jtd.2018.12.94

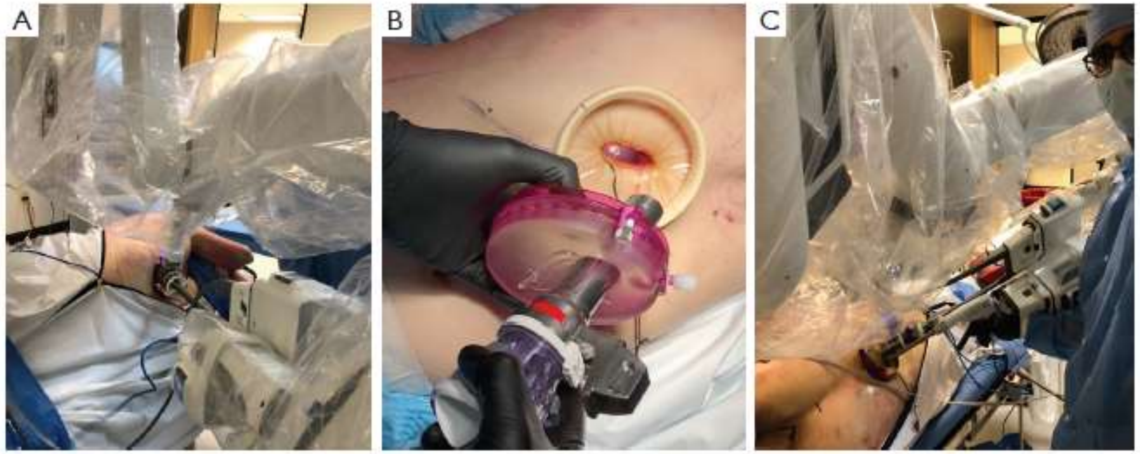
### Introduction

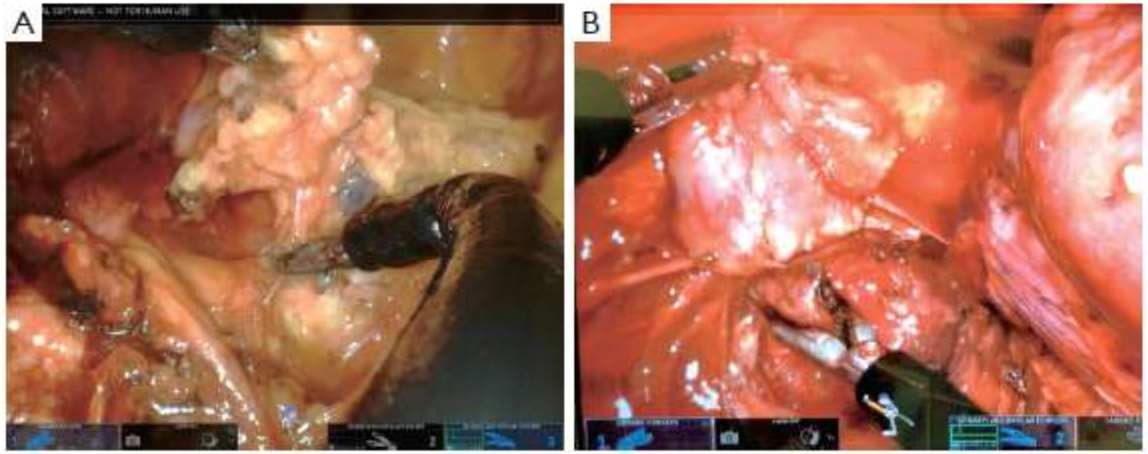
During the past several years minimally invasive thoracic surgery has evolved from thoracoscopic approaches using 3–4 ports to a single incision video-assisted thoracoscopic surgery (VATS) techniques (1-3). Recently, the experience acquired with the uniportal VATS technique through the intercostal space has allowed the development of use of a uniportal VATS subxiphoid or subcostal approach for major pulmonary resections (4,5). The advantage of using a subxiphoid or subcostal entry is to reduce pain by avoiding possible trauma of intercostal nerves caused by thoracic incisions. However, the longer distance from the subxiphoid or subcostal incision to the hilum makes this approach more difficult to perform major pulmonary resections. Nevertheless, in expert hands this technique allows the possibility to perform complex resections (6), lymph node dissection (7) and anatomic segmentectomies (8).

During this same period of evolution into uniportal VATS surgery, robotic thoracic surgery has gained popularity as an alternative to traditional VATS. In some areas of the world such as the United States, robotic multiport thoracic surgery trends—uniportal surgery and robotic-assisted surgery—and has resulted in a single port robotic system, the da Vinci SP by Intuitive Surgical (Sunnyvale, California, USA). The single port (SP) platform is notable for a single 2.5 cm cannula through which an articulating 3D camera and 3 fully articulating instruments with 7 degrees of freedom can be passed. With its commercial introduction, we became interested in developing a robotic uniportal thoracic application by conducting experimental cadaver labs in the research setting. As of this writing (December 2018) the da Vinci SP has Food and Drug Administration (FDA) clearance in the US for urological procedures only, and the contents of this chapter are based on cadavers.

### Overview of the da Vinci SP system

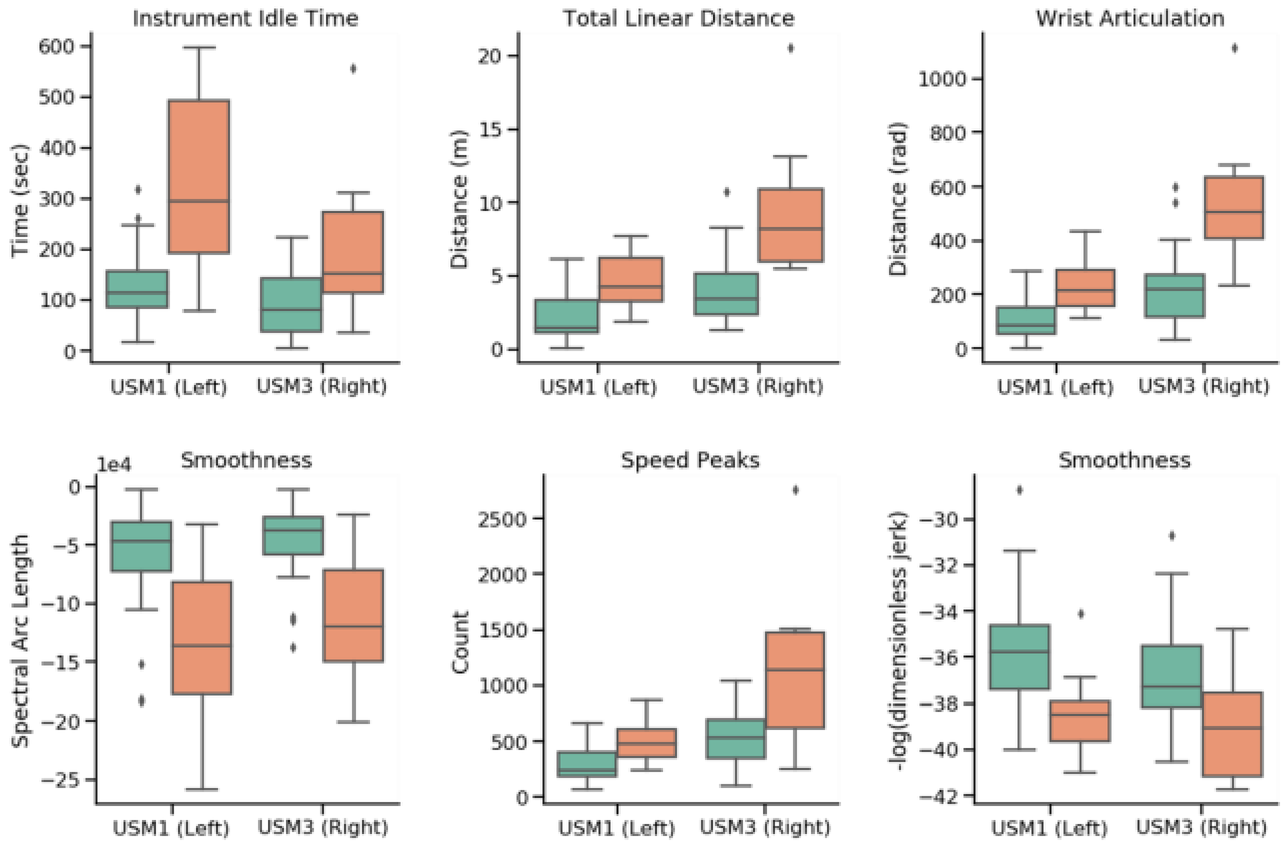
Like the conventional multiportal da Vinci Xi or X robotic platform, the SP system includes a free-standing surgeon console, a vision cart, and the patient side cart that consists of a single arm that controls up to 3 wristed instruments




Note: da Vinci SP is FDA cleared only for urological and certain transoral procedures at this time.

# New Training Data: Intuitive Data Recorder (IDR) Research: Kinematic activity of residents who caused bleeding vs. no bleeding are different




Lazar, Oh, D'Souza, Nesbit, Feins, Sancheti, Lin, Yang, et al AATS 2021 – Oral Presentation, Manuscript Submitted

# Stapler technology

## Pillars of SureForm staplers

### Complete surgeon control

The positioning, gripping, and firing of SureForm™ staplers is completely controlled by you from the surgeon console.

You don't have to rely on your assistant during the crucial moment of firing the stapler.

SureForm staplers are compatible with the da Vinci X® and da Vinci Xi® surgical systems.

### More maneuverability

A 120° cone of articulation gives you the freedom to maneuver your stapler and position it where you prefer.

With a SureForm stapler in your toolkit, you can operate with a greater range of motion than the human hand or leading laparoscopic staplers.*


### More intelligence

1,000+ measurements per second**, with one press of a pedal.

SmartFire technology monitors tissue compression before and during firing, making automatic adjustments to the firing process as staples are being formed and as the transection is being made.

This helps you ensure a consistent staple line, while preventing tissue damage across a range of tissue thicknesses.**

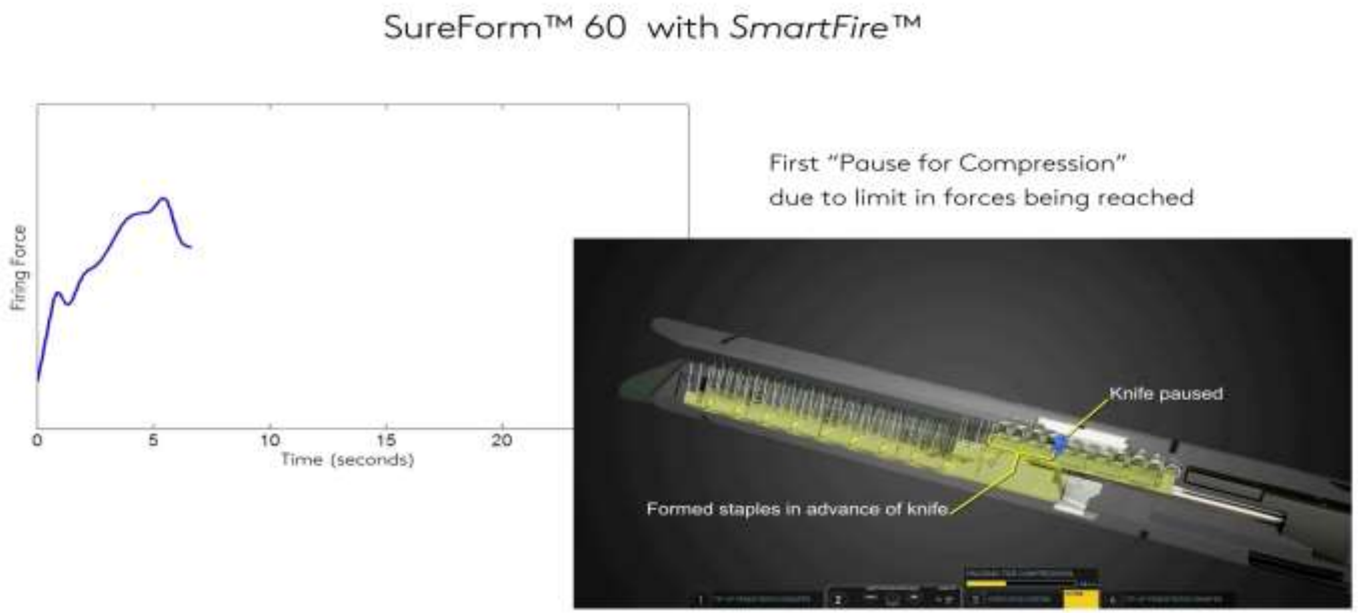
# Stapler technology

## Pausing for compression

During the firing cycle if additional compression is required, the system pauses, displays the “Pausing For Compression” message and plays audio feedback.

Once the appropriate compression is gained on the target tissue, the system resumes firing.

Additional pauses can happen during a single firing cycle as SmartFire continuously monitors the appropriate variables that influence staple line formation.



# 8 mm SureForm 30 Curved-Tip Stapler

Enhances access and visibility in narrow spaces of target anatomy

Enables stapler to port hop between 8 mm and 12 mm Stapler cannula

Facilitates easier placement of stapler on targeted tissue

## Indicated Specialties

General, Thoracic, Gynecologic, Urologic and Pediatric surgery

.
8 mm SureForm 30 is 510(k) cleared. It is not for sale in the U.S yet. 8 mm SureForm 30 is not CE Marked, and cannot be placed on the market or put into service

120° of articulation

- 8 mm Shaft and Jaws
- Anvil Centric
- Curved-Tip
- Fits through an 8 mm cannula
- Single Patient Use (Disposable)

**Reload (4 rows of staples)**

# • Ion by Intuitive

- Ion™ is a new robotic platform for minimally invasive biopsy in the peripheral lung.

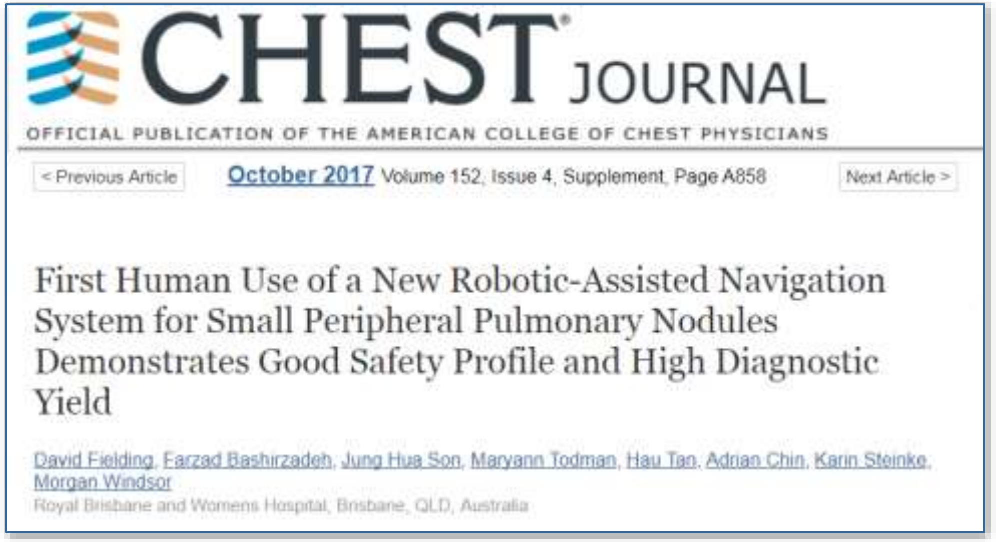
# Ion Robotic Bronchoscopy System

- 3.5mm outer diameter
  - 2mm inner diameter for need and 3rd party instruments
- Fully articulating catheter with 180-degree bend
- Fiber optic shape sensing technology
  - 7 fiber optic cables in the catheter measuring at 200 microns
  - Catheter holds shape and stability
  - No electro-magnetics
- Proprietary flexible needle to articulate tight corners.
- Not an EMB system.  No need to map out room.
  - Unlike Super D, Veran and Auris - Ion does not use electro-magnetics.
- PlanPoint software is proprietary.  Not licensed out by another company.

# Investigational Study*
# Presented at the 2017 CHEST Annual Meeting

## Study Design

| | |
|---|---|
| **Primary Endpoints** | **Feasibility**<br>Facilitate sampling of SPNs ≥10 mm to <30 mm in largest diameter<br>**Safety**<br>Pneumothorax and excessive bleeding |
| **Sample Size** | 30 patients |
| **Follow-up** | Up to 6 months |


CHEST JOURNAL

OFFICIAL PUBLICATION OF THE AMERICAN COLLEGE OF CHEST PHYSICIANS

< Previous Article | October 2017 Volume 152, Issue 4, Supplement, Page A858 | Next Article >

First Human Use of a New Robotic-Assisted Navigation System for Small Peripheral Pulmonary Nodules Demonstrates Good Safety Profile and High Diagnostic Yield

David Fielding, Farzad Bashirzadeh, Jung Hua Son, Maryann Todman, Hau Tan, Adrian Chin, Karin Steinke, Morgan Windsor

Royal Brisbane and Womens Hospital, Brisbane, QLD, Australia

# Study Results

## Nodule Demographics

### Nodule Location

- **7th ± 1.5** Generation
- 66.7% UL's
- 10% RML
- 23.3% LL's

### Nodule Size

- **Largest Oblique ⌀: 14.8 mm**
  [R: 10 - 26.4mm]
- **Largest Cardinal ⌀: 12.3 mm**
  [R: 4.5 – 26.4mm]

## Primary End Points:

### Feasibility and Safety

**97%** Feasibility

**0%** Pneumothorax or Excessive Bleeding

## Subject and Sample Results:

### Clinical Diagnosis through 6 month F/U

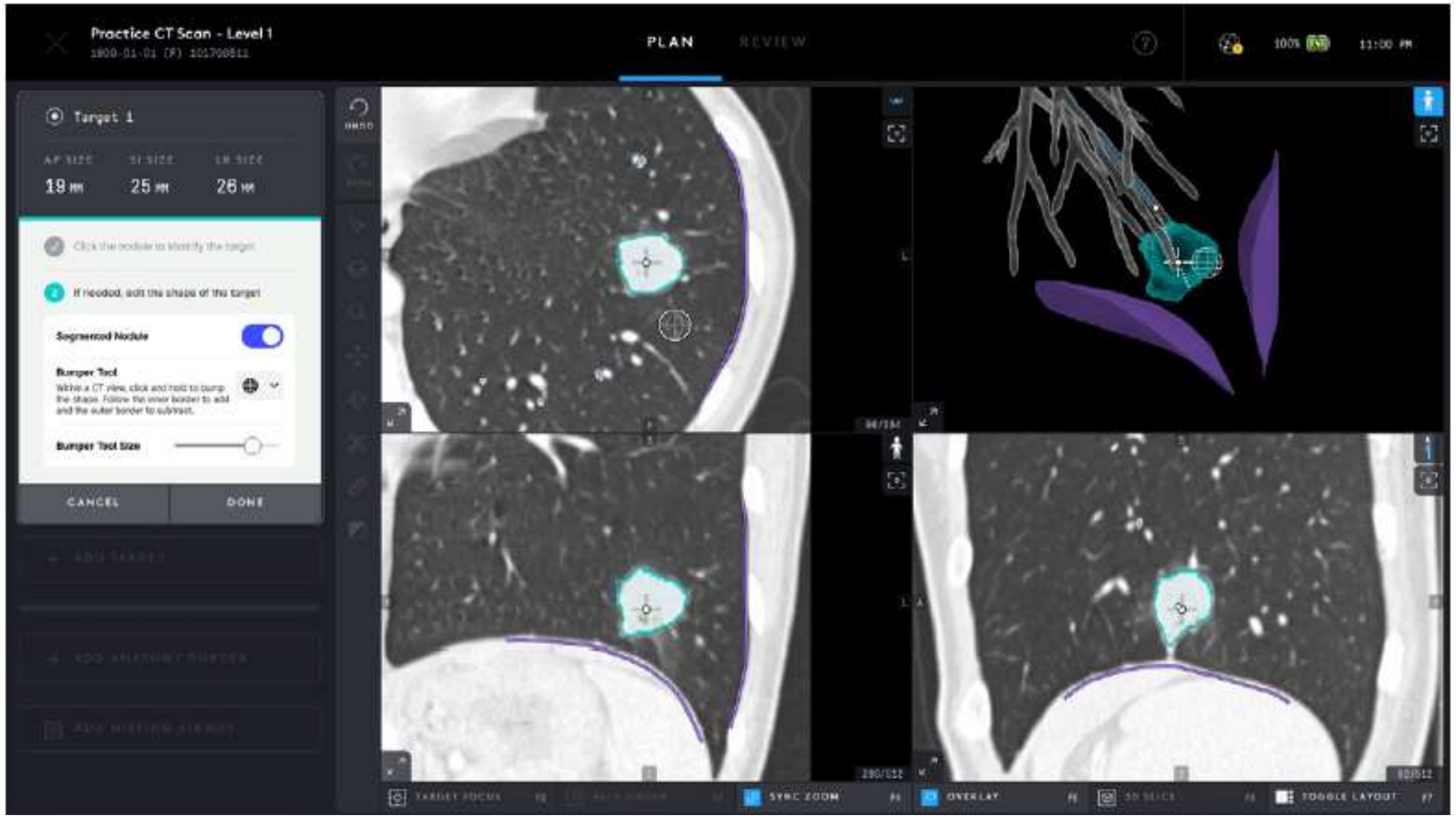
**80%** Diagnostic Yield – System Sample

**89%** Diagnostic Yield - Malignancy

# PlanPoint 2.2: Nodule segmentation and biopsy point adjustment

PlanPoint 2.2 automatically segments the shape of the nodule and includes editing capability to support customization.[1]

Now the user can edit the virtual nodule shape in an individual CT slide resolution and change the biopsy point from the center of the lesion to any point.[1]

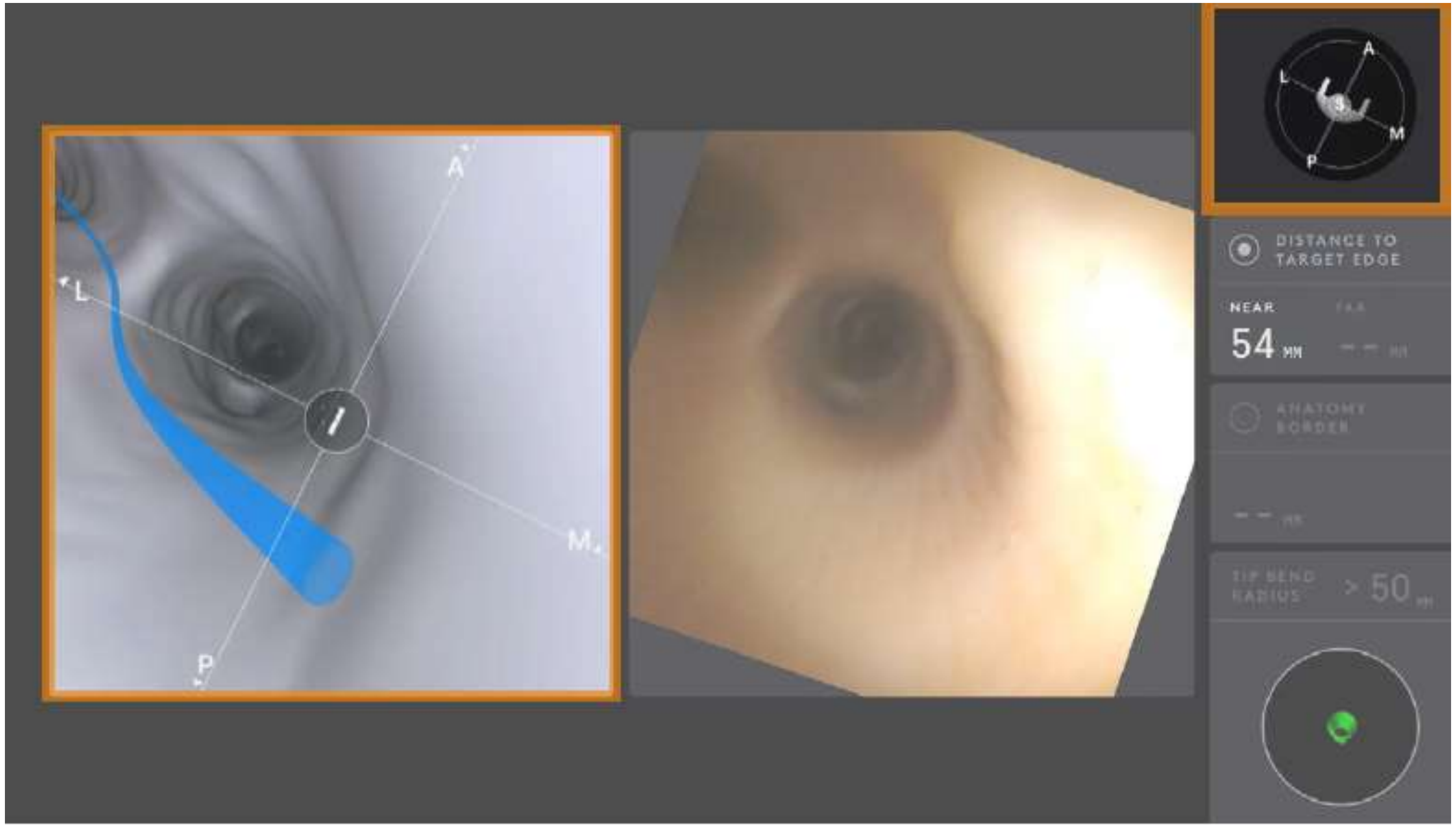


# P3b system software: The Ion endoluminal compass

The Ion endoluminal compass enables easier catheter articulations.[1]

It displays anatomical indicators of the catheter's direction within the Navigation View in real time.

The compass translates the direction of the catheter to anatomical directions on the screen in real time. This provides additional guidance to the physician.

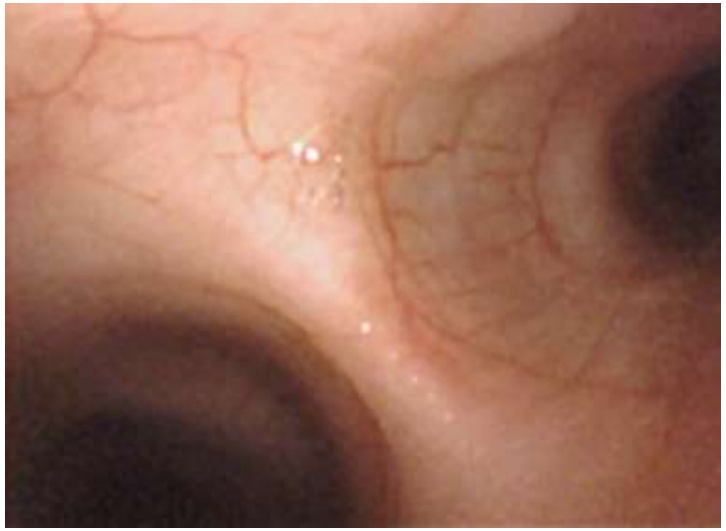


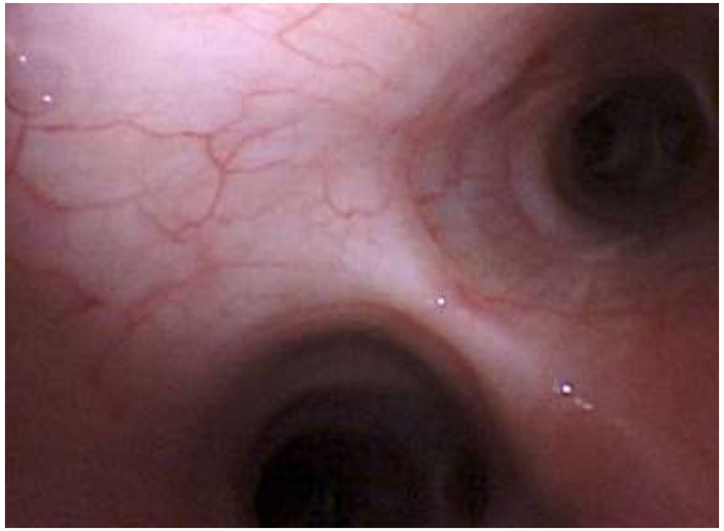
# New vision probe[1] (PN 490206): Enhanced vision and usability

Wider field of view for navigation.[2]

Sharper videoscopic image for anatomy identification.[2]

User-friendly design for easier installation and removal.[2]





**Current vision probe (490106)[3]**

90-degree field of view

**New vision probe (490206)**

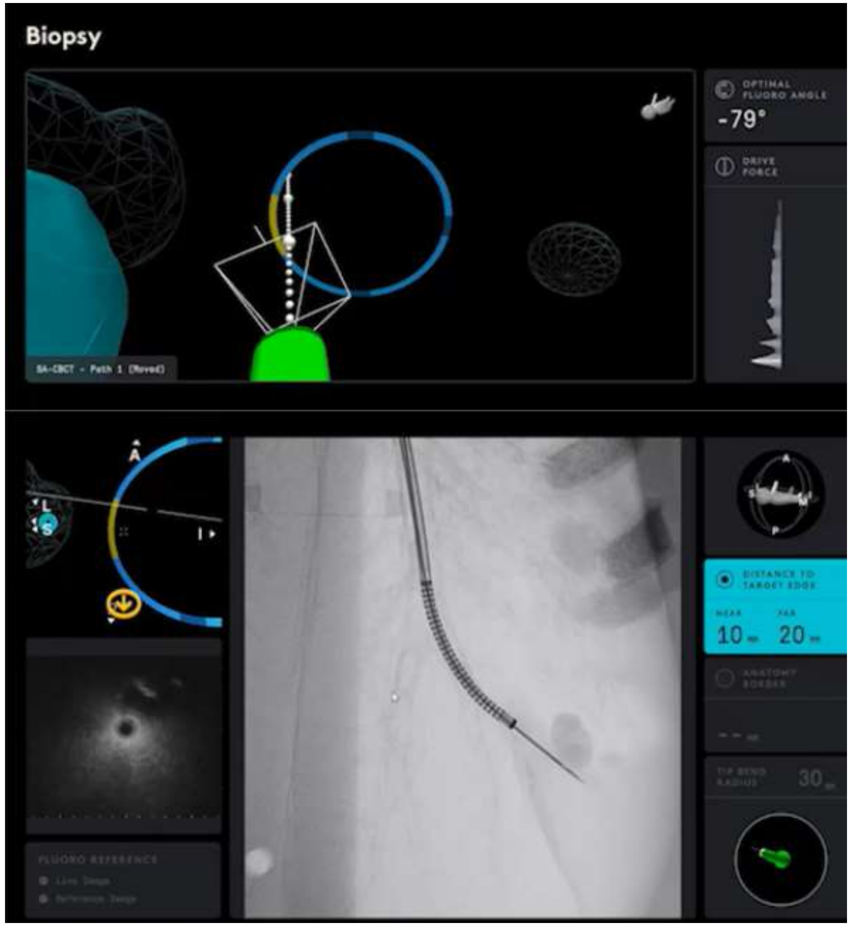
120-degree field of view[4]

Sharper videoscopic image with 2x better image quality.[4]

# P3b system software: Articulation guide

The articulation guide for Radial EBUS localization is designed to streamline the target localization process.[1]

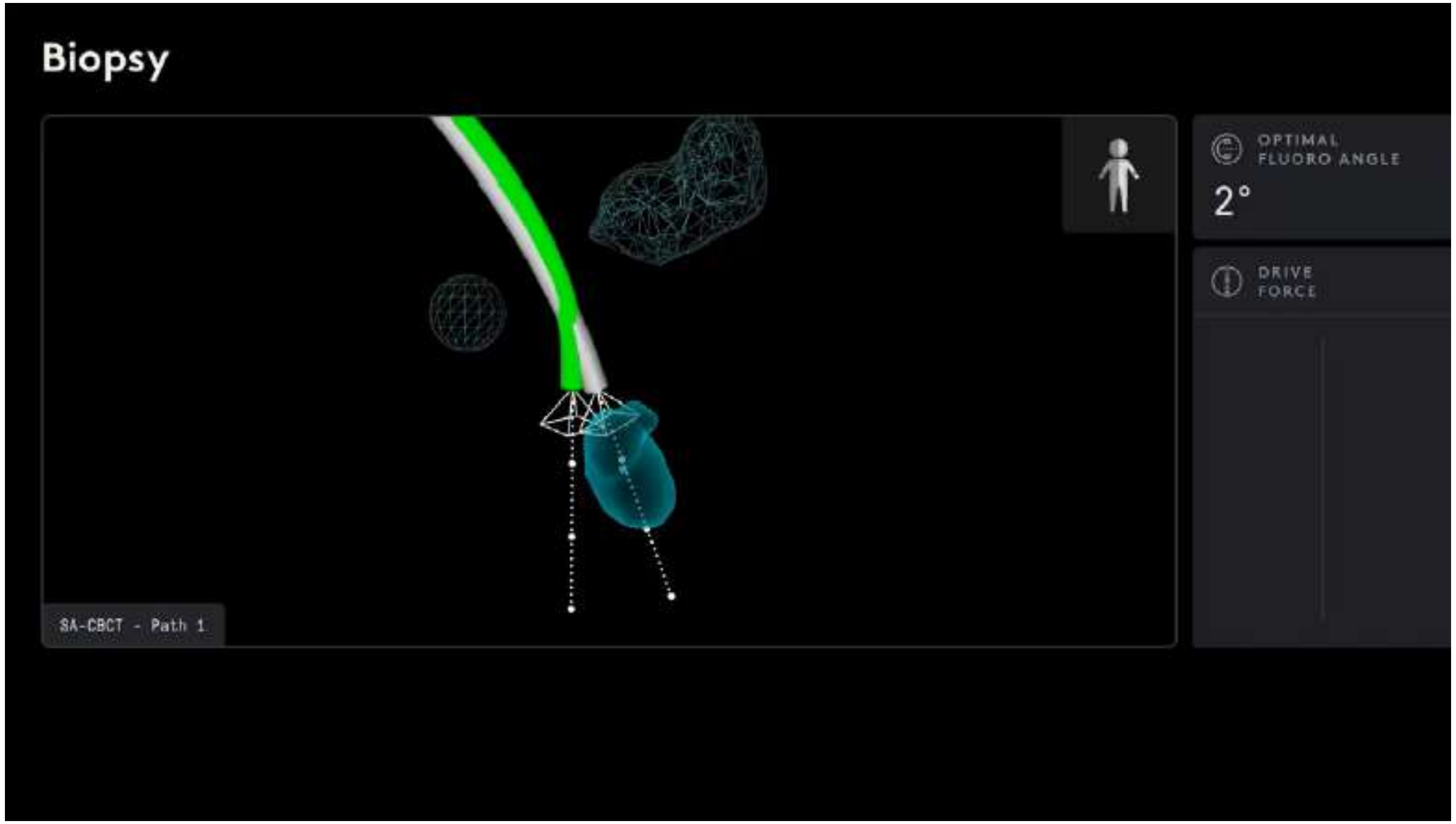
The guide visualizes the airway using a virtual ring, providing orientation guidance and allows the user to mark the spot where the strongest signal was detected by the R-EBUS probe.



# P3b system software: Catheter reference

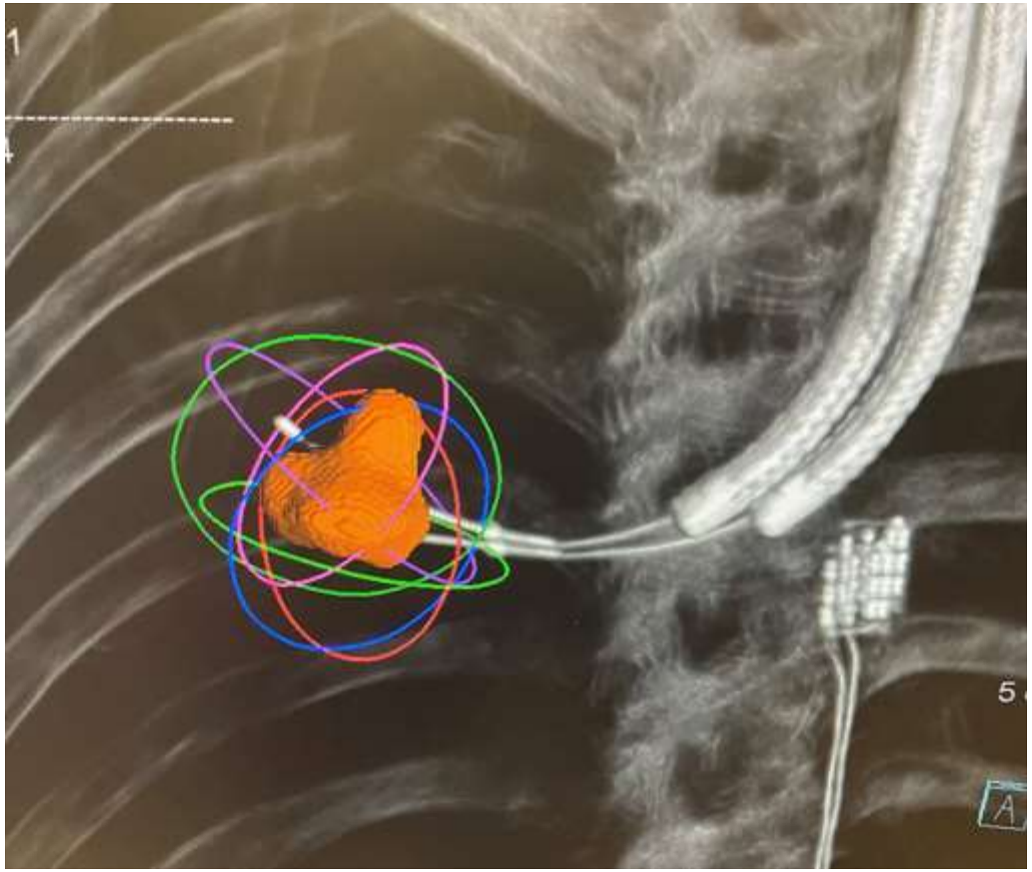
The catheter reference feature marks the current catheter position in the three-dimensional biopsy view (gray catheter).[1]

This acts as a reference to help the user with catheter adjustments or articulations.



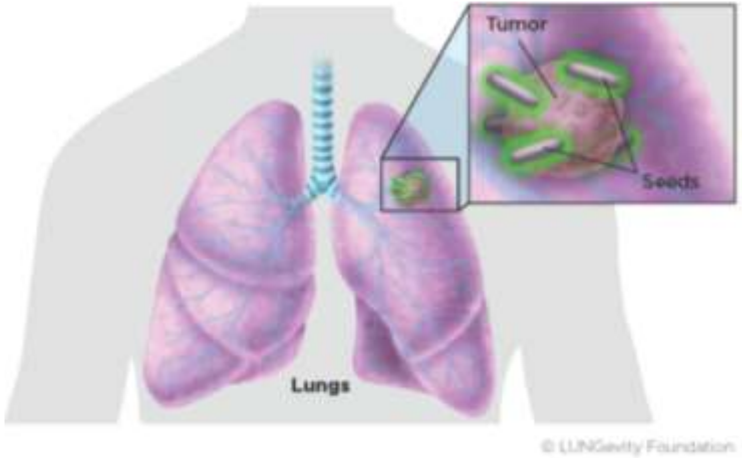
# Potential Ion-based lung cancer therapy

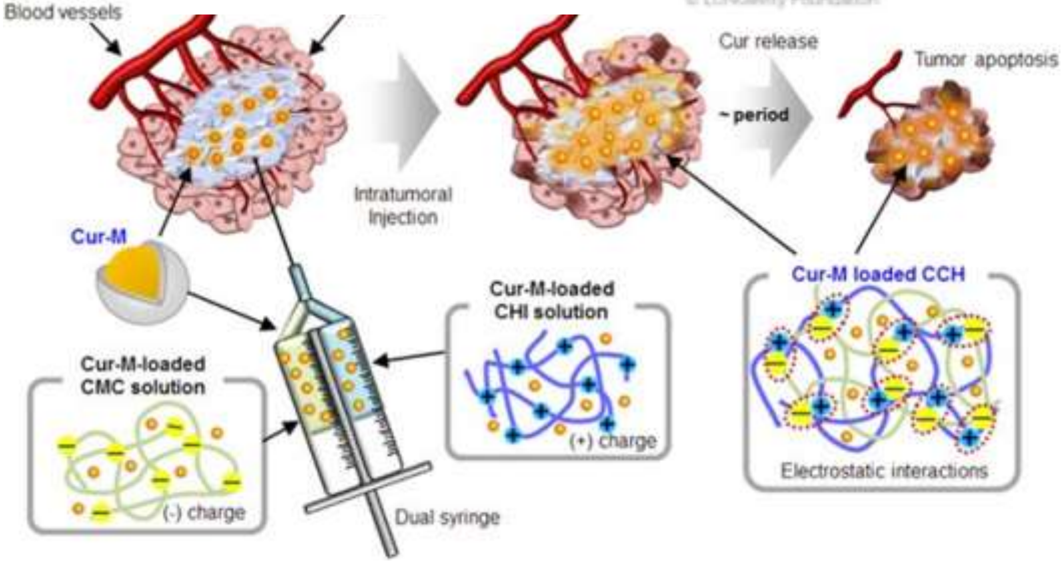
## Ablation



Endoluminal ablation with navigational bronchoscopy by Dr Calvin Ng, Prince of Wales Hospital, Hong Kong

## Intra-tumoral Therapy




Intratumoral injection schema. Park SH et al NPG Asia Materials 2017

Note: These therapies are not cleared by FDA at this time and are investigational research only

# System dashboard: Provides a detailed view of the user’s system utilization and procedure data*

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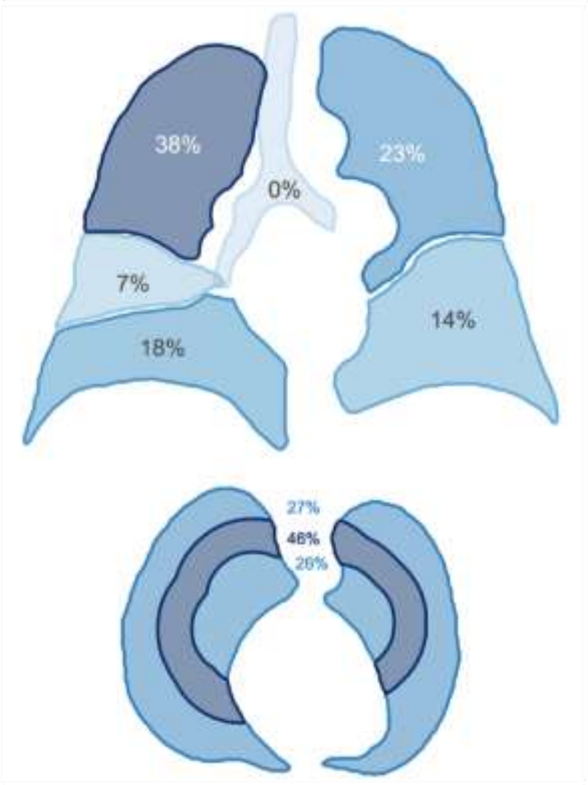


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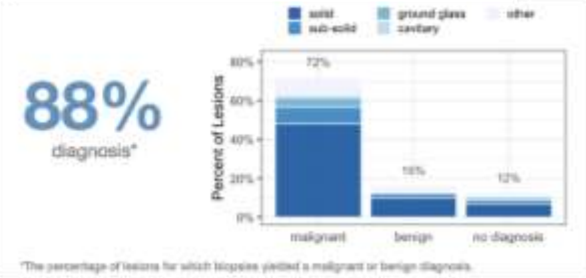


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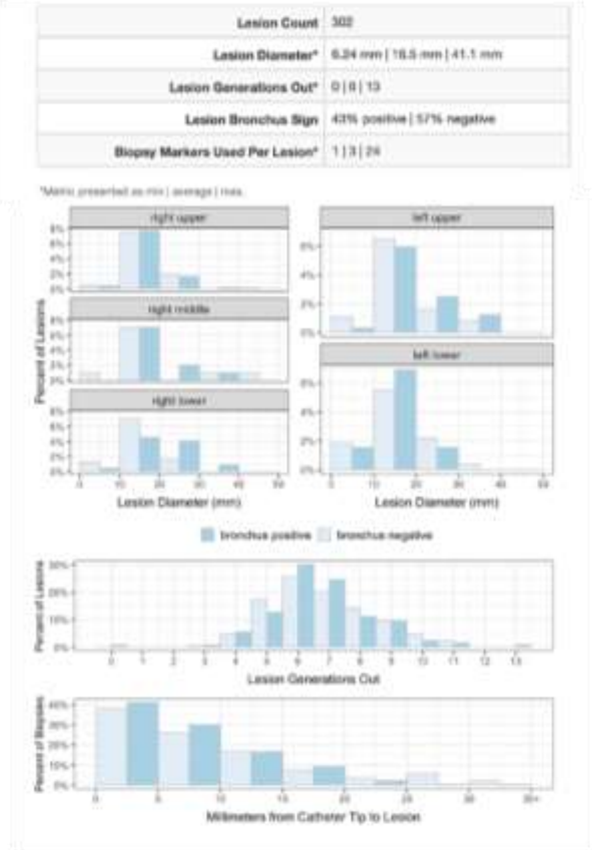



* This data is an example and is for illustration purposes only, not intended to reflect actual data, including results and sample sizes.

Home ›

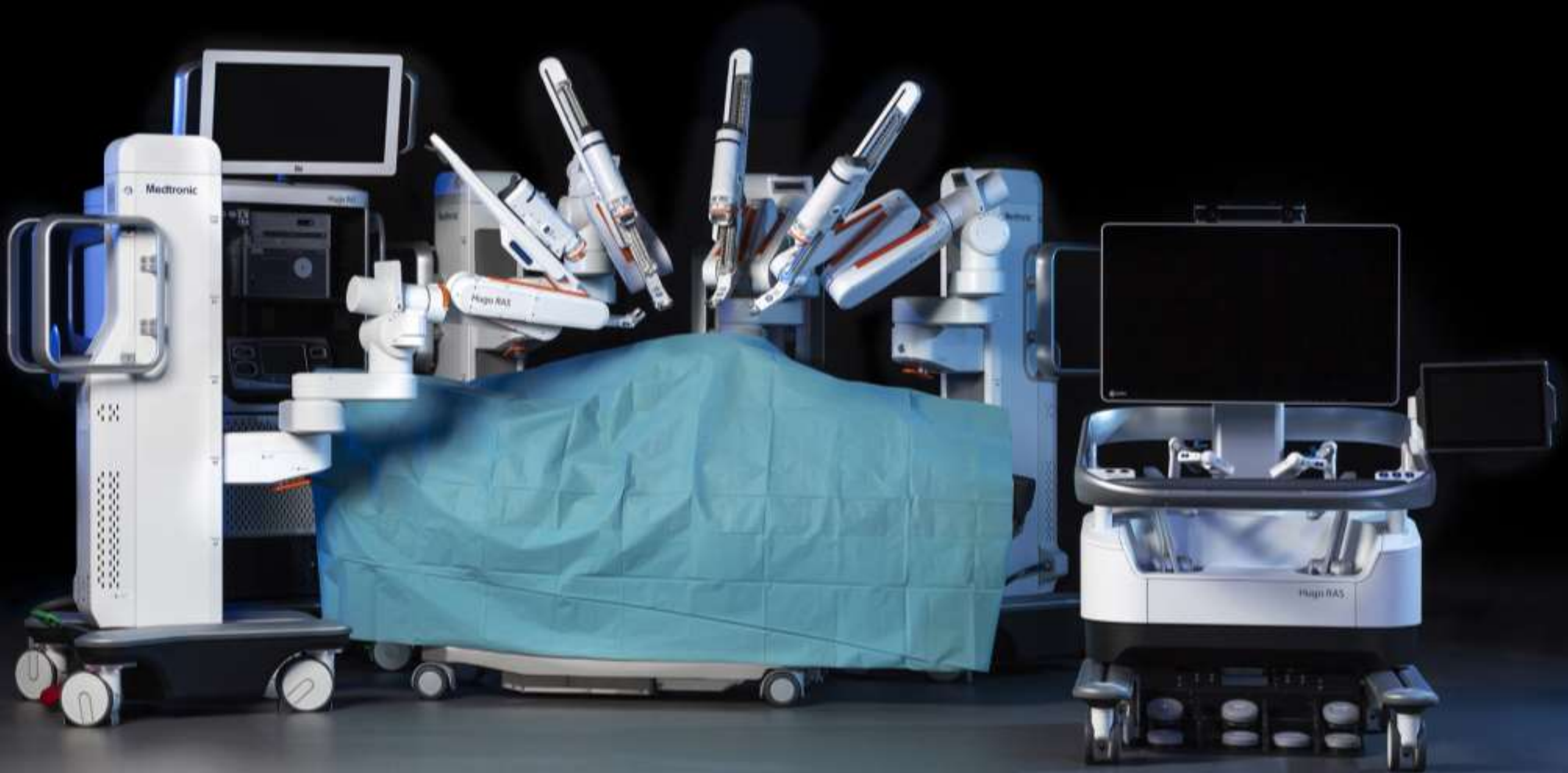
# Auris/Monarch (Ethicon/J&J)




# New Surgical Systems?

- Medtronic Hugo
  - Modular system (each arm will roll in separately)
  - Promises similar cost to laparoscopy
- Google/Johnson&Johnson
  - Arms attached to the system
  - Promises better big data

# HUGO™ RAS




Investigational device currently under development. Not cleared or approved for sale in U.S. or any market.

# Key features

- Modularity
- Universal use
- Upgradable
- Flexible
- Open

# ROBOTIC ARMS

## MODULARITY FOR ACCESS

**Adjustable height** facilitates preferred access to anatomy while **eight degrees of freedom** for instruments delivers dexterity to reach anatomical targets

## MODULARITY FOR MOBILITY

**Easily moved between ORs** for use in another case, or to free up space


## MODULARITY FOR SPEED

Quick collapse supports **shorter setup** and take down times

## MODULARITY FOR CHOICE

From the number of arms in use during a case to positioning around the patient

# Universal use

The system supports:

- RAS and laparoscopic surgery
- The generator support open surgery devices

# Tower

The Hugo™ vision cart houses components that interface between the robotic console and arm carts — and serves as a standalone laparoscopic solution

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KARL STORZ IMAGE 1 S™* **3D system HD**

## Touch Surgery™ enterprise

A powerful tool for training, performance measurement, and procedural efficiency, DS1 computer are an **easy-to-use surgical video recording, storage, and analytics platform**


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Valleylab™ FT10 energy platform delivers consistent performance across all our energy-based devices

# Surgeon Console

- 3D HD vision- upgradable
- EASY-GRIP CONTROLLERS: Allows you to control instruments at a variety  of scales
- Ergonomic: customizable settings  for each surgeon


# Summary

- 3D vision and wristed instruments are helpful and facilitate more precise surgery
- Haptics and proximity to the patient would be nice