

Development of a Thoracic Robotic Program for Lung Cancer Surgery

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Disclosures

- Intuitive Surgical - Education

Overview

- Robotic History
- Robotic Lobectomy Outcomes Data
- Robotic Financials
- Successful Program Development

Robotic history and an old Grand Rounds presentation...

2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ



Robotic Surgery: A Technology Looking For An Application?

William B. Tisol, MD
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2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Brief History of Surgical Robots

- 1985 – Puma 560 used by Kwoh et al for neurosurgical biopsies
- 1988 – PROBOT for prostate resection



2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Brief History of Surgical Robots

- Late 80's – NASA and DOD begin work on telepresence surgery



- Early 90's - Stanford Research Institute develops dexterous telemanipulator



2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Brief History of Surgical Robots

- 1998 – ZEUS surgical robot system
- 1999 – da Vinci surgical robot system



2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Failed application of proven technology...



- October 14, 1947, Bell X-1 accelerated to a speed of Mach 1.06
- 24 October 2003 British Airways operates last commercial services

2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Proven technology failing to meet expectations...



2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

Applied technology for a price...



Following a 1 ½ day pig lab in Hackensack, NJ

The image is a composite of three photographs. The top-left photo shows a hand holding a black Starfleet communicator against a dark, textured background. The bottom-left photo shows a man in a Star Trek uniform (William Shatner) holding a communicator to his mouth. The right side of the image is dominated by a large, detailed photograph of the original Starfleet communicator. It is a black, rectangular device with a silver-colored metal flip-screen at the top, which is open, revealing a grid of small, square, gold-colored lenses. Below the screen is a circular silver-colored dial with a black face and a small black knob in the center. Underneath the dial are three small, round, colored buttons (yellow, red, and green). At the bottom of the device is a silver-colored rectangular plate with a small speaker grille on the left and two small, round, silver-colored buttons on the right.



2006 Grand Rounds...

Following a 1 ½ day pig lab in Hackensack, NJ

What will the surgical robot become?



Why I became a robotic thoracic surgeon

2006...

- **I wanted to evaluate and understand the technology for myself**
 - How does this work in my practice
 - Already believed in the benefits of MIS/VATS
- Improved instrument motion
 - 6 Degrees of “wristed” motion versus “sticks”
- 3D optics and 10x magnification
 - Steady and always positioned where you want it
- Improved ergonomics
 - No more “looking over your shoulder”
- Benefits not fully realized until I gained robotic proficiency
 - Need to accept a learning curve

Evolution of Robotic Thoracic Surgery

2006

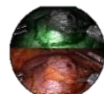


da Vinci® S™

2009



da Vinci® Si™



FIREFLY™

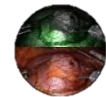


ADVANCED
INSTRUMENTS

2014



da Vinci® Xi™



FIREFLY™



INTEGRATED
ENERGY

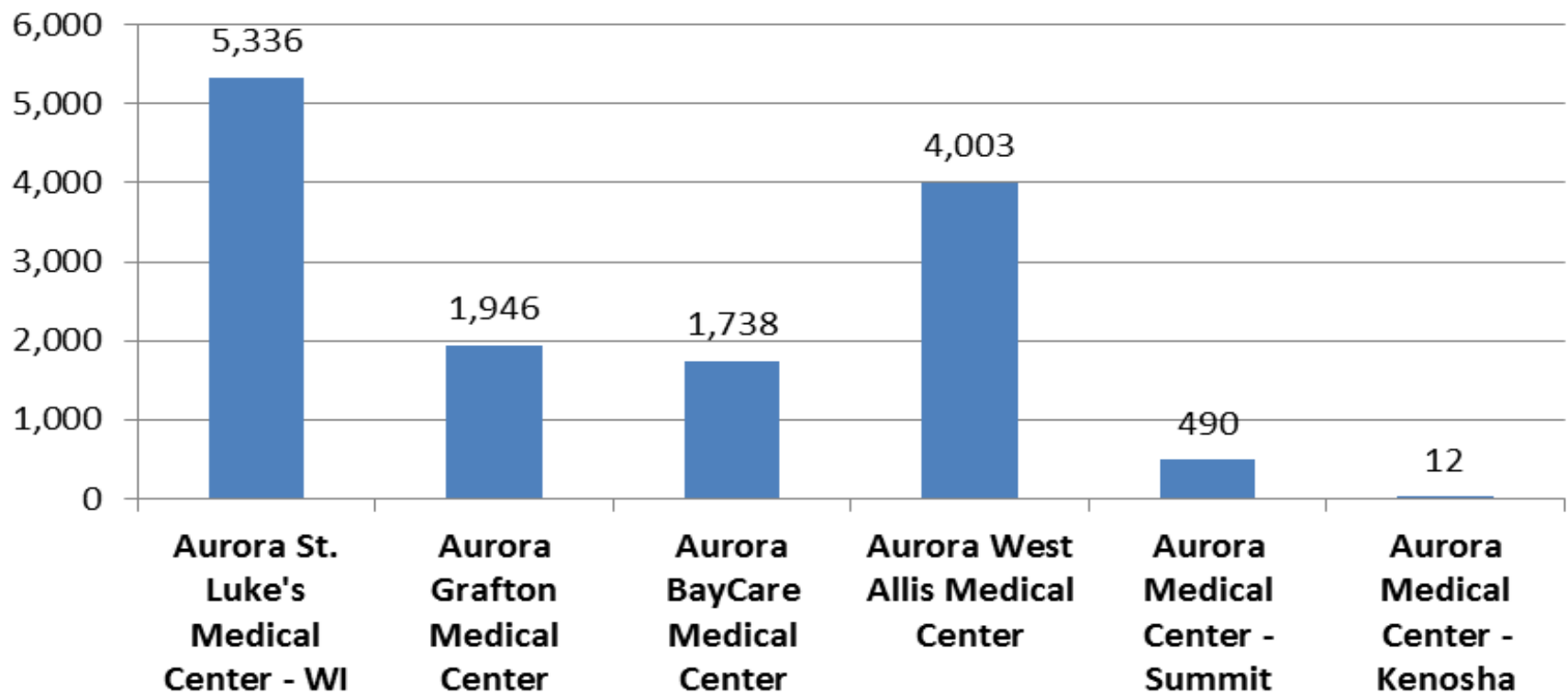


STAPLER

Aurora Healthcare Robotic Production

17,146 All time cases completed from 2001 through 2017

Aurora All Time Case Total Through 2016



Aurora System 3 Year Robotic Volume Trends

7 Robotic Programs

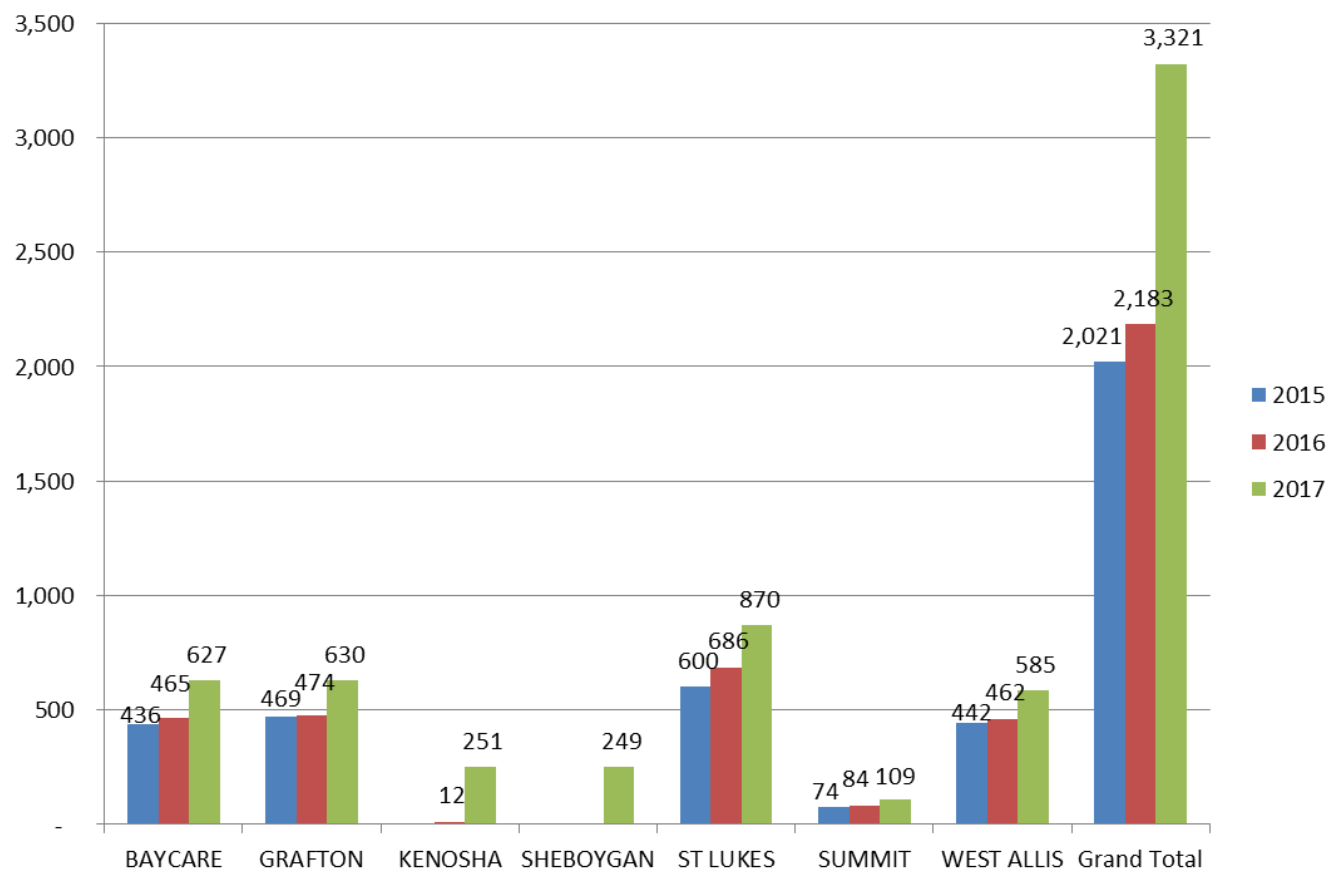
- 3321 cases 2017
- 52% increase from 2016

13 daVinci Systems

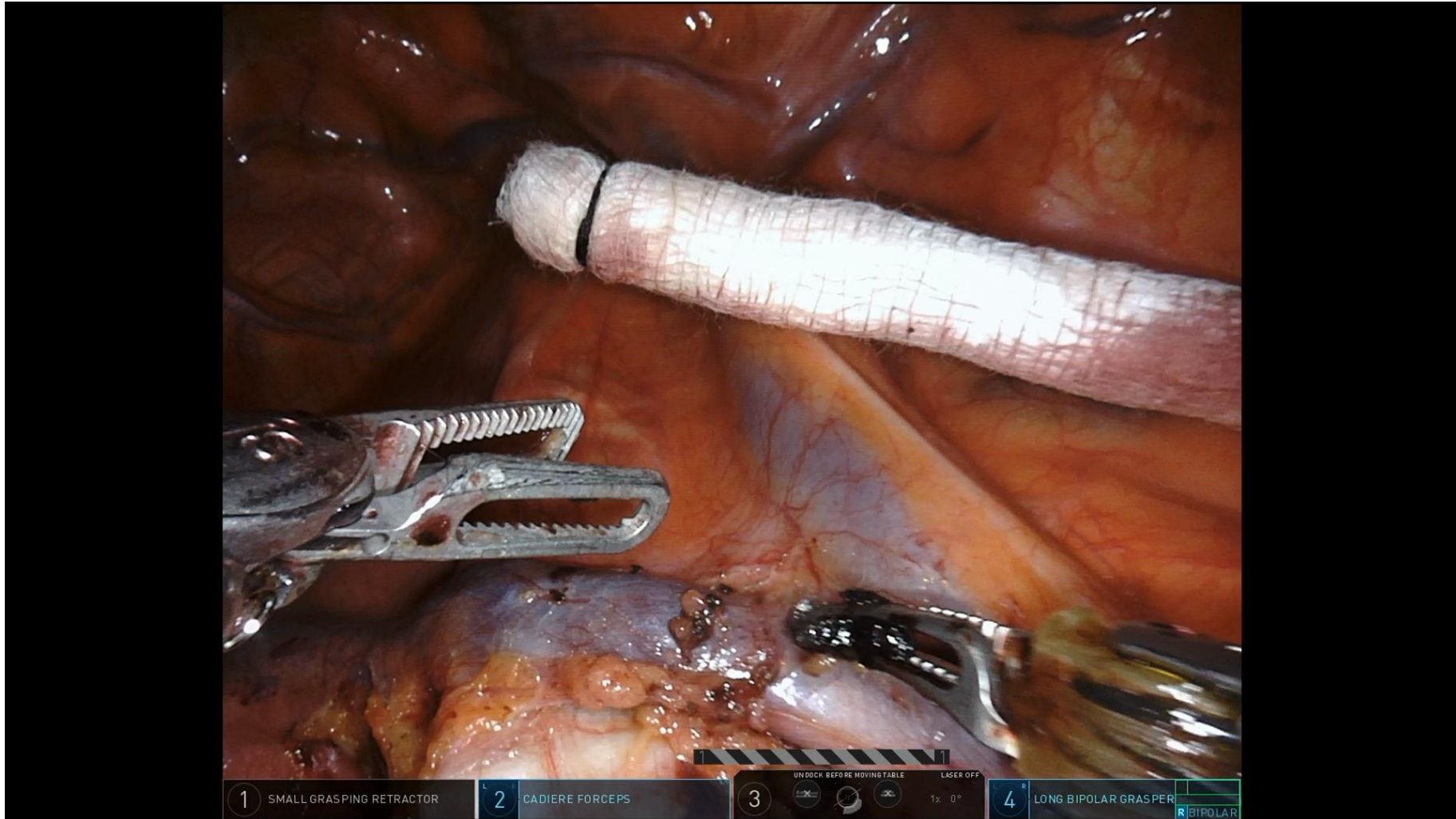
- 10 *Xi* Systems
- 3 *Si* System

Variable case mix

- URO, GYN, GYO, GS, THOR, CARD



2R, 4R and 10R Lymphadenectomy



Why minimally invasive surgery benefits patients

Oncologic **equivalent** to open technique

- **Less post operative pain**

- Less post operative pain medication administration
- Fewer analgesic side effects
 - Nausea
 - Dizziness
 - Constipation
- Increased mobility
- Fewer complications
 - Pneumonia
 - Ileus
 - DVT
- Shorter LOS
- Accelerated recovery and return to work/recreation

Outcomes data

Aurora Robotic Lobectomy Outcomes

Demographics

N = 256

Male – 38.7%

Mean age – 68.5

Mean BMI – 28.4

Co-morbidities

DM – 16.9%

HTN – 62.1%

CVD – 32.7%

COPD – 33.5%

Smoking (former) – 62.5%

Smoking (current) – 25.4%

Preop CRT – 6.1%

Aurora Robotic Lobectomy Outcomes

Lobectomy Breakdown

RUL - 91

RML - 26

RLL - 35

LUL - 68

LLL - 36

Bi-lobes - 8

Aurora Robotic Lobectomy Outcomes

Pathology

Adenocarcinoma 149 (60.8%)

Squamous cell carcinoma 68 (27.8%)

Other (11.4%)

- Neuroendocrine 3

- Carcinoid 8

- Mixed 2

- Small cell carcinoma 3

- Bronchiectasis 1

- MAC 2

- Metastasis 2

- NED 2

Aurora Robotic Lobectomy Outcomes

Intraoperative

Single Surgeon/Dedicated OR teams

Median op time – 125 min

Median console time – 102 min

Mean Total LN's – 14.1

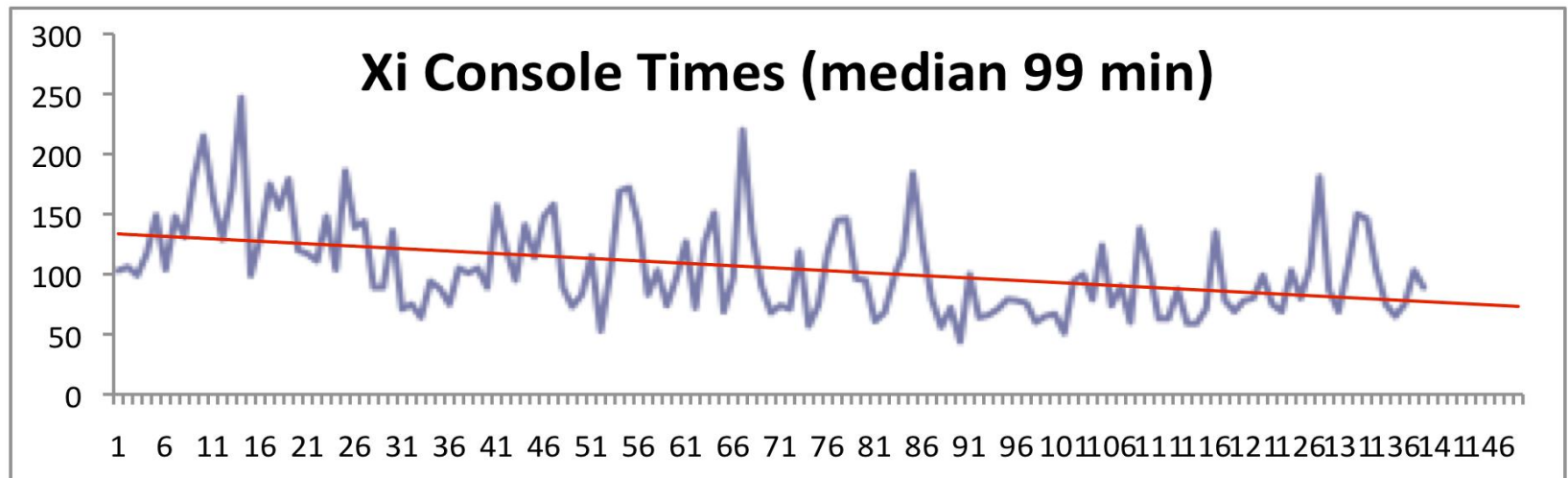
Conversion rate – 2.4%

Inadequate single lung ventilation – 3 (1.2%)

Bleeding – 3 (1.2%)

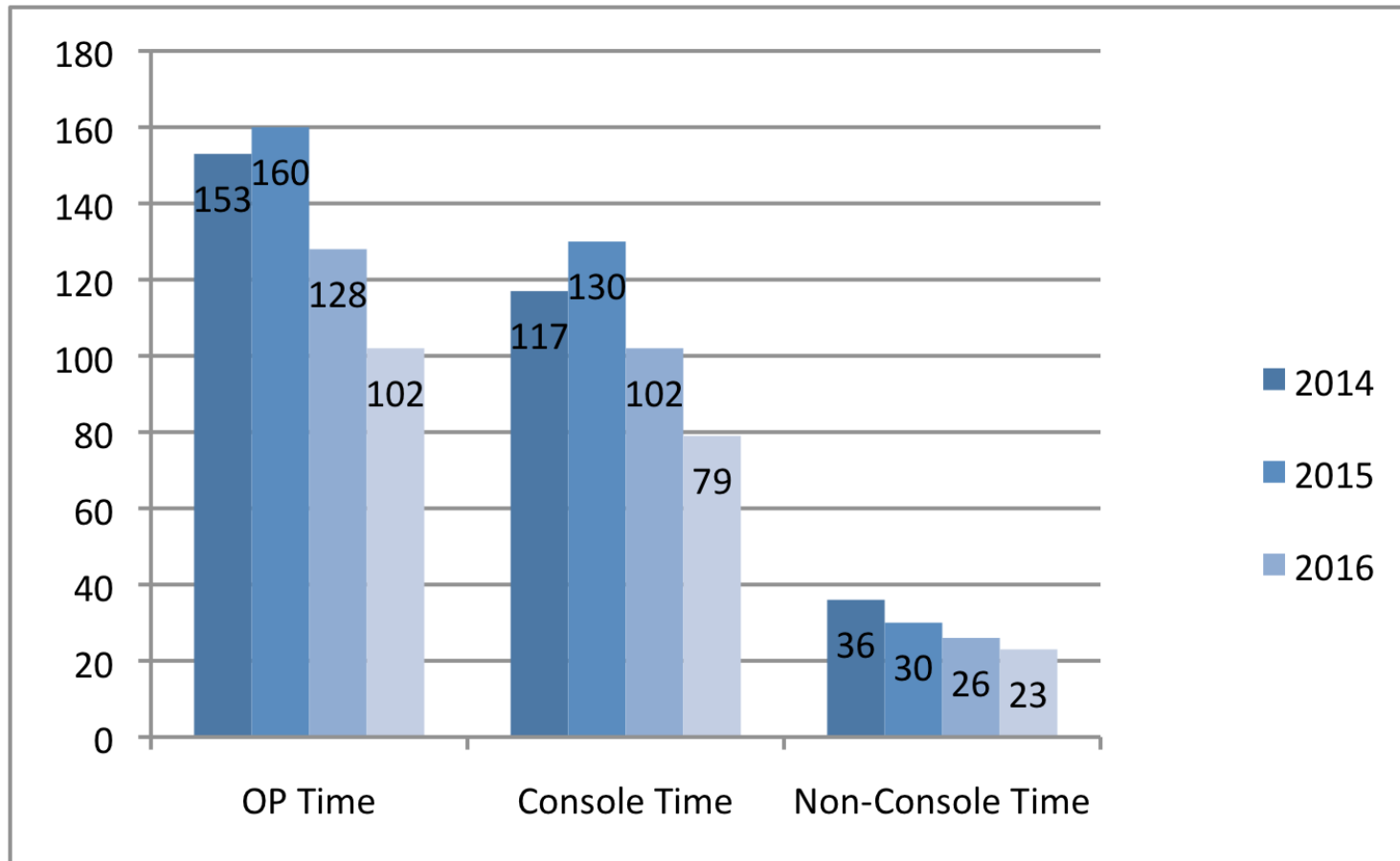
Xi times

Improving...



Operative times

Improving...



Aurora Robotic Lobectomy Outcomes

M&M

A-fib – 7.3% (10.6% - STS)

Pneumonia – 1.6% (3.9%)

30d mortality – 0.4% (0.8%)

LOS 3.0d (4.0d)

Post op transfusion 0.4%

Chest tube >5d – 23.3% (11.5%)

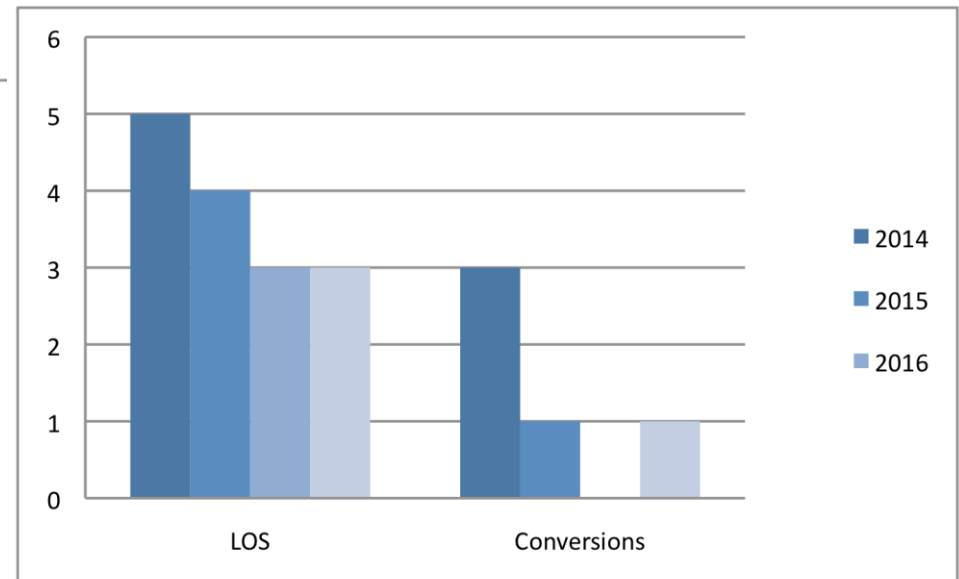
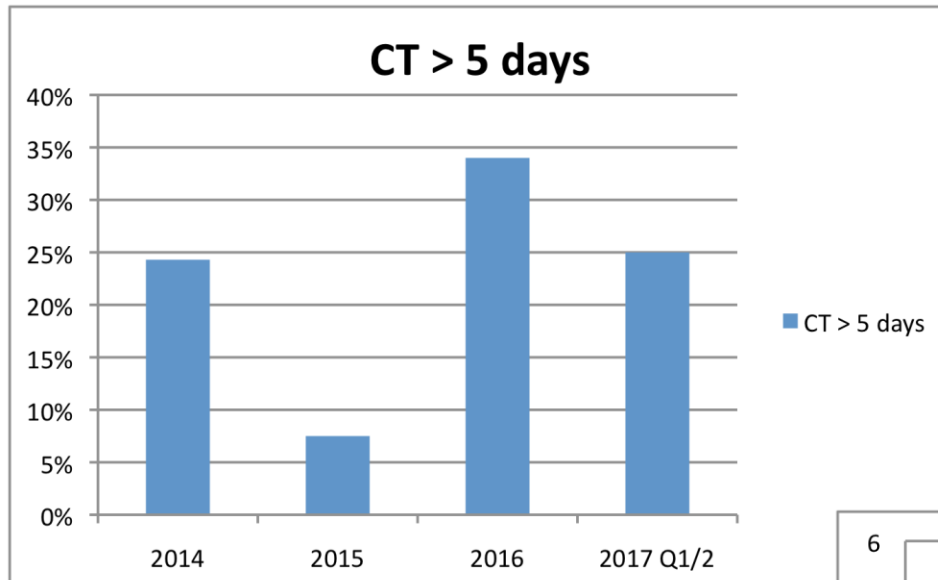
CT duration

Median 3d

Mean 6.4d

Chest tube > 5 days, LOS and conversions

Seems intertwined...



Robot Financials

Robot Finance South East Wisconsin

I am not a finance expert...

Service Line	Cases	Days	Charges	Paid	Direct Cost	Indirect Cost
GASTROENTEROLOGY	12	25	\$447,407	\$219,987	\$110,639	\$87,656
GENERAL	119	266	\$4,001,564	\$1,749,478	\$729,573	\$533,259
UROLOGY	50	75	\$1,656,302	\$862,053	\$263,949	\$175,798
WOMEN'S HEALTH	203	239	\$5,655,653	\$2,240,809	\$1,064,771	\$933,660
	384	605	\$11,961,126	\$5,072,327	\$2,168,992	\$1,730,373

Per Case Average

					Contribution	Contribution
ALOS	Charges	Paid	Reimb%	Direct Cost	Margin	Margin %
2	\$37,284	\$18,332	49.2%	\$9,225	\$9,107	49.7%
2	\$33,627	\$14,701	43.7%	\$6,131	\$8,571	58.3%
2	\$33,126	\$17,241	52.0%	\$5,279	\$11,952	69.4%
1	\$28,847	\$11,038	38.3%	\$5,245	\$5,793	52.5%
2	\$31,149	\$13,209	42.4%	\$5,648	\$7,561	57.2%

Robot Finance South East Wisconsin

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Robot Finance South East Wisconsin

I am not a finance expert...

Reimbursement

Outpatient 26-39%

Inpatient 30-49%

All 31-42%

TOTAL	Inpatient	Outpatient	Total	Inpatient	Outpatient	Total
Cases	113	271	384	217	187	404
Days	312	293	605	672	198	870
Gross Revenue	\$4,545,804	\$7,415,323	\$11,961,126	\$11,897,601	\$5,298,173	\$17,195,774
Net Revenue	\$2,217,030	\$2,865,297	\$5,072,327	\$4,310,378	\$1,939,668	\$6,250,046
Reimbursement %	49%	39%	42%	36%	37%	36%
Direct Expenses	\$844,610	\$1,324,382	\$2,168,992	\$2,094,955	\$775,031	\$2,869,986
Contribution Margin	1,372,420	1,530,915	\$2,903,335	2,215,423	1,164,637	\$3,380,060
Contribution Margin %	62%	54%	57%	51%	60%	54%

Contribution Margin

Outpatient 36-77%

Inpatient 48-69%

All 49-76%

Inpatient	Outpatient	Total	Inpatient	Outpatient	Total	Inpatient	Outpatient	Total
45	13	58	435	152	587	50	401	451
103	13	116	1339	263	1602	137	453	590
\$1,890,593	\$375,086	\$2,265,679	\$31,608,870	\$8,944,640	\$40,553,510	\$2,633,573	\$15,979,067	\$18,612,640
\$720,693	\$136,478	\$857,172	\$10,107,267	\$2,363,534	\$12,460,801	\$795,941	\$5,335,990	\$6,131,931
38%	36%	38%	32%	26%	31%	30%	33%	33%
\$376,506	\$63,356	\$439,862	\$4,521,540	\$1,513,909	\$6,035,449	\$243,423	\$1,223,382	\$1,466,805
344,187	73,122	\$417,309	5,585,727	839,625	\$6,425,352	552,518	4,112,608	\$4,665,126
48%	54%	49%	55%	36%	52%	69%	77%	76%

Financial Advantage

Open v. VATS v. Robotic Lobectomy

Potential Cost Offsets Clinical Measures - Lobectomy

● OPEN (N=5,913)*
● VATS (N=4,612)*
● DAVINCI (N=106)

Length of Stay
(days)

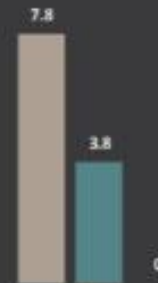


Cost:

\$1,553

(per bed day)

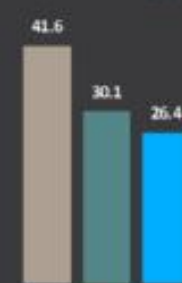
Transfusions
(percentage)



\$1,142

(per transfusion)[†]

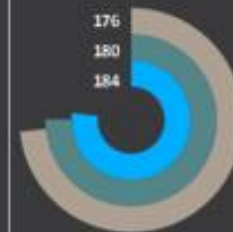
Major Complications
(percentage)



\$7,657

(per complication)*

OR Room Time
(minutes)



\$11

(per minute)[‡]

Estimated Cost Savings Per Procedure

\$ **5,508** vs. Open

\$ **1,523** vs. VATS

Estimated Total Cost Savings

\$ **583,823** vs. Open

\$ **161,426** vs. VATS

*Adams RD, et al. Initial Multicenter Community Robotic Lobectomy Experience: Comparisons to a National Database. *Ann Thorac Surg* 2014 June;97:1893-900. doi: 10.1016/j.athoracsur.2014.02.043.

Be aware of your environment

Abbas Abbas, MD



The slide features a large iceberg floating in the ocean. The tip of the iceberg, which is visible above the water line, represents the 'visible' costs of care. The much larger portion of the iceberg, which is submerged below the water line, represents the 'hidden' costs of care. The background of the slide is a dark blue gradient.

Cost of Care

- Capital cost
- Instrument cost
- OR time

- Salaries
- Administrative overhead
- Non-robotic instrument expense
- Length of Stay
- Conversions
- Complications
- Readmissions
- Surgical Infections

Know the whole picture

Abbas Abbas, MD



The slide features a large iceberg floating in the ocean. The tip of the iceberg, which is above the water line, is labeled with a list of financial metrics. The much larger, submerged part of the iceberg is labeled with a list of strategic and operational tools. This visual metaphor emphasizes that the visible financial results are only a small portion of the overall organizational picture.

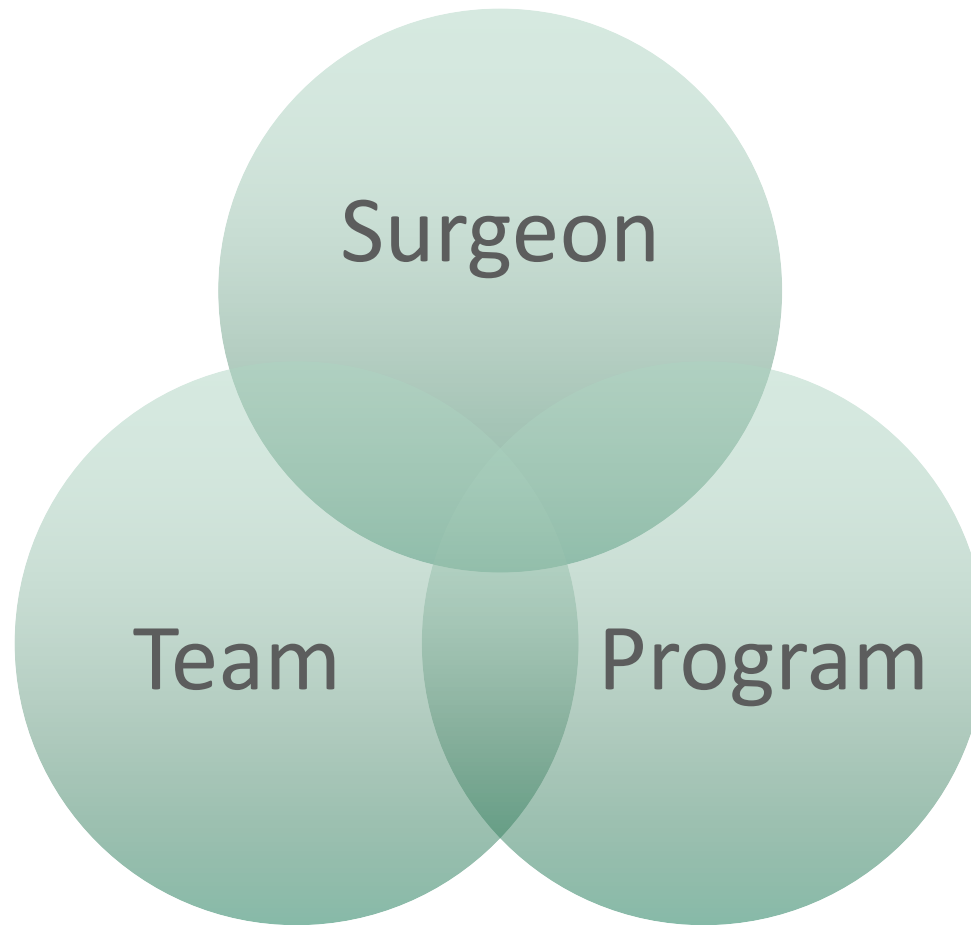
Revenue and Return

- Contribution margin
- Net margin

- Marketing return
- Competitive tool
- Educational tool
- Research tool

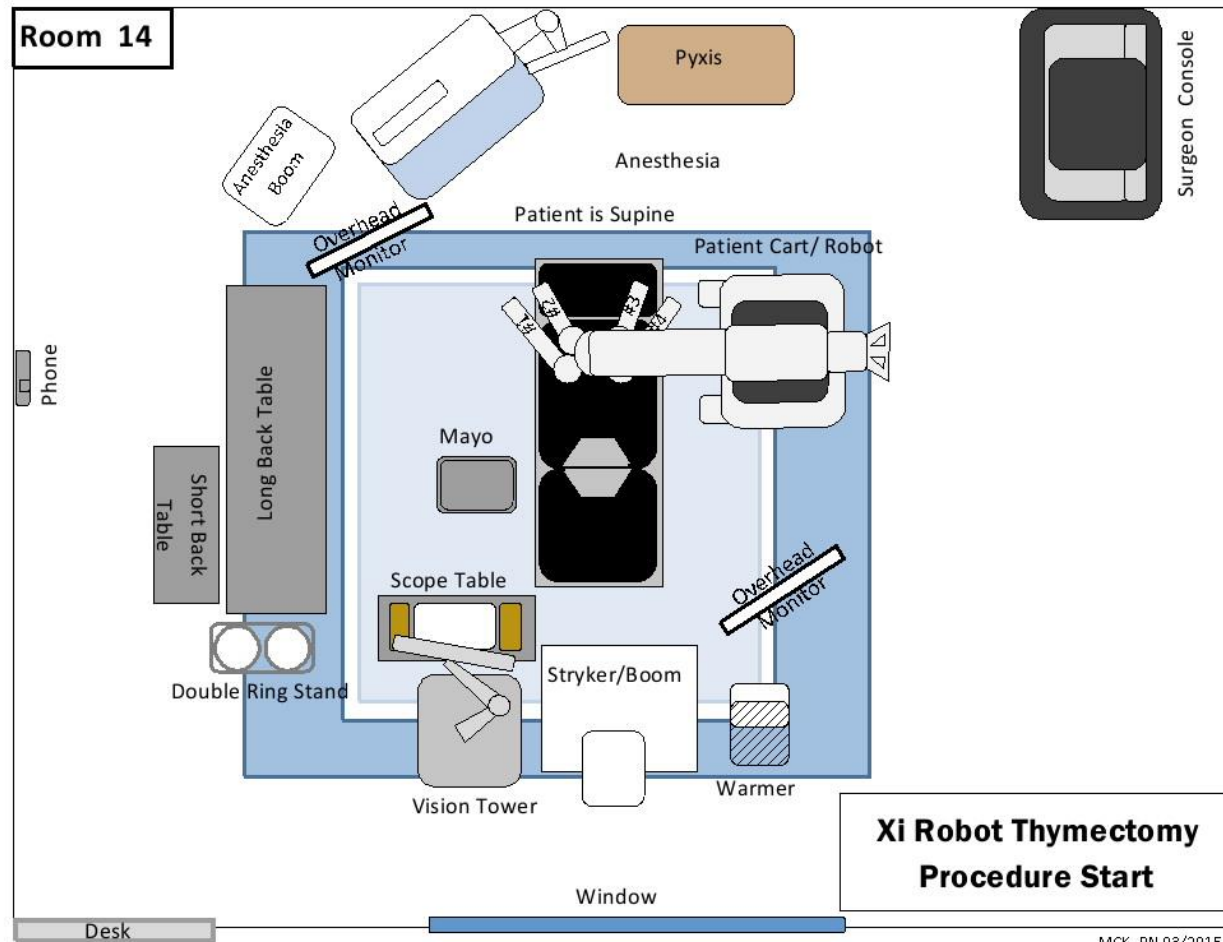
Robot Lobectomy Program and Successful Program Development

Development areas requiring attention



Room Set up

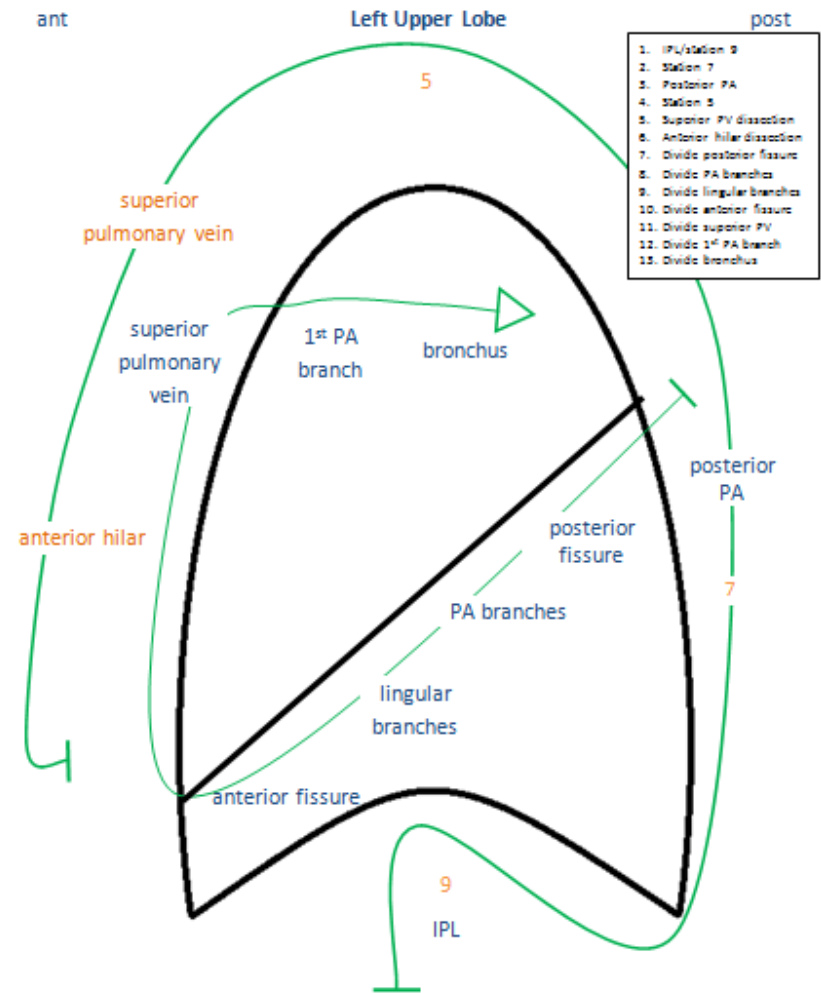
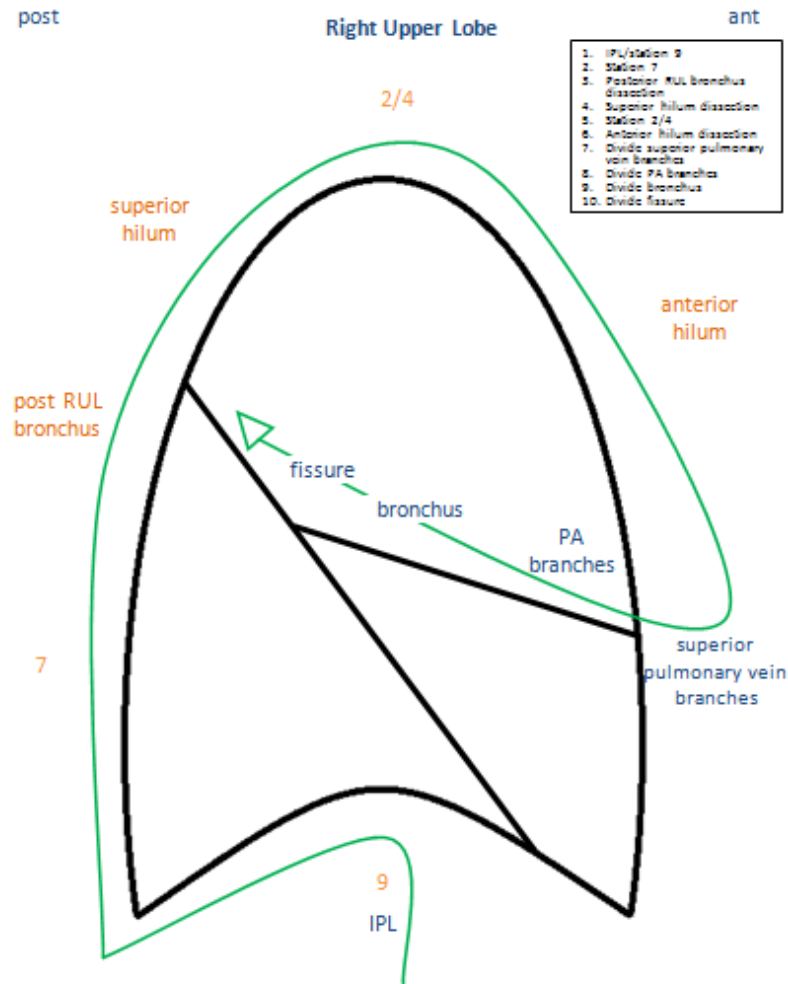
Planning and dry run essential.



MCK, RN 03/2015

Lobectomy Maps

RUL and LUL



MIS Pathway

We can do cool stuff in the OR but...

MIS Lobectomy Pathway

Period	Pre-Operative Clinic		Intra-Operative	Post-Op Day of Surgery
Assess	Clinic -CT scan (3mo) -ECOG -smoking hx/cessation counseling -dx/stage (if known) May order if not done pre-clinic -PET (60d) -PFT (6mo) -needle bx for dx	Pre-op testing -EKG (6mo) M>40, F>50 -CBC, CMP, INR (30d) -A1C if DM (3mo) -T&S (14d) -UA w/ reflex (30d) -MRSA swab (14d) *surgery scheduled once testing complete (prefer within 7-14d)	Update H&P with EKG review Mark correct surgical site Patient bed status (inpt vs obs) Signed consent	CXR (reviewed and documented w/in 4hr of anesthesia end time) PACU - Anesthesia for pain control Transfer to floor (3W/3/9ST) Higher acuity patients to ICU Patient will have 5 incisions, 1 with chest tube
Consults	Cardiology for clearance if appropriate PT		Anesthesia	Pulmonary/Critical Care as needed
SCIP measures	Beta-blocker am of surg if appropriate Antibiotics ordered		Antibiotics given within 60 min cut time SCDs in place	Foley d/c HS
Nutrition	Nutrition class NPO after midnight			Clears Up in chair for all meals
Activity	Ad lib			Ambulate within 4-6 hrs of arrival from PACU Progressive ambulation every 4h around the clock
Treatment	Stop ASA/anticoagulation 5 days before surgery (unless stents) Hibiclens scrub pm before and am of surgery		Clip surgical site Foley placed (if surg >1.5h) Peripheral IV Time Out	CT to gravity (-8cm suction) Mucinex RT/HHN per order IS, cough and deep breathing q1 h/every TV commercial IVF @100 mL/h Tele for 72h
Pain Mgmt			Paravertebral block by anesthesia	Oxycodone for pain (PCA if uncontrolled) NO Toradol unless ordered by thoracic surgery
D/C needs	Patient and family education about surgery and expectations of hospitalization		Patient extubated in OR	Resume home meds as appropriate

MIS Pathway

We can do cool stuff in the OR but...

MIS Lobectomy Pathway

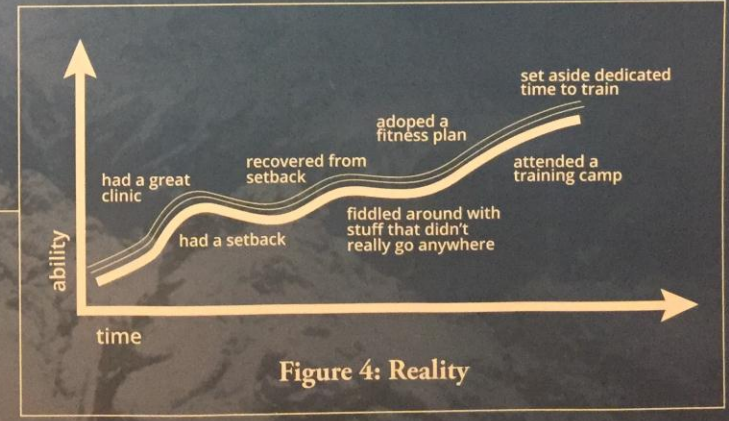
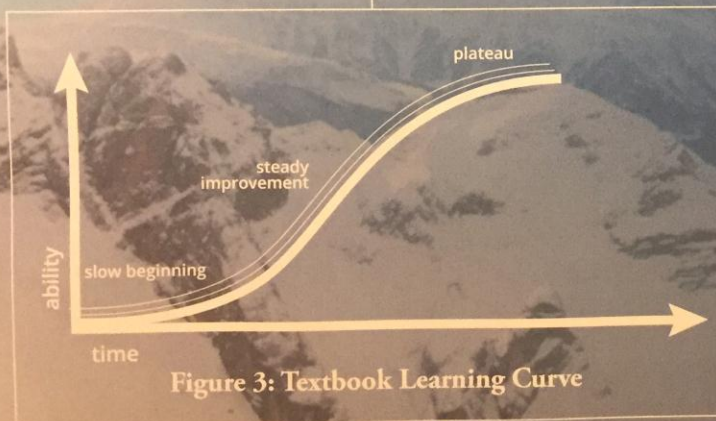
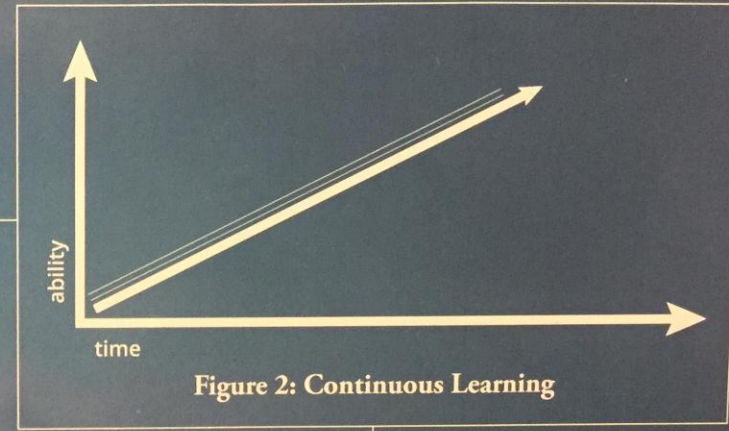
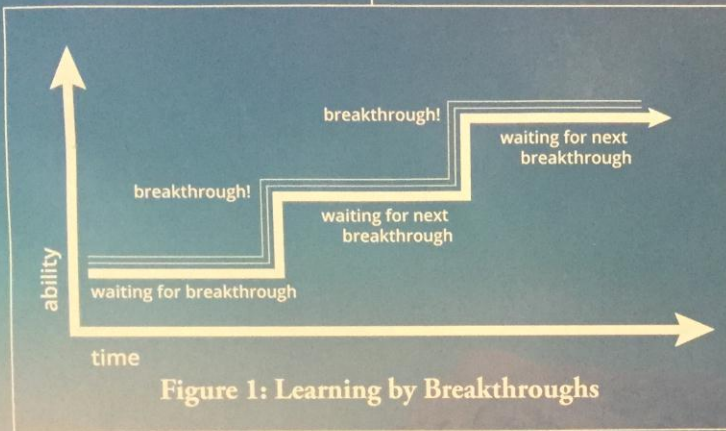
Period	POD #1-D/C	D/C Criteria	Post-op Clinic
Assess	CXR, portable, daily while CT in CT for flow and output, document output q shift Physical assessment/V/S per protocol	1. CT out or to pneumostat/mini-atrium Criteria for CT removal: Stable CXR No flow Drainage <400/24h	F/U in 2 weeks with CXR (appt. made prior to d/c) Post-op CXR Wound check Pain control Discuss pathology and staging Discuss surveillance Smoking cessation
Consults	PT/OT Cardiac rehab for thoracic exercises		Oncology as needed
SCIP measures	Antibiotics completed DTV-document foley out Lovenox (start 24h after surgery)		
Nutrition	Advance diet as tolerated to home D/C IVF	2. Tolerating diet	
Activity	Ambulate q4h	3. Ambulating safely	
Treatment	IS, cough and deep breathing q1 hr/every tv commercial	4. Voiding (BM not required)	
Pain Mgmt	PO narcotics Muscle relaxants Lidoderm patch Massage therapy Ice Aromatherapy	5. Tolerating oral pain meds	
D/C needs	Social services as needed	Majority home by POD#2-3 CT site occlusive dressing remains on for 48 hrs May shower once occlusive dressing off, no baths Wash incisions daily with soap and water	

Surgeon Development

- Patience, practice and perseverance
- Learn the surgeon console
 - Use the simulator
- Assist another surgeon
 - Learn from other's experiences
 - Understand being at the bedside
- Overcome being away from the table
- Have a plan and set goals
- Accept the learning curve
 - It will take longer at first

What's the Learning Curve?

Learning to ski...



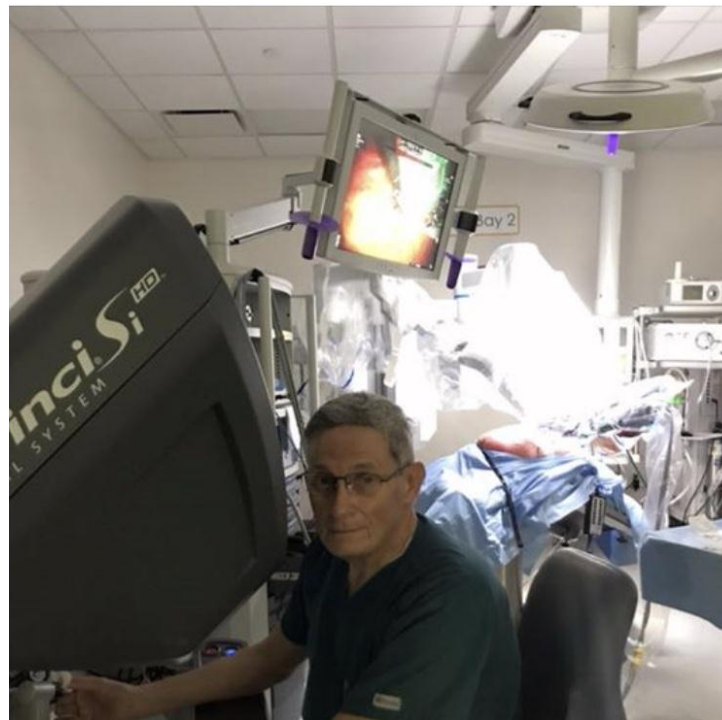
What's the Learning Curve?

Dr. Lyle Anderson (72) Harrisburg, PA

Learning robotics at a Luminary course today.

What's more impressive he spent >100 hours on the simulator with his CSR **Joel Sweigart** before the course /

A role model - we never stop learning.
He's going to join RSC later today !



Team Development

- Find volunteers as team members that want to learn the robot
 - Teach your thoracic team the robot
- Build team rapport
- Open communication
- Debrief after case
 - What went right/wrong?
 - What could we do better?
- Be encouraging
- Team sport

Team Development

Knowing your role

Robotic Roles	RN	ST	Support (RN)	Assist (ST)
Team Arrives	Robot Cords	Wiping flat surfaces/ moving equipment	Setting room around	Starting to open supplies
Set Up	Look up Pt, Pull up films, Make bed, Pull meds, Go for Pt and Pre-case Check-in with Surgeon	Open back table, gowning table, pans, Scrub and Count with RN	Open sterile supplies, count with ST, Drape robot	Open sterile supplies, drape robot
Patient in Room	Assist Induction, Foley, Clip, Position and Prep	Organize back table, Drape robot	Assist with Positioning, Clipping and Prepping	Assist with Positioning, Clipping and Prepping
Draping	Plug in cords, lights and Do Time out	Drape Patient, Throw off cords, Port placement		Assist in draping and Port placement
Ports Placed	Drive in Robot	Instrument arms		Docking, Insert Instruments
Console Time	Start recording case, Charting, Prepare for next robot (Meds/Look up Pt)	Assist with surgery		Assist with surgery
Surgeon Off Console	Gas off, Lights up, Switch bovie, Count, Procedure check out, Burn CD and Undrape robot (cords up if last case/moving Robot),	Counts, Help close, Clean instruments and Breakdown table	Help undrape robot and clean up	Help undrape robot and clean up
Incision Closed	Call PACU and EVS, Dressings get the patient bed to move them off the OR table	Break down tables, Help move the patient onto bed, Take garbage to decontam	Help move Patient onto bed and breakdown room	Help move Patient onto bed, breakdown room
Pt Transfer to PACU	Drop off Pt, Start next set up	Help housekeeping, Start next set up	Help housekeeping, Start next set up	Help housekeeping, Start next set up

Team Development

Knowing your role

Robotic Roles	Anesthesia	Anesthesia Technician	Surgeon	PA/ NP/ Resident
Team Arrives	See Patient	Check Anesthesia machine	See Patient, Mark site, Sign consent and Do H&P update	See Patient, Mark site if in procedure and do H&P update
Set Up	Set up medications set out needed supplies for Intubation, See Patient, do lines and blocks	Collect needed supplies for intubation (difficult airway cart) help with lines and blocks	Pre Case Check in	Put films up
Patient in Room	Induction, OG, Bronchoscope (if needed) and help position the patient	Help with induction, (Bronchoscope), Positioning and Placing warmer on Patient	Arrive in room, Oversee positioning of patient and Scrub	Oversee positioning of patient and Scrub
Draping	Draping and table positioning	Check with Anesthesiologist if a blood gas needs to be tested	Draping, Port placement	Draping, Port placement
Ports Placed	Monitor patient		Docking	Docking, Insert instruments
Console Time	Monitor patient	Check if Patient needs an ICU bed, if so help get the bed and set up	At console	Assist with surgery
Surgeon Off Console	Monitor patient		Procedure Check out (Sign out Time out) Determine to save recording or not, Scrub and Close	Undock and close
Incision Closed	Extubation and Transfer Patient onto bed	Help with extubation, Transfer monitoring (if needed) and move Patient onto bed.	Dictate, Orders, See Patient's family and See next Patient	Dictate, Orders, See Patient's family and See next Patient
Pt Transfer to PACU	Drop off Pt, See next Patient	Help drop off patient in ICU (if needed) and Turnover room	See next Patient	Check post op films and See next Patient

Achieving Proficiency and Finding Success

Team Sport...

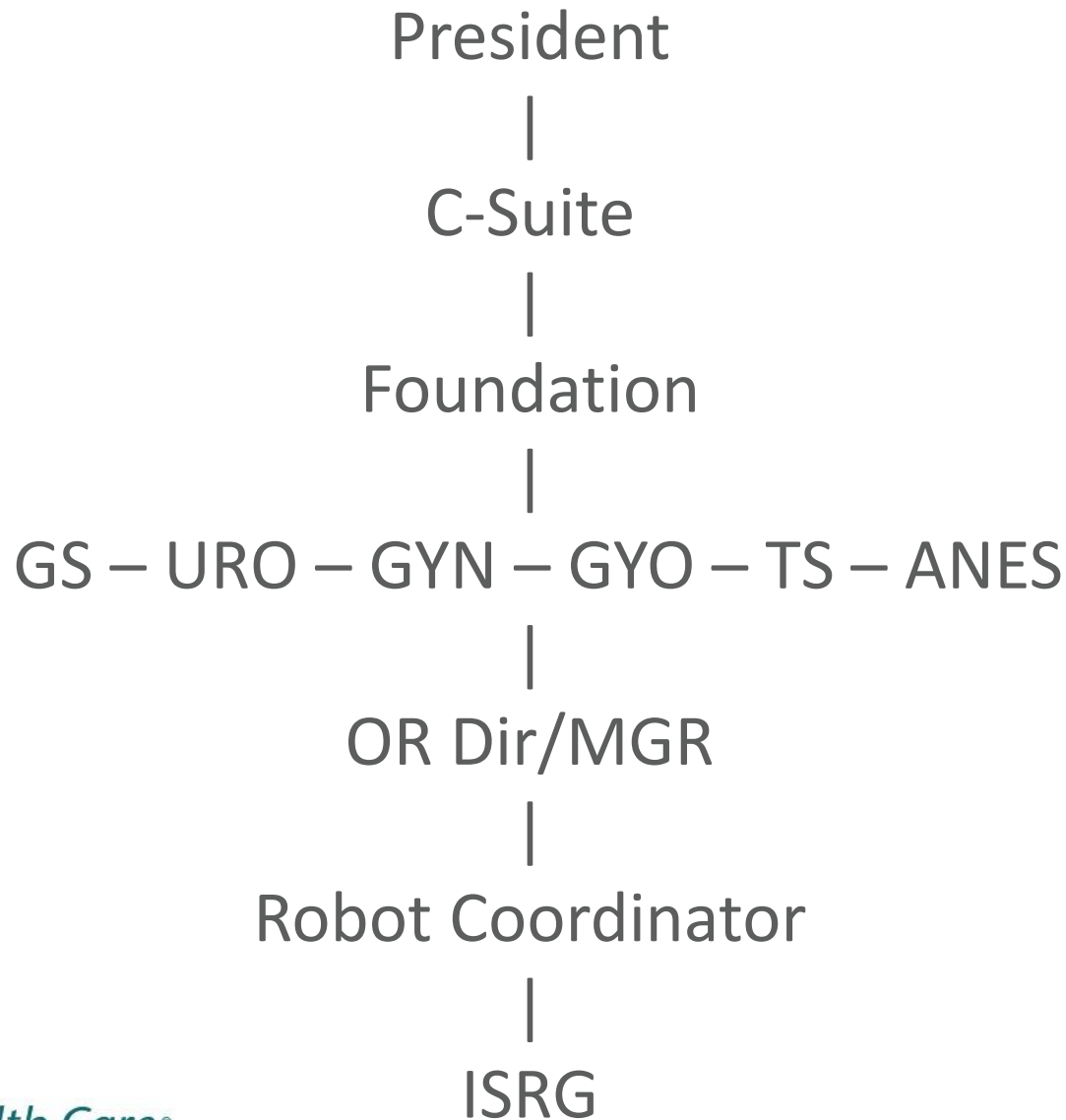
Robotic Surgery Daily Wrap Up Sheet				
DATE: _____		ISSUE	SOLUTION	OWNER
Was any needed equipment missing from the room?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Did you have to remove any unneeded equipment from the room?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Were any stocked items missing?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Were any items from preference card missing from case cart?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Where there any changes that need to be made to the preference card or cards?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Did you have any issues/problems with the DaVinci system today? Was assistance accessible?	Yes <input type="checkbox"/> No <input type="checkbox"/>			
Was the case picked or scheduled properly?	Yes <input type="checkbox"/> No <input type="checkbox"/>			

Comments:		
Case 1 Scheduled Time _____ Surgeon: _____ Previous case wheels out _____ Rm Ready _____ In room _____ Start _____ Docked _____ Console _____ Undock _____ Staff _____ Comments: _____	Case 2 Scheduled Time _____ Surgeon: _____ Previous case wheels out _____ Rm Ready _____ In room _____ Start _____ Docked _____ Console _____ Undock _____ Staff _____ Comments: _____	Case 3 Scheduled Time _____ Surgeon: _____ Previous case wheels out _____ Rm Ready _____ In room _____ Start _____ Docked _____ Console _____ Undock _____ Staff _____ Comments: _____

Program Development

- Create a Robotic Committee
 - Outcomes and safety
 - Resource utilization
 - Training
- Horizontal integration between surgical specialties including Anesthesia
- Vertical integration from OR to Administration
- Promote milestones and results

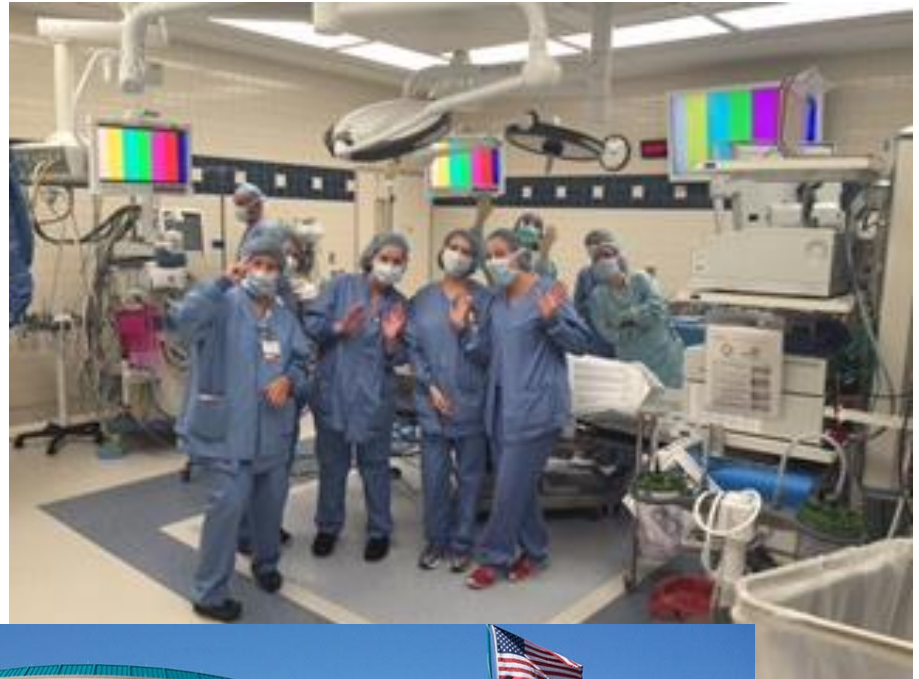
Effective Robot Committee Structure



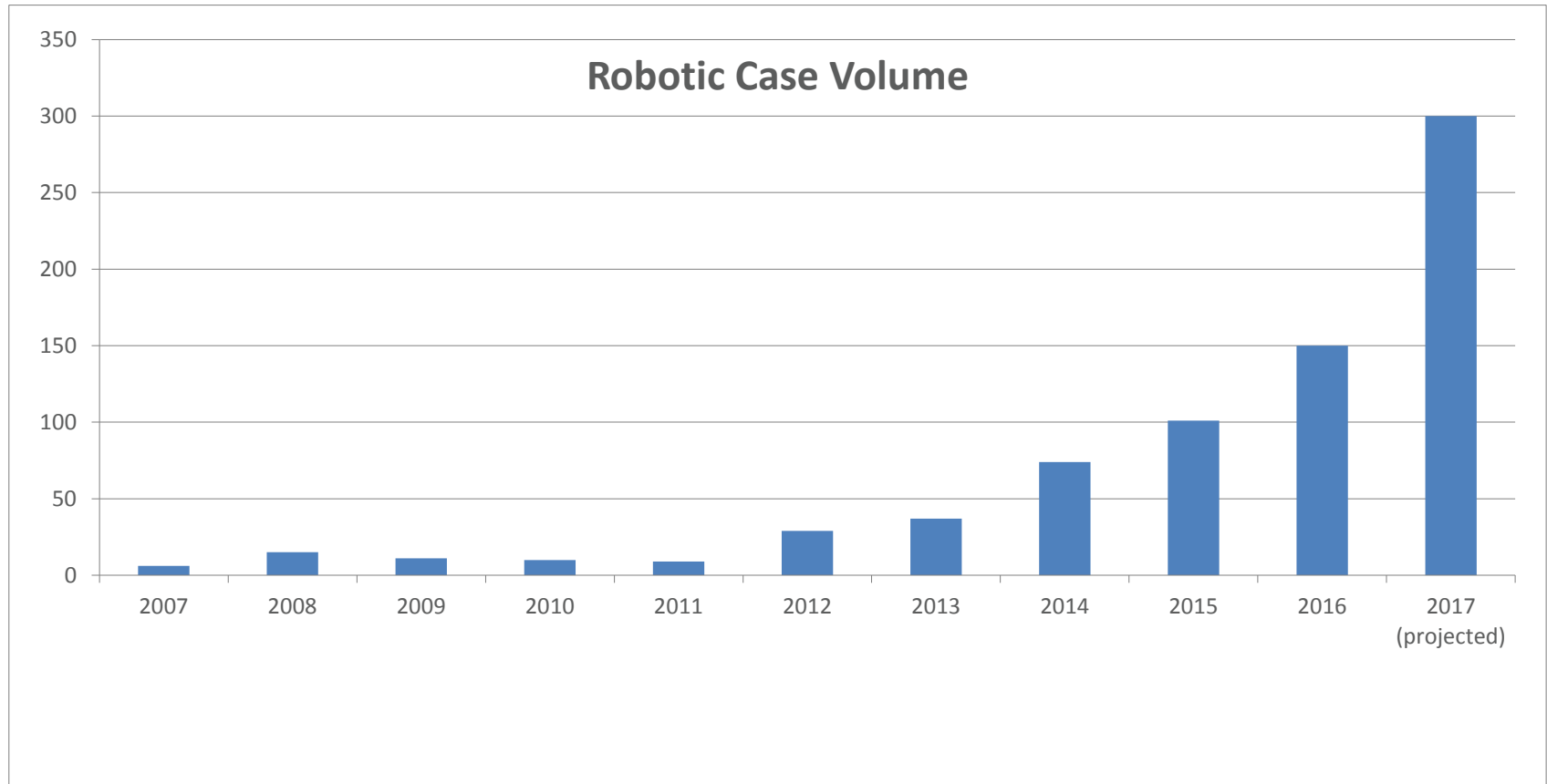
AURORA MEDICAL CENTER IN GRAFTON A NATIONAL CASE OBSERVATION SITE FOR THORACIC ROBOT-ASSISTED SURGERY

- Established January 2016
- 1 of 19 national programs (1 of 2 in Midwest)
- Most visited thoracic observation site in the world - 2017
 - 88 outside visitors hosted
 - 100+ total guests
- Highest rated thoracic observation site
 - Score 9.91/10
- Locations of Visitor's Home Institution: Wisconsin, Illinois, Indiana, Minnesota, Iowa, California, Nebraska, North Carolina, Ohio, Colorado, Kentucky, Michigan, Arizona, South Dakota, Florida, Georgia, Washington, Texas, Tennessee and China.

Questions?



Surgeon Development



LLL Pulmonary Artery Stapling – Curved Tip

