

The Future Applications of Robotic Surgery

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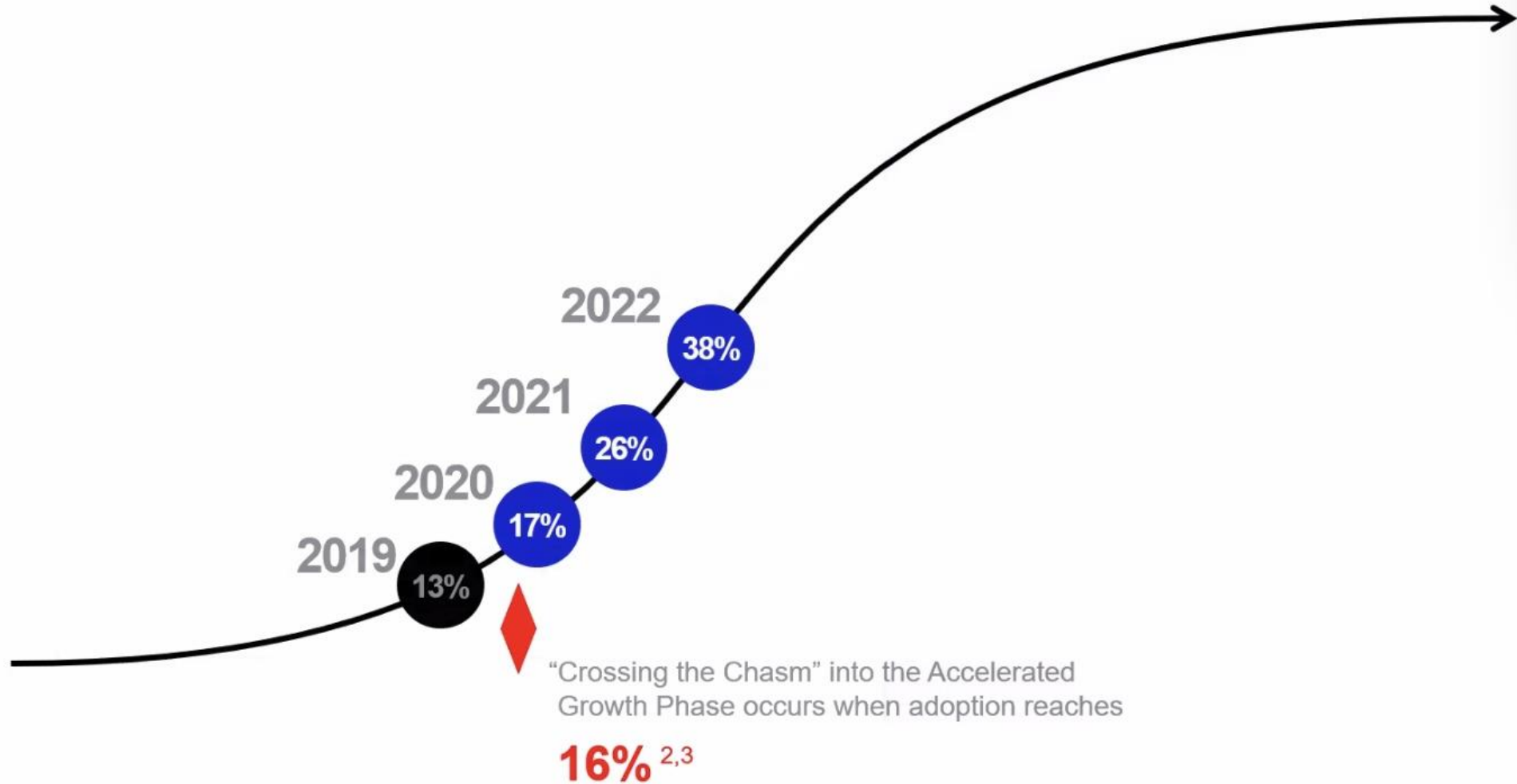


My Disclosures

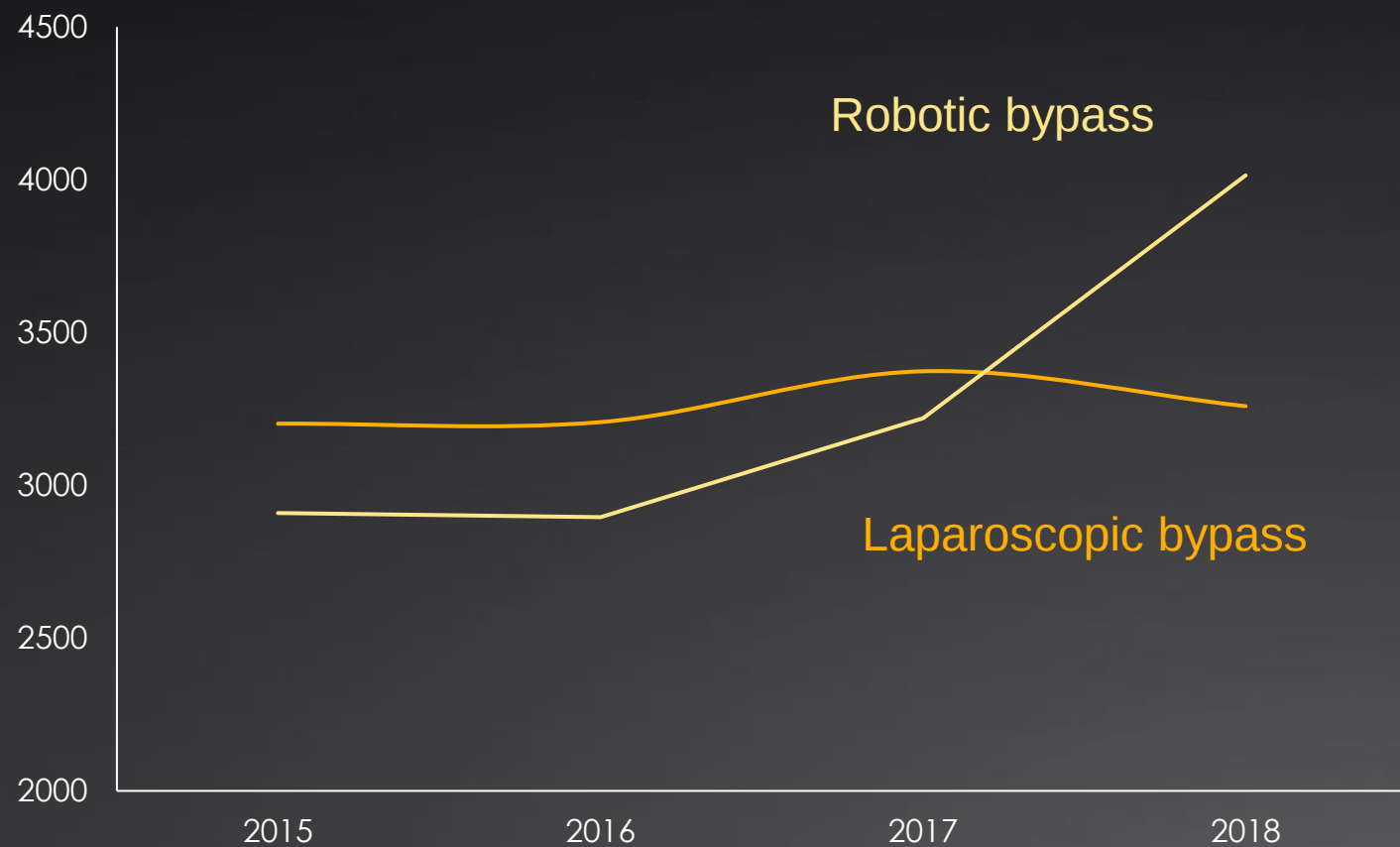
Intuitive-Teaching/Research

- * Covidien-Teaching
- * Johnson&Johnson-Teaching/Research
- * Gore-Teaching
- * Activ Surgical-Research
- * Apollo Endosurgery-Research
- * USGI-Research
- * Many of the systems shown today are in development and not regulatory approved

Bariatrics today ...



>80,000 robotic bariatric cases in 2022: more than 1/3 of all cases



Operative time, minutes (median (IQR))						
Procedure	Lap (n)	Lap	Robotic (n)	Robotic	Op-time Δ (min)**	p value *
RYGB						
2015	3202	105 (77, 137)	2910	137 (111, 176)	+ 32	< 0.0001
2016	3207	105 (78, 139)	2896	139 (109, 182)	+ 34	
2017	3373	105 (78, 139)	3220	144 (113, 191)	+ 39	
2018	3259	106 (79, 143)	4015	143 (113, 186)	+ 37	
Sleeve						
2015	7176	65 (50, 88)	5465	93 (72, 123)	+ 28	< 0.0001
2016	8365	63 (48, 85)	7299	89 (67, 121)	+ 26	
2017	9067	61 (46, 82)	9251	87 (65, 118)	+ 26	
2018	9252	61 (46, 82)	11,845	89 (66, 119)	+ 28	

IQR interquartile range, *Lap* laparoscopic

*Analyzed using sqrt transformation

**Difference in robotic and laparoscopic median operative times

Slower Times in Robotic Bariatrics

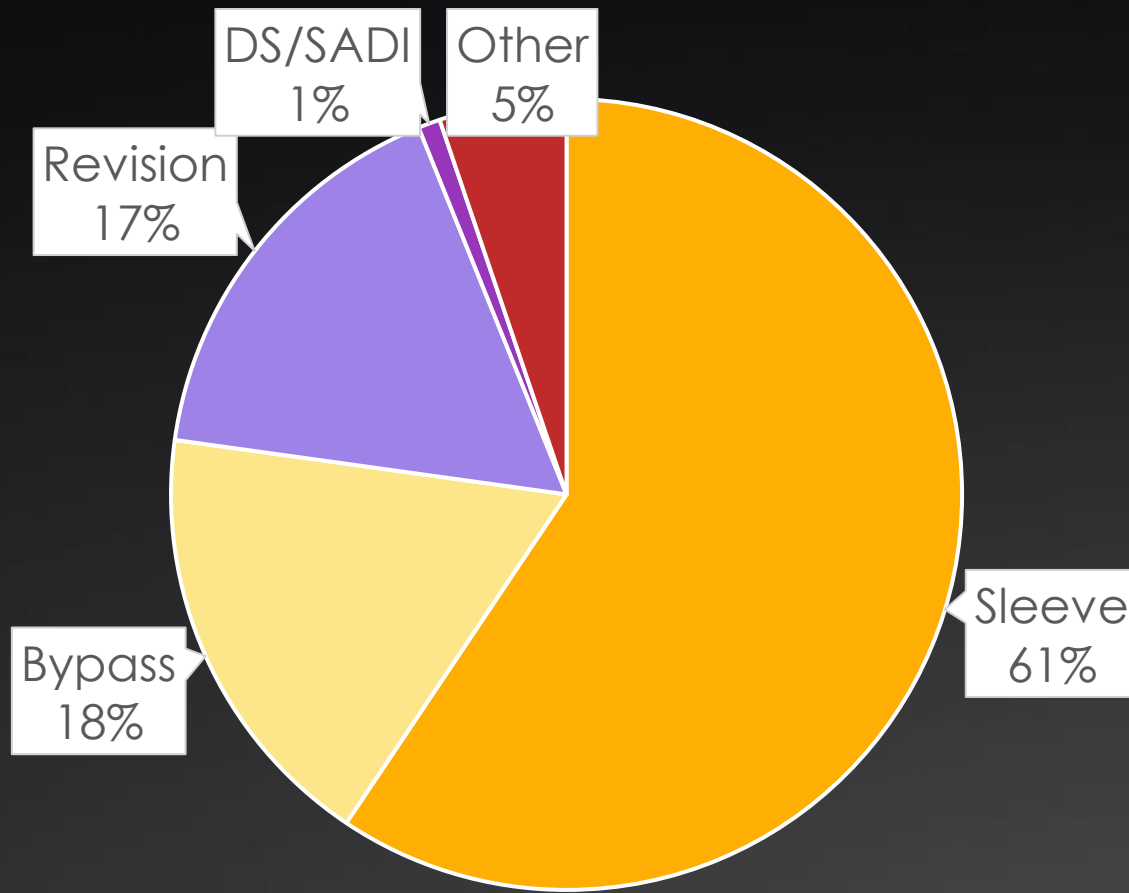
But Lap Bypass Growth is Flat

Robotic Bypass Growth is Accelerating
35% of Robotic Cases Bypass

Robotic DS Growing Too
Many more robotic DS than Lap DS

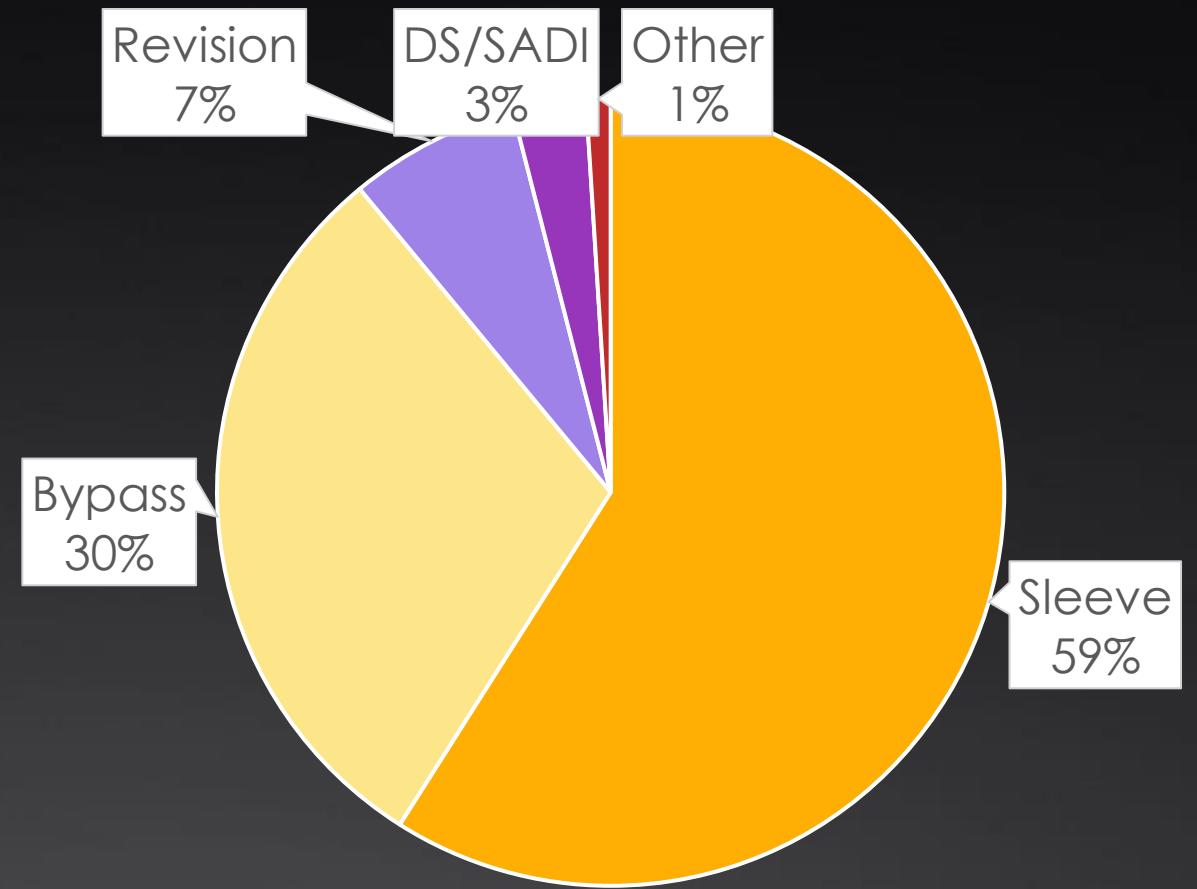


Robotics Preferring Anastomotic Procedures



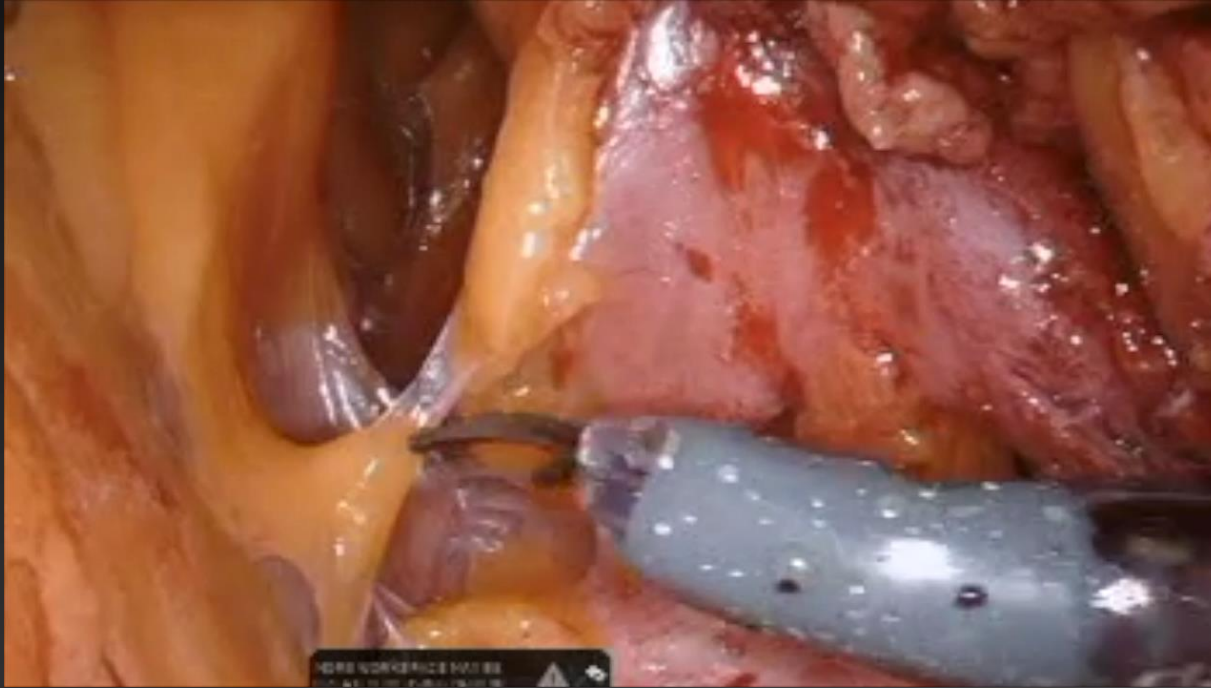
2020 Overall Bariatric
Procedure Mix*

**based on MBSAQIP
procedure estimates*



2022 da Vinci Bariatric
Procedure Mix

Complex Robotic Dissection



Robotics is Surgical Driving Improvement

Low complications and high safety in trained hands

Precision for dissection and reconstruction

Complete control and autonomy

Similar operation when the body habitus is different

Potential for longer surgical careers

The evolution of surgical technique

High Performance Robotics?



High Performance Robotics?

Culture of converting
open surgery to
laparoscopy with
robotics

Raising the Floor

Not Raising the
Ceiling?



Robotics is Surgical Driving Improvement?

Slower

Haptics

Hybrid approaches

Ports and setup variability

Lots of learning curves and feedback overload?

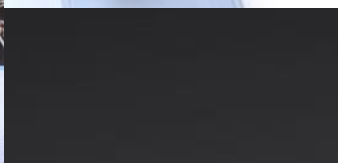
The roller coaster of surgical technique

High Performance Robotics

We are still 20 minutes
slower on average cases

Reduced Latency
Reverse Scaling
Rotational Scaling
Very fast instrument
exchanges
More ports and arms
Multiuse instruments
Combined endolumenal and
laparoscopy at one console





THE
AR
Design
▪ M
▪ F





SURGICAL DISRUPTIVE TECHNOLOGY SUMMIT

www.surgicaldisruptivetechsummit.org

The 7th Annual Surgical Disruptive Technology Summit is the preeminent forum for innovation in general minimally invasive surgery bringing together entrepreneurs, venture capitalists, surgeons, and medical device companies all in one place to showcase new ideas, products and procedures. There will be multiple in depth panels in surgical robotics, endolumenal surgery, artificial intelligence, surgical training and many more.

NEXT SUMMIT: Feb 22-24, 2024

Sunday, March 3
7:00 – 9:00 PM

Surgical Robotics: The Next 5 Years

The surgical innovation dinner this year will again focus on the changes in robotic platforms over the next several years. Many of the companies growing and driving into this space are represented on a panel as has occurred in past years of the Summit. Developers will discuss the potential growth of surgical digital platforms and what are the key concepts to driving better surgery in an open forum with active participation by the audience.

- Open vs Immersed Surgeon Side Cart
- Multiport vs Single Port vs Endolumenal
- Modular vs Boom vs Table vs Bedside
- 12mm, 8mm, 5mm, or 3mm instruments
- Autonomy



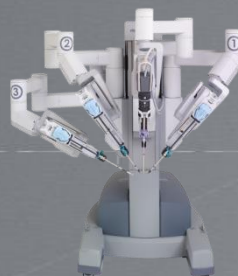
Evolution of Robotic Platforms



1999

da Vinci®

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



2006

da Vinci® S™

- 3D HD Vision (720p)
- Cross-quadrant access
- Streamlined set-up



2009

da Vinci® Si™

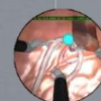
- Dual Console option
- Enhanced HD Vision (1080i)
- Upgradable architecture



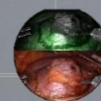
2014

da Vinci® Xi™

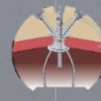
- Multi-quadrant access
- Crystal clear 3D HD vision
- Platform for future technologies



- FIREFLY™



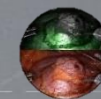
- SINGLE-SITE™



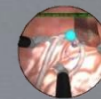
- SKILLS® SIMULATOR™



- ADVANCED INSTRUMENTATION



- FIREFLY™
(EXPECTED MID 2014)



- XI SKILLS SIMULATOR™
(AVAILABLE NOW)



- INTEGRATED ENERGY
(AVAILABLE NOW)



- VESSEL SEALER
(EXPECTED MID 2014)



- STAPLER
(EXPECTED MID 2014)



- FUTURE INNOVATION
SINGLE PORT SURGERY

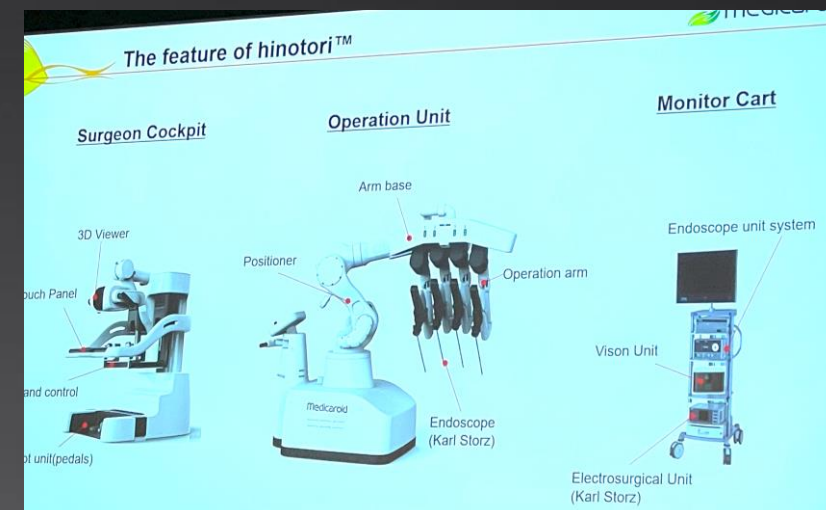
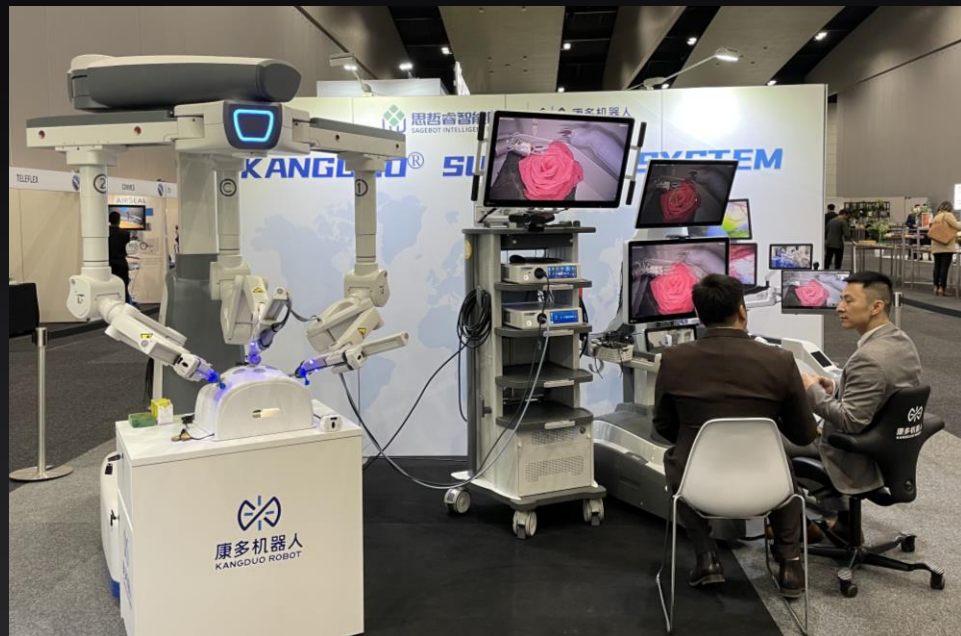
Complimentary systems for the spectrum of minimally invasive ca



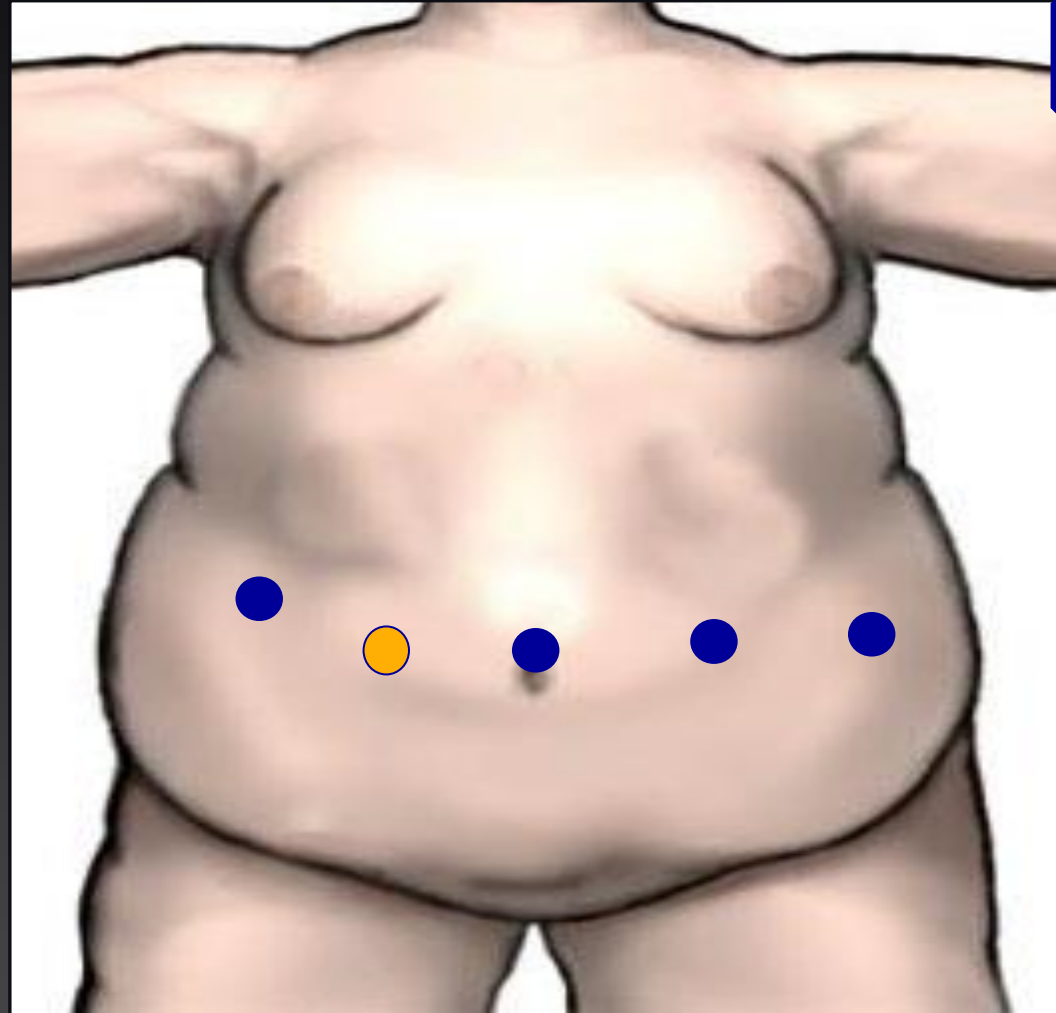
Boom Mounted Arms

- * One surgical cart to move
- * External interferences physically managed currently by the boom
- * Easy potential software recognition of arms in relation to each other
- * One arm's down you can't swap it
- * Limitations on multiquadrant access?
- * Boom system often will have to be large for stability with big footprint

Boom Mounted Arms



Foregut for Boom System



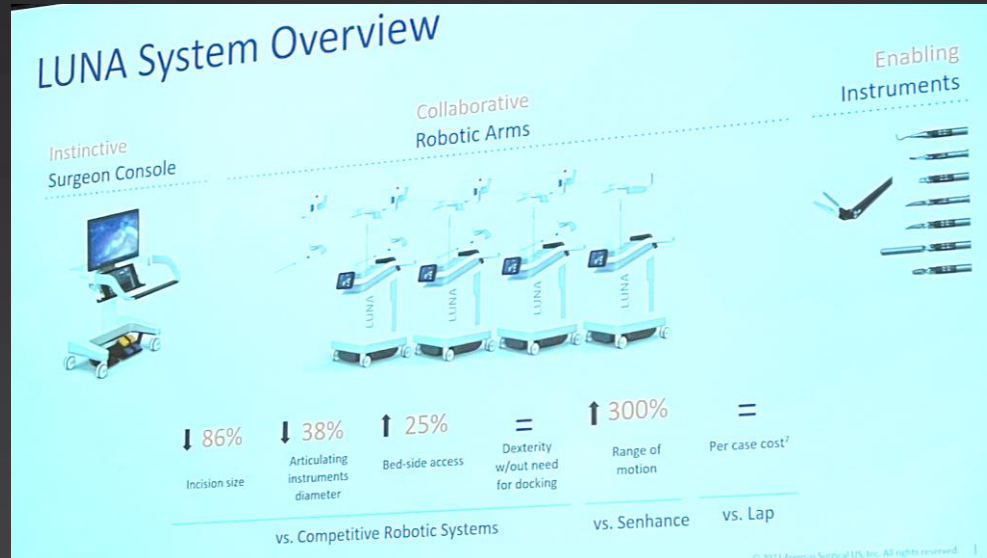
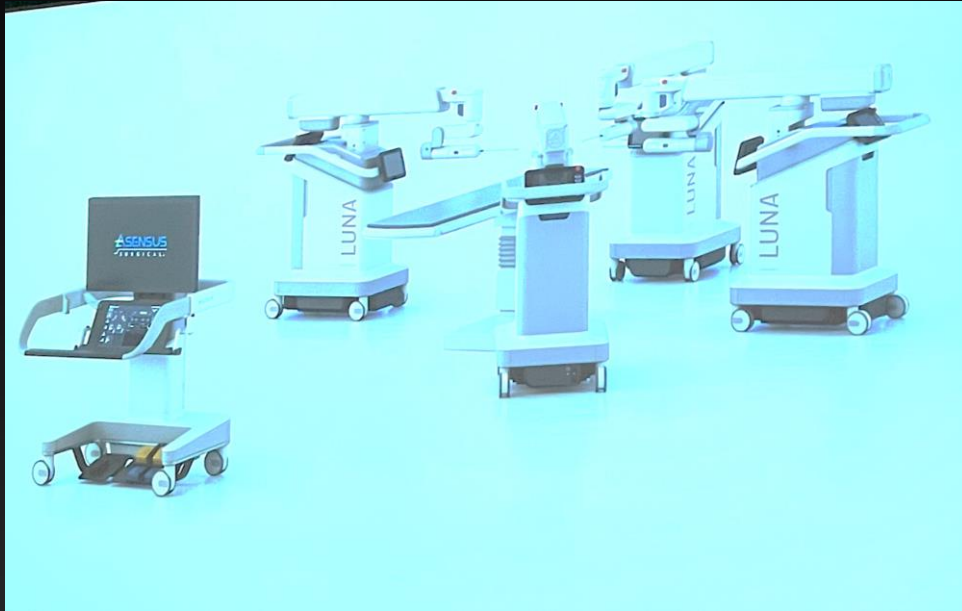
Robot
Boom

Modular Mounted Arms

- * Multiple surgical carts to move
- * External interferences must be software managed
- * More difficult for software recognition of arms in relation to each other but still possible
- * One arm's down you easily swap as many as you need
- * Fewer limitations on multiquadrant access
- * Footprint totally depends on the module
 - * small modules small footprint
 - * large modules large footprint



Transenterix/Asensus



Laparoscopic open console
Wristed and unwristed instruments
Long instrument life
3 mm and 5 mm instruments
3 or 4 arms

Medtronic

- Open surgical cart
- Modular design 2-4 arms
- Full complement of robotic driven lap wristed instruments
- Cost focused

THE TOWER
Designed to be:

- Universal (RAS and lap)
- Upgradeable

THE SURGEON CONSOLE

- Open design
- 3D HD visualization

ROBOTIC END EFFECTORS

- Medtronic expertise

THE ROBOTIC ARM CART
Designed for:

- Mobility
- Flexible use

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

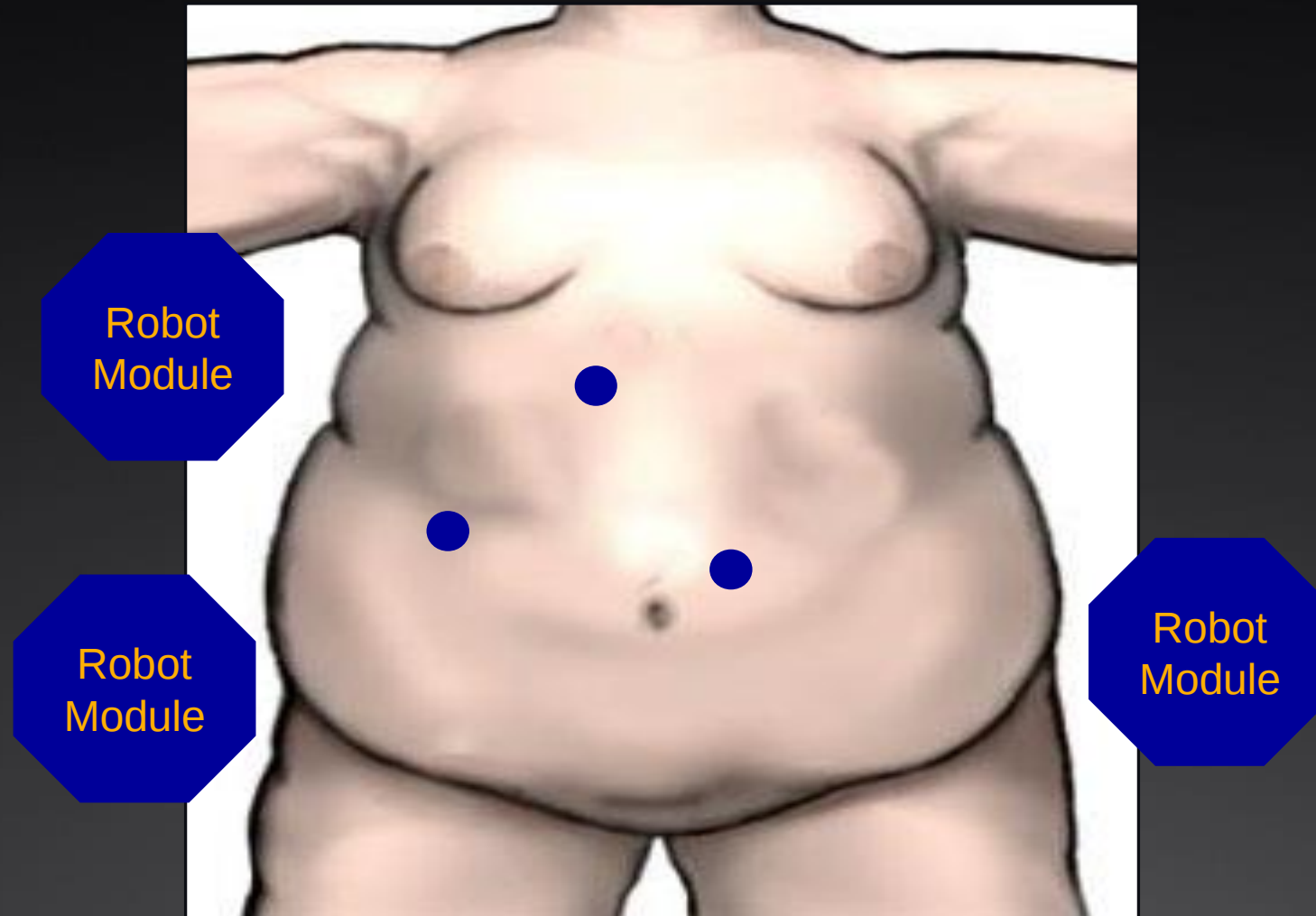
Cambridge Medical Robotics

- Open surgical cart
- Modular design 2-4 arms
- Robotic driven 5 mm lap wristed instruments
- Mimicking the human arm
- Cases being performed UK and India

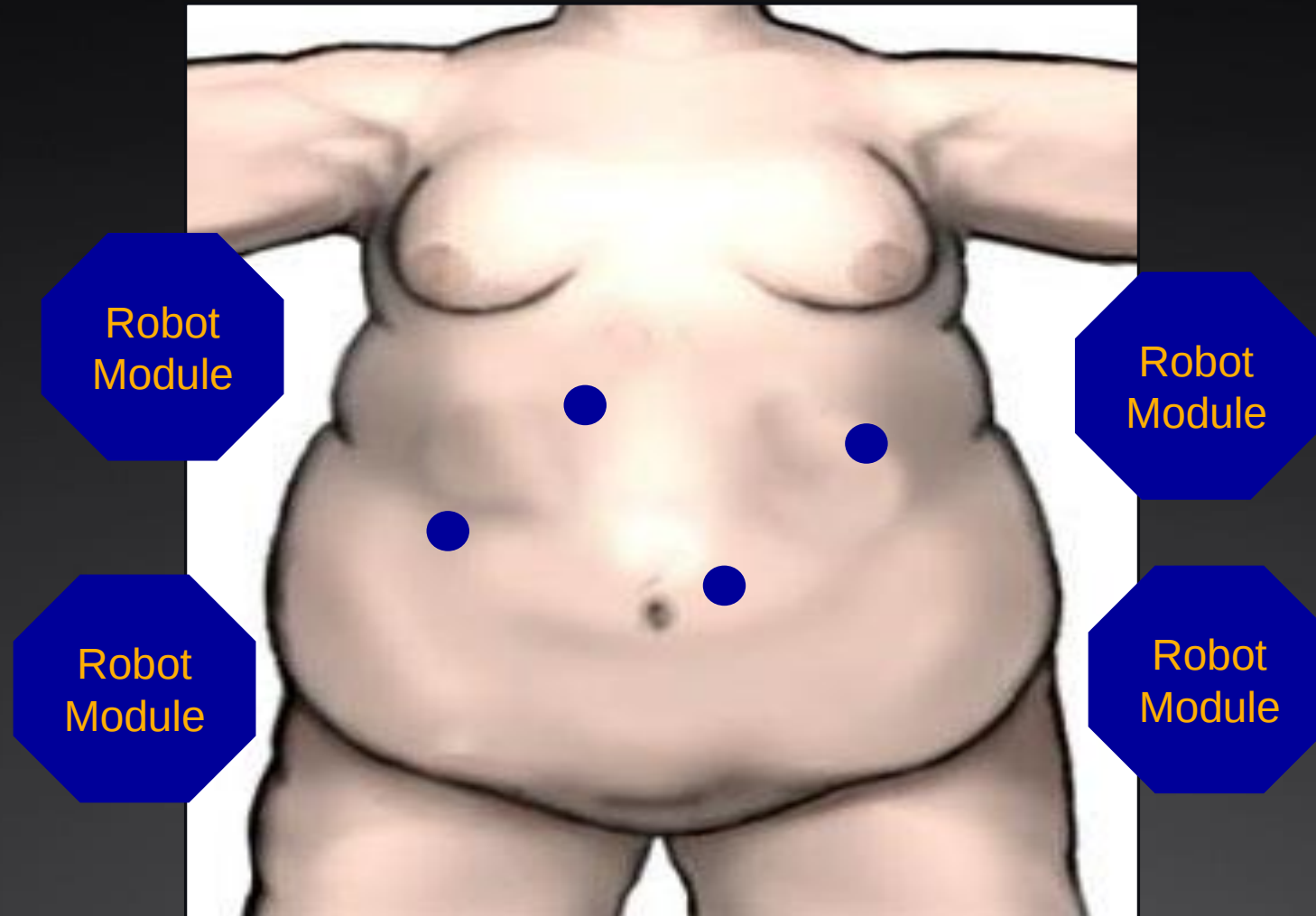
Not FDA approved



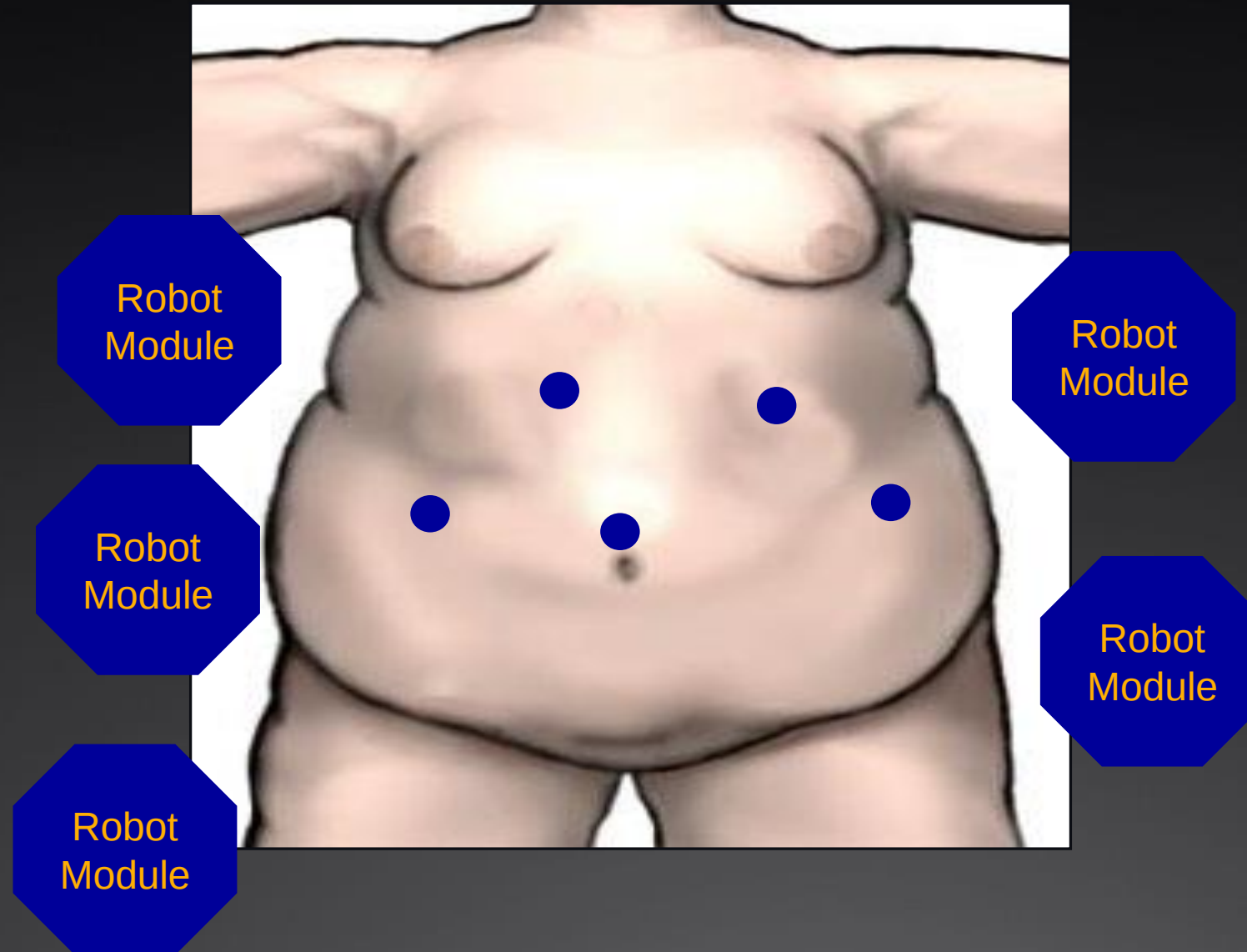
Foregut for Modular System



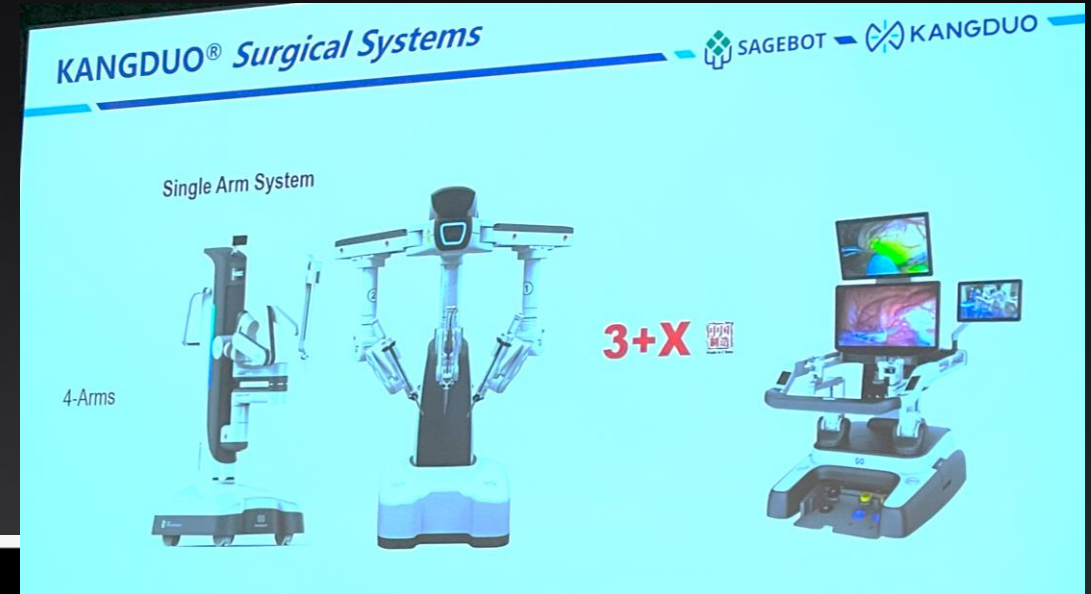
Foregut for Modular System



Foregut for Modular System



Modular Arms



Task Focused Modules

MOON SURGICAL

Large scale adoption



Keeps Surgeon at Bedside
Restores Complete Control
Improved Ergonomics
Preserves Clinical Practice

Accessible & Labor Saving
Applies to Broad Indications
Surgeon Happiness & Volume

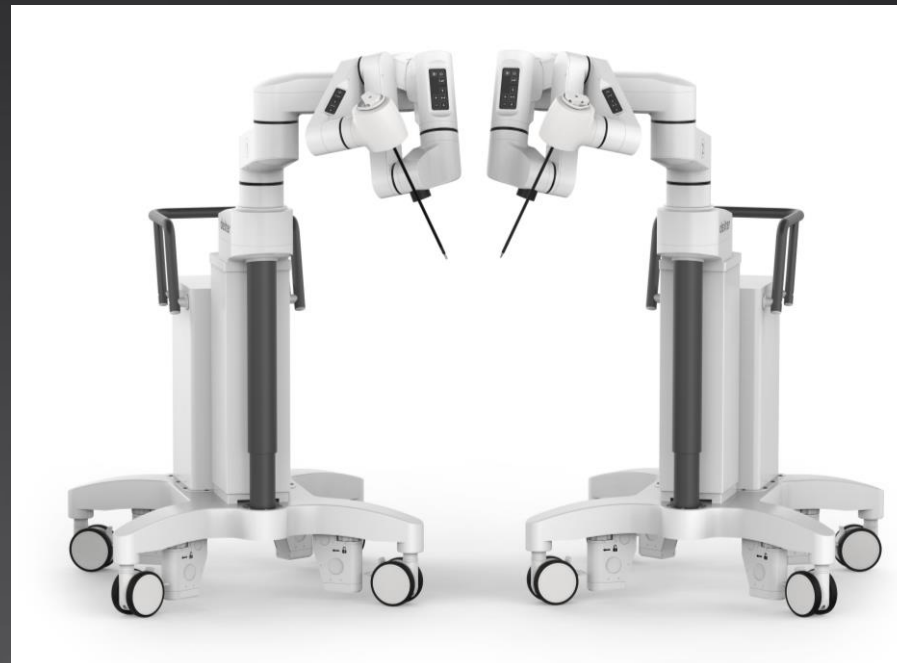


Table Mounted

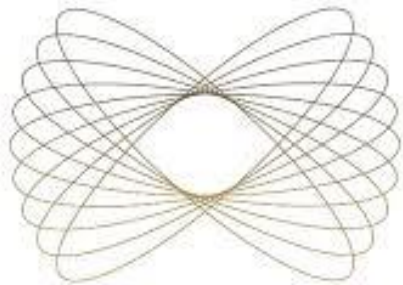
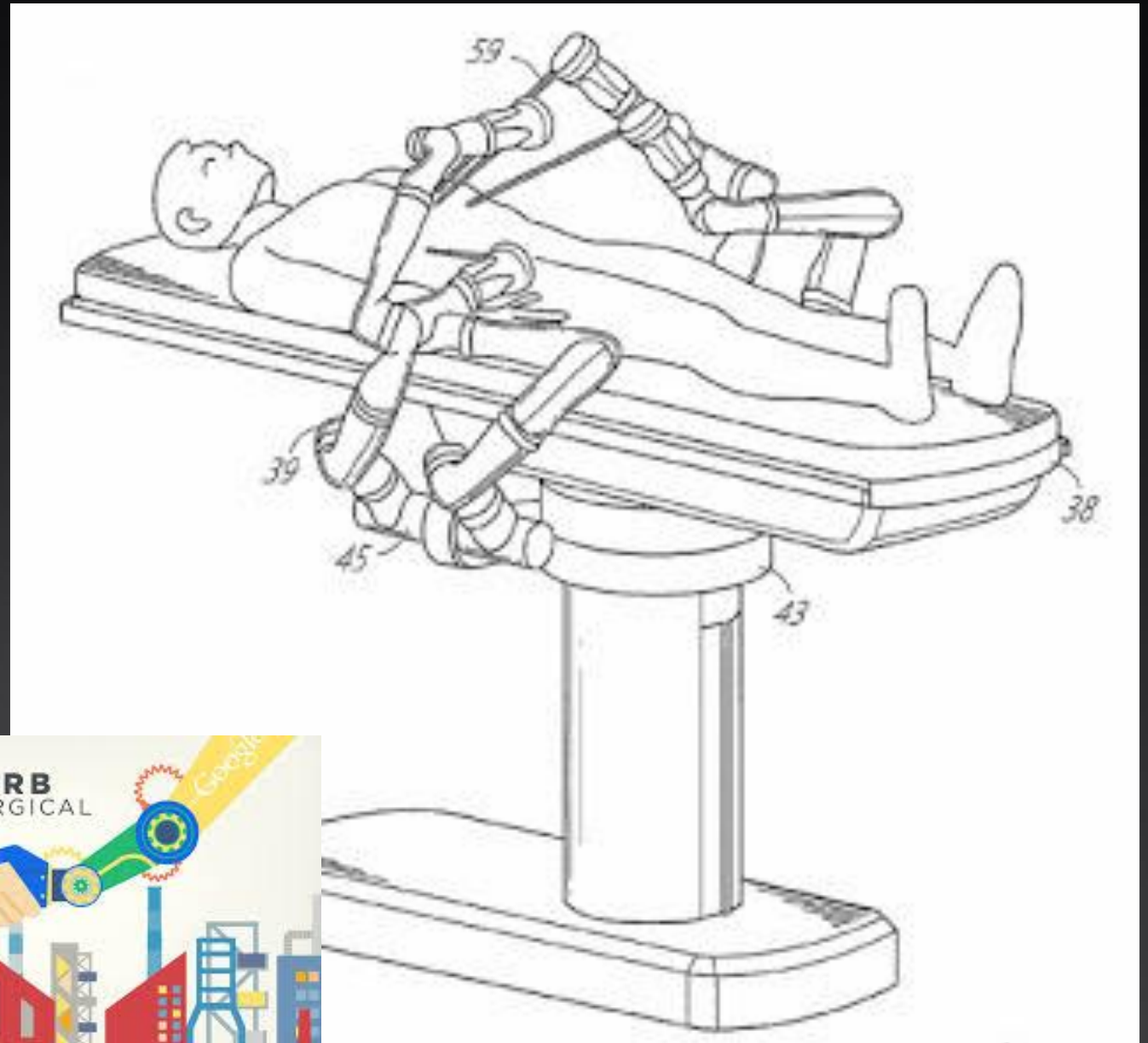


Johnson & Johnson: Auris and Verb

- Open/Immersed surgical cart
- Table based designs
- Endolumenal designs too
- Full complement of robotic driven lap wristed instruments
- Focused on procedure analysis
- Possible integrated robotic CELS

Monarch FDA approved

Lap systems not FDA approved



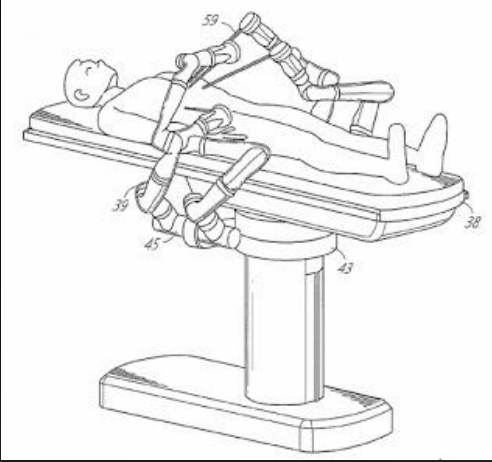
AURIS



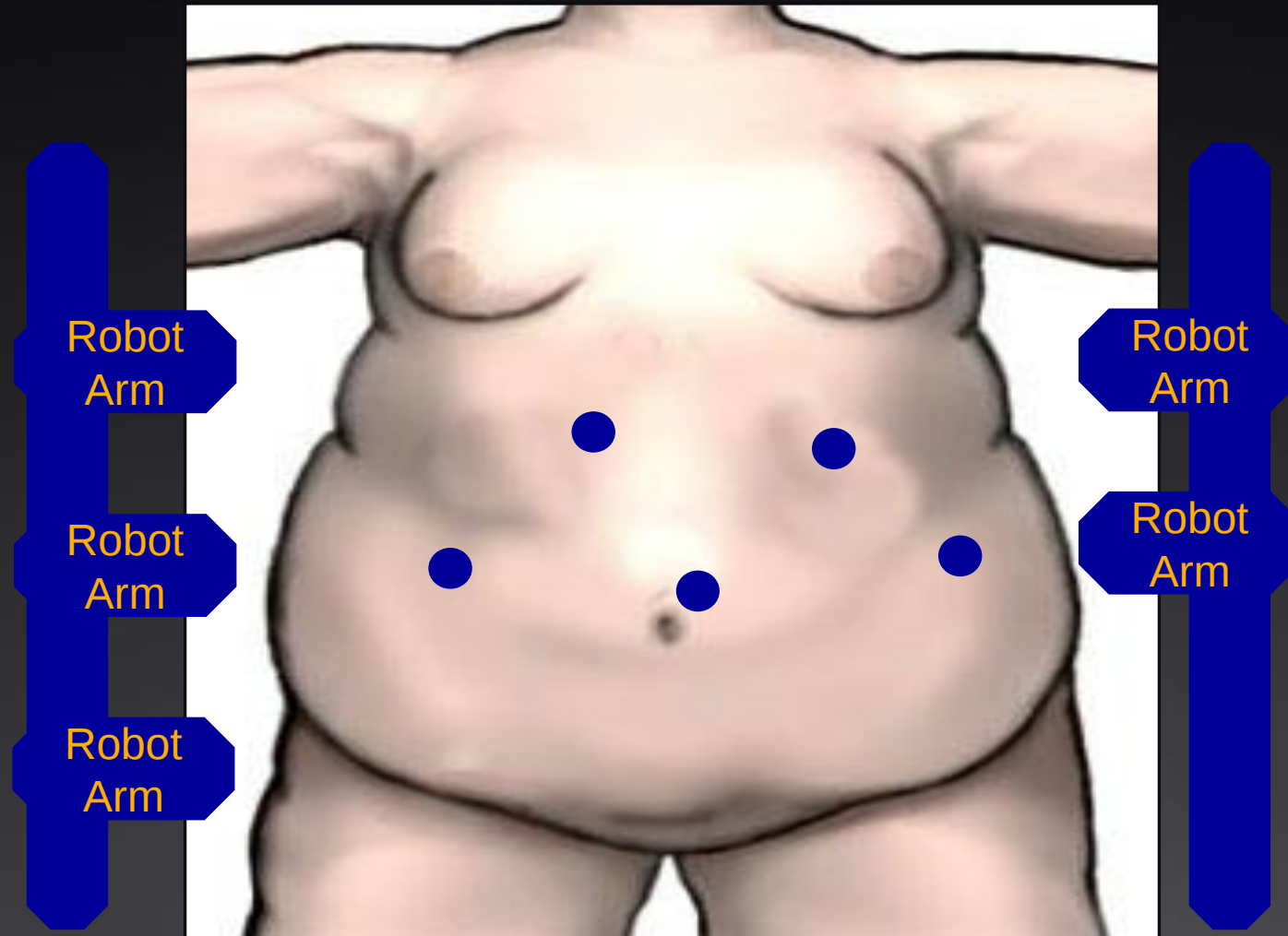
Table Mounted Arms

- * No surgical cart to move
- * External interferences can be physically managed currently by the table but also software management is an option
- * Table motion mechanically integrated
- * Easy potential software recognition of arms in relation to each other
- * One arm's down you can't swap it unless the table has extra arms
- * Less limitations on multiquadrant access: Easy left side vs right side, easy upper vs lower abdomen
- * Table system not as large potentially for stability and smaller footprint or no footprint larger than the bed

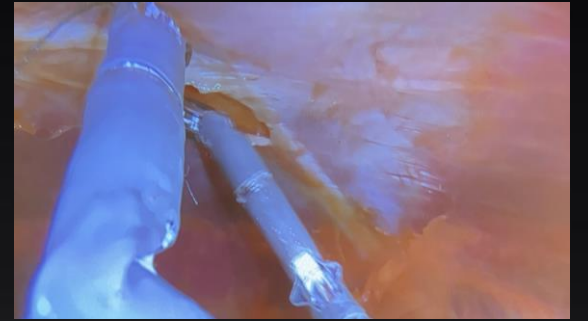
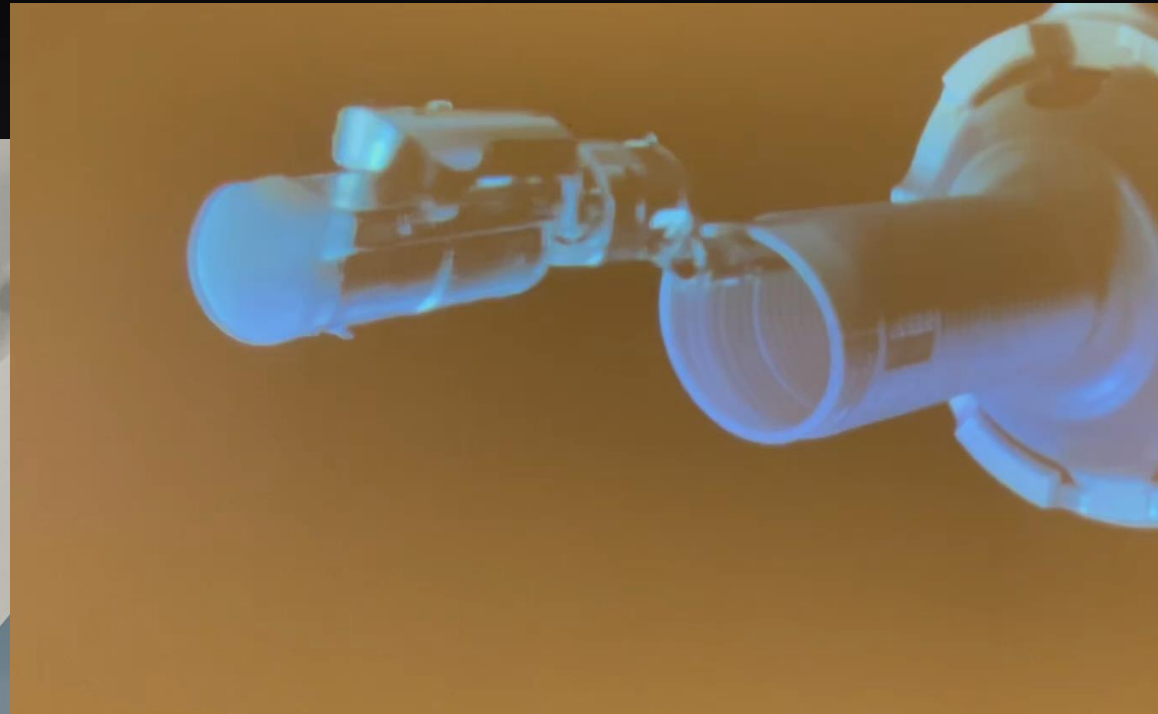
Johnson & Johnson: Auris/Verb



Foregut for Table System



Single Port



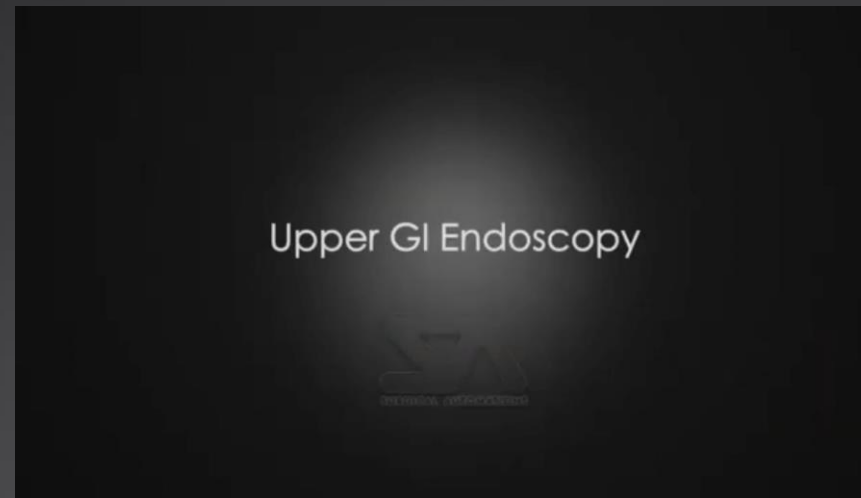
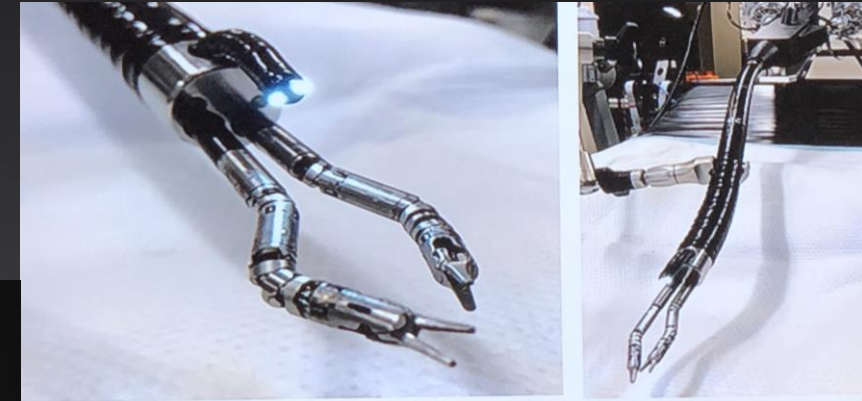
- Flexible shafted transoral or transanal with robotic driven camera
- Passive instruments evolving to active instruments
- Involved in first Robotic CELS (combined endolumenal laparoscopic surgery) cases



Endolumenal Robotics

- 3 arms in 1 flexible port
- Open surgeon console
- Limited excursion of arms
- Goal towards 15mm diameter and long length

- Table based designs and cart designs
- Endolumenal designs too
- Possible integrated robotic CELS with Verb



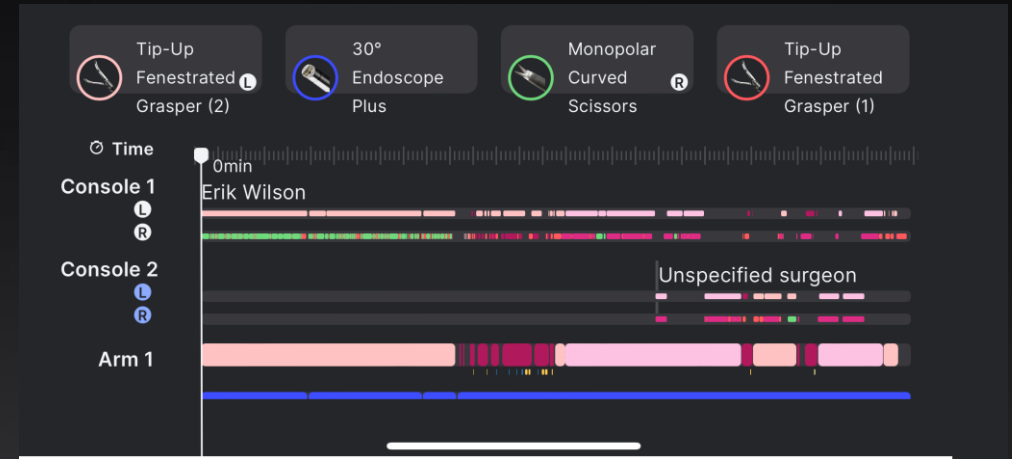
Opening the Black Box in the Operating Room

Acquire the data

Classify it (annotate and segregate)

Analyze it (self, experts,
cloudsourced, machine learning)

Make it useful



OR Black Box

Proximie

Theator

Touch Surgery

CSATS

Activsight

Versius

Orpheus

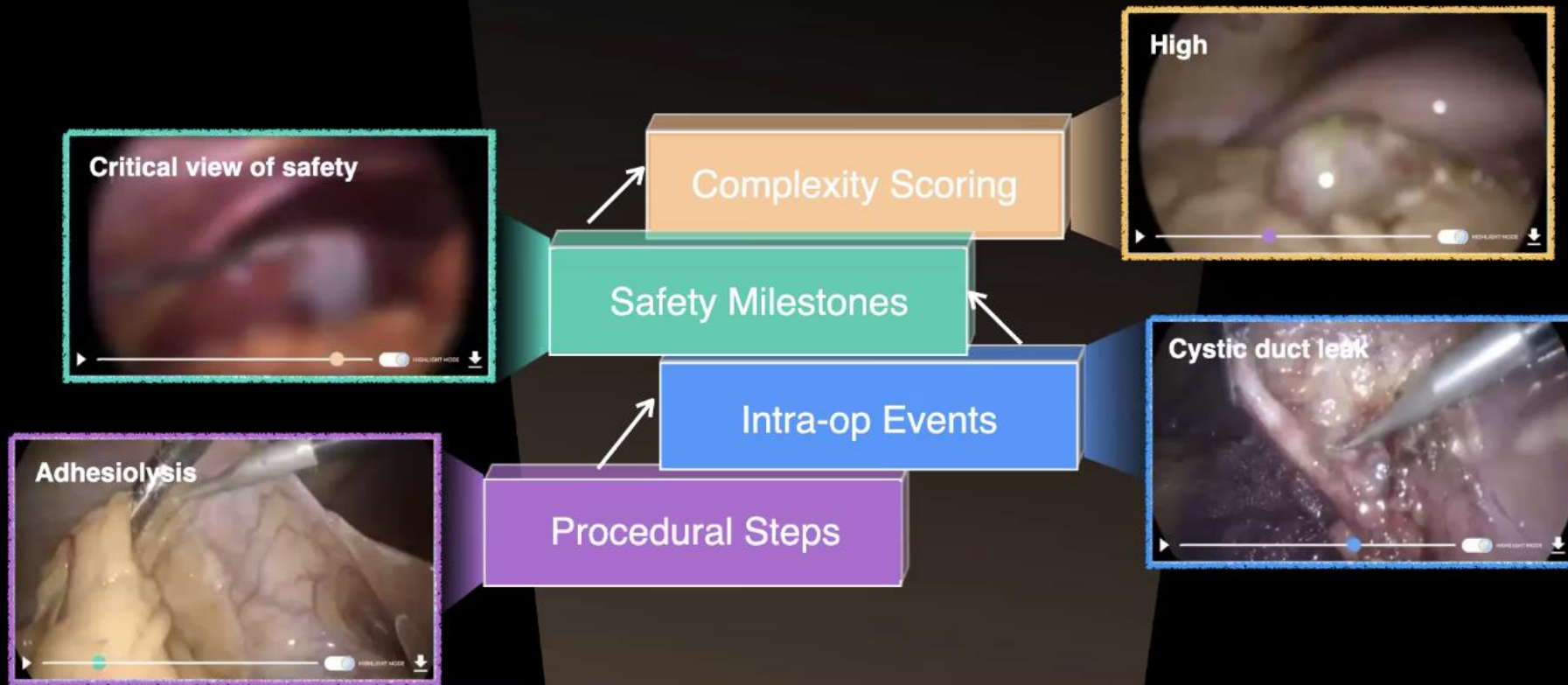
Apella

Artisight

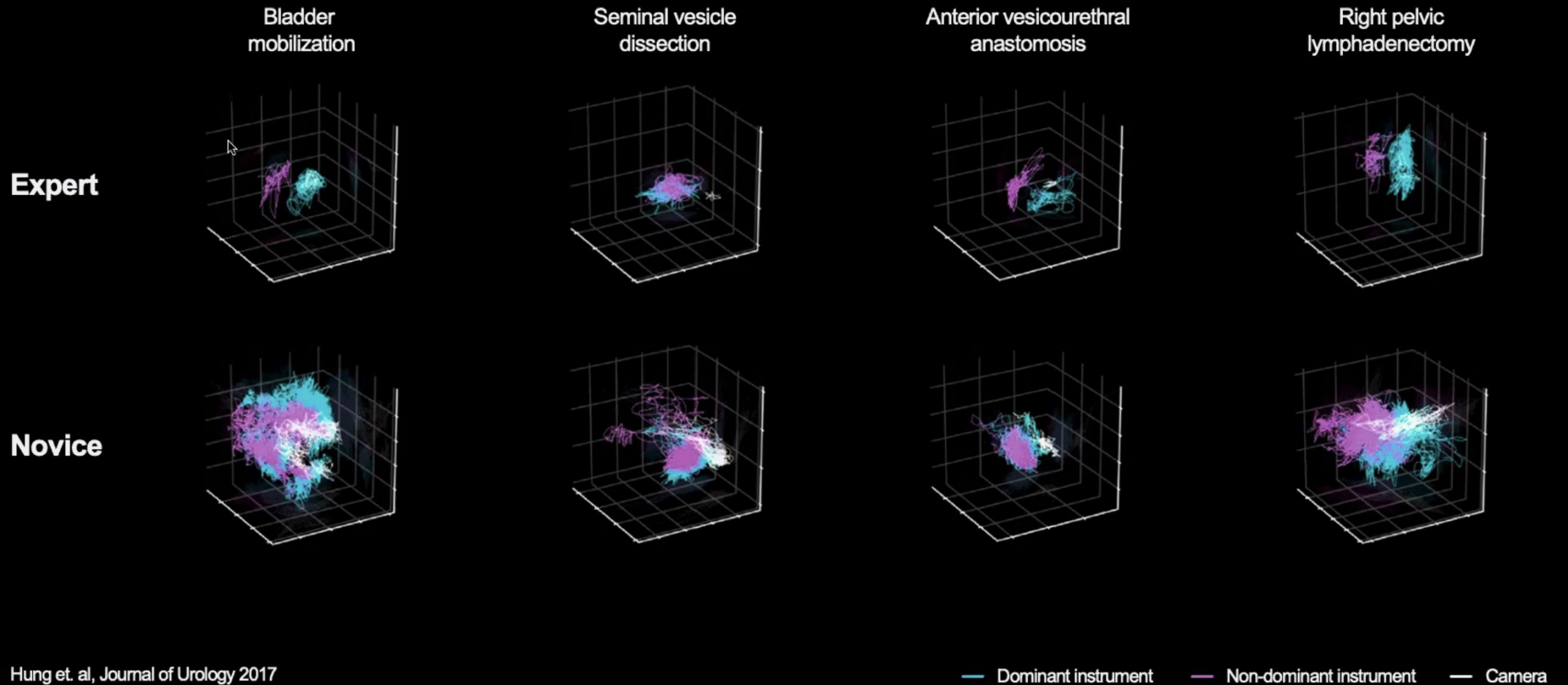
CareSyntax

- Intraoperative video recording, streaming and live tele-mentoring, storage and annotation—all HIPAA
- Environmental cameras and audio
- Ancillary clinical data
- Intracavitary algorithmic focus
- AI powered performance analysis and segmentation vs crowd sourced analysis
- Hardware agnostic or vertically integrated
- Augmented reality powered remote feedback
- Robotically integrated with telemetry and kinematic data
- Phone apps

Accurate data structuring and annotations



Task based instrument & camera trajectories: Expert vs. novice



Robotic Objective Performance Indicators

Completion time

Camera activation count

Camera control duration

Camera distance traveled

Instrument distances and trajectories

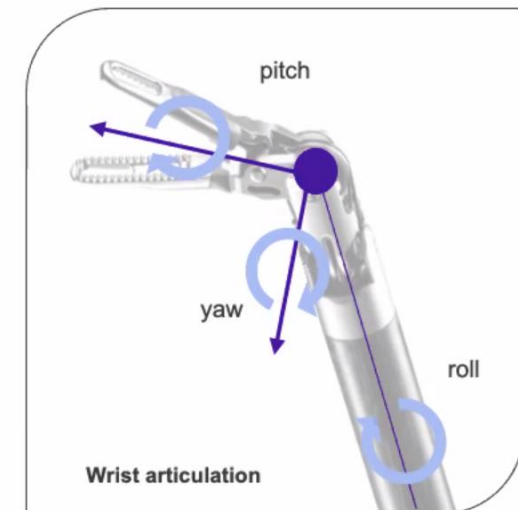
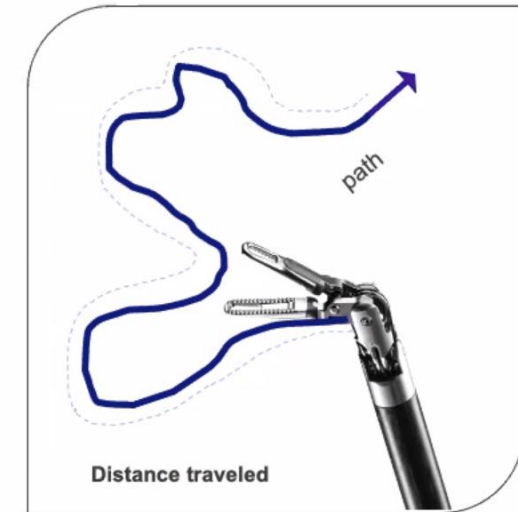
Movement speeds

Third arm swap count

Ratio of dominant / non-dominant arm use

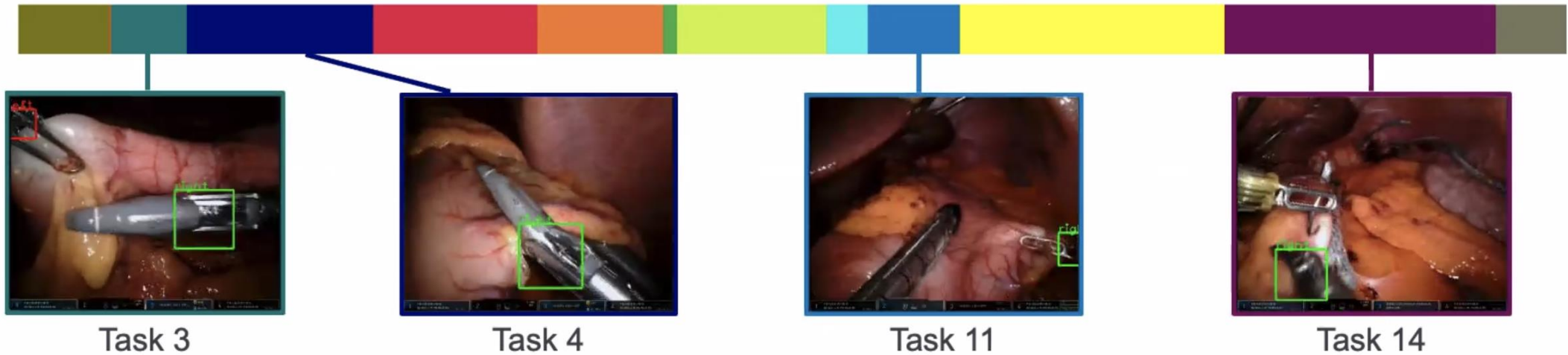
Wrist articulation

Instrument idle time

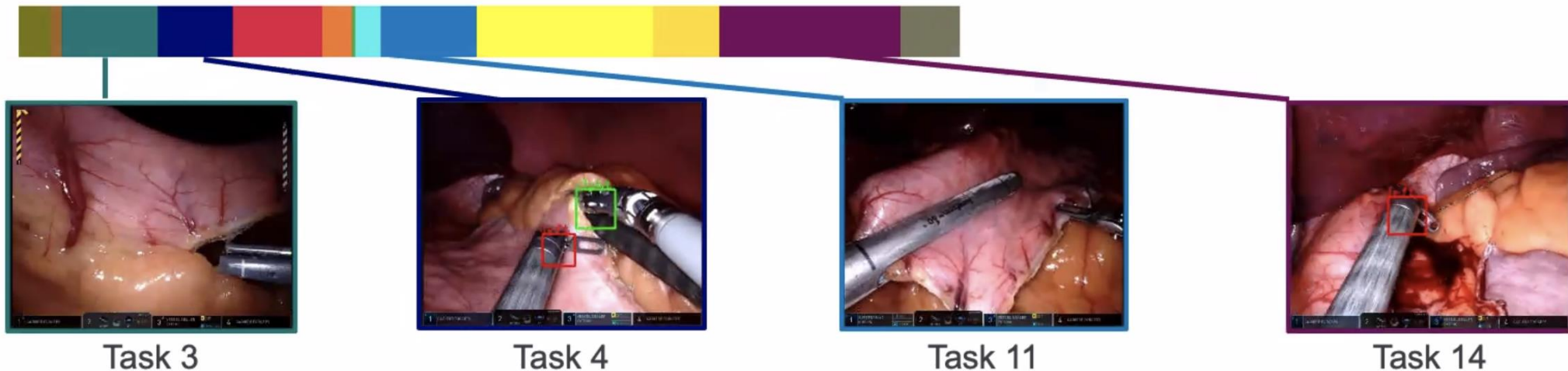


Machine Learning Task Recognition

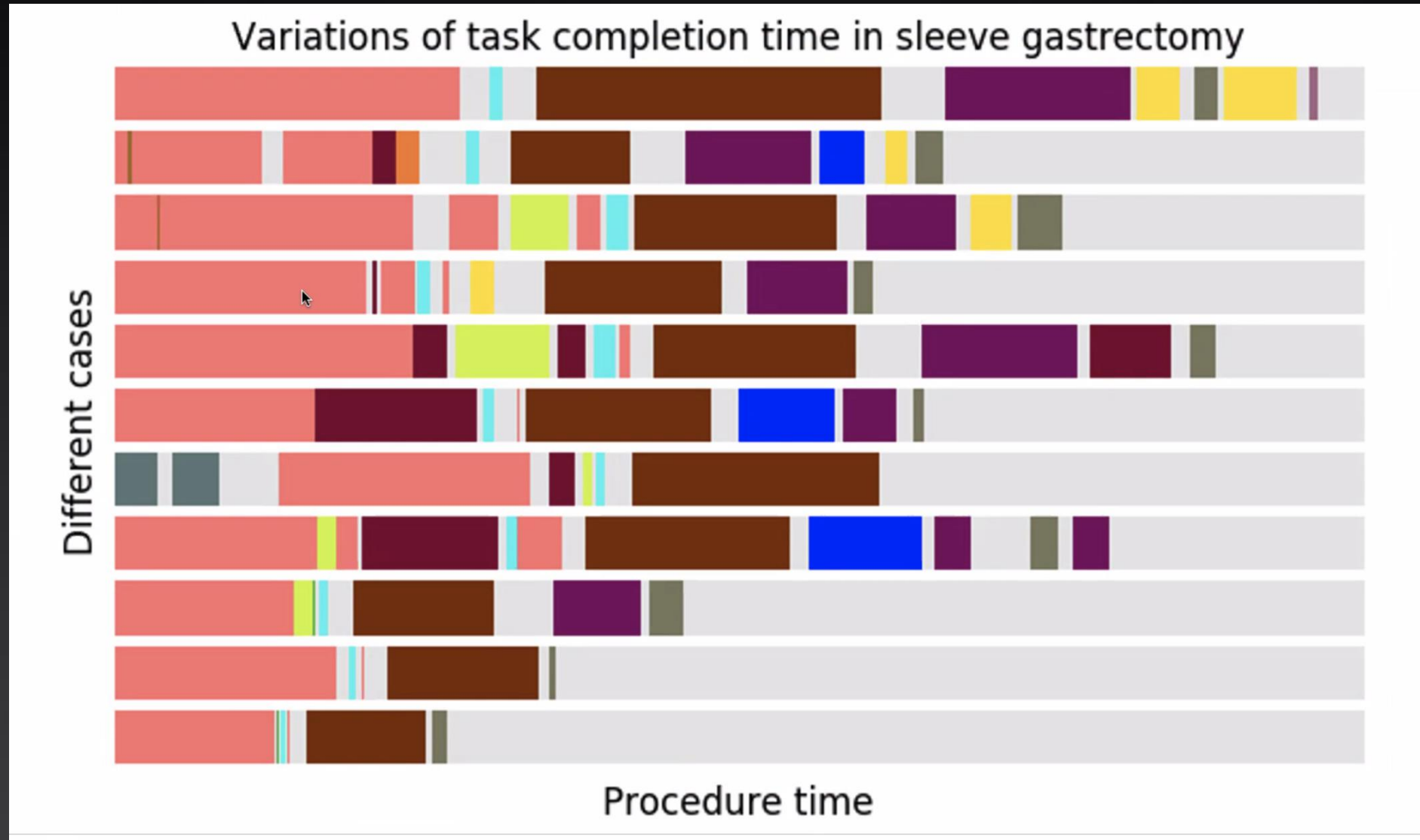
Inexperienced:



Experienced:



Algorithms to Identify Workflow Variability



Conclusion

It makes surgery better more most surgeons but not every surgeon, it raises the floor and raises surgical skill set in difficult situations

It hasn't changed dramatically in its form and function in 20 years—but lots of welcome changes likely soon

- * The drive to more minimally invasive with smaller and fewer access points and endolumenal will be led by robotic platforms—combined approaches (CELS)
- * Task specific vs specialty specific vs procedure specific digital platforms are all being developed.
- * Ergonomics is something the next generation of surgeons seriously care about
- * Autonomy is something the young surgeons need
- * Kinematic data is very powerful and justifies robotic platforms
- * Robotic platforms are hard to make and hard to make better but that's not stopping massive efforts and investments in new platforms

Thank You

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THE UNIVERSITY of TEXAS
Health Science Center at Houston

