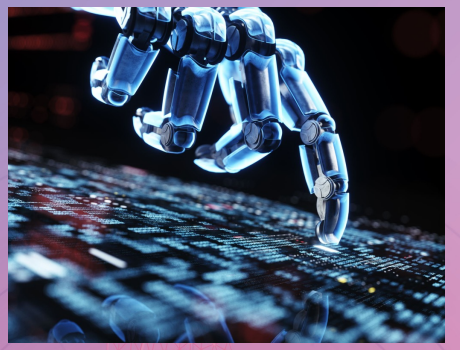
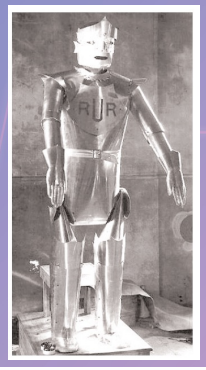
Past, Present, and Future of Robotic Heart Surgery



Bob Kiaii MD, FRCS, FACS
Professor and Chief of Division of Cardiac Surgery
Department of Surgery, UC Davis Health
Sacramento, California, USA



DISCLOSURES

Consultant with:

- Medtronic
- Abbott
- Corcym
- Johnson and Johnson

History

- Aristotle was first to bring the concept of Automation.

“ If every instrument could accomplish its own work, obeying or anticipating the will of others…if the shuttle could weave, and the pick touch the lyre, without a hand to guide them, chief workmen would not need servants,….”

Fourth century B.C.

History

- 1350 automated roaster on Cathedral in Strasbourg, France
- 1920 Term Robot first appeared
  - Czech word for serf (robota)
  - Attributed to Karel Capek for
    - Rossum's Universal robots
    - A play where all labor performed by machines freeing man to enjoy life of leisure

History

- 1942 Isaac Asimov -- Robotics in“Runaround”
- Three Laws:
  - 1. Robots may not injure a human being or allow to come to harm
  - 2. Robot must obey the orders given by human being except if conflicts first law
  - 3. Robot must protect its own existence as long as no conflicts with first and second law

History

- 1951 Raymond Goetz--the first teleoperated articulated arm for the Atomic energy Commission
- 1954 George Devol-- first Programmable robot
- 1962 General Motors Installed robots onto production.

History

- 1974– NASA use of Robotic Arms
- 1980– Fujitsu in Japan first totally automated factory
- 1980’s – Rational for a surgical robot was science fiction
  - Military Intention “ A Doctor in every Foxhole”
  - Severely wounded soldier in battlefield be treated in an ambulance equipped with a robot by surgeon in a Mobile Army Surgical Hospital
  - NASA similar vision, a terrestrial physician able to remove an acutely inflamed appendix from a patient in a robot-equipped space station

Surgical Robots

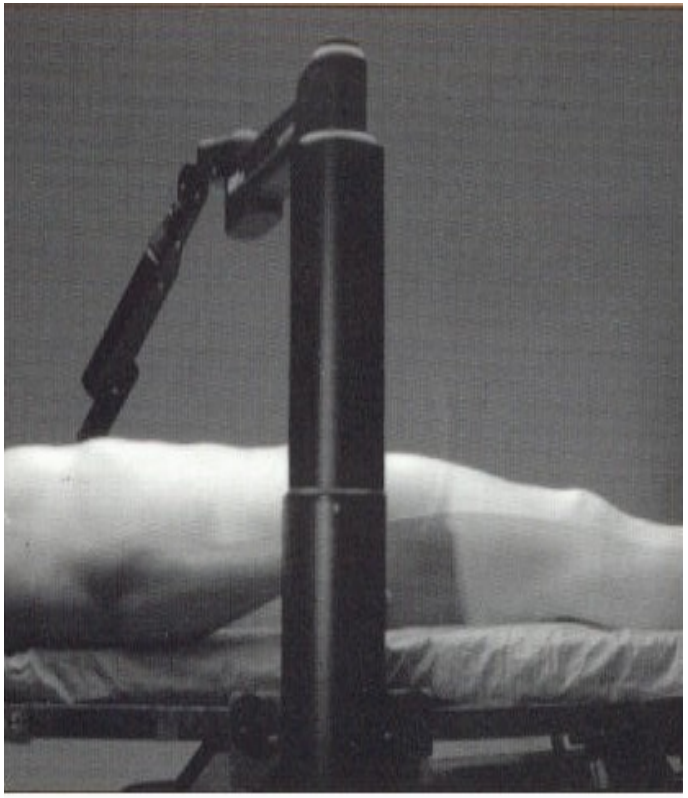
- 1989– Yulun Wang, PhD founded Computer Motion Incorporated
  - 1993 AESOP
  - 1996 First voice controlled robot cleared by FDA
  - 1998 ZEUS Robotic Microsurgical System

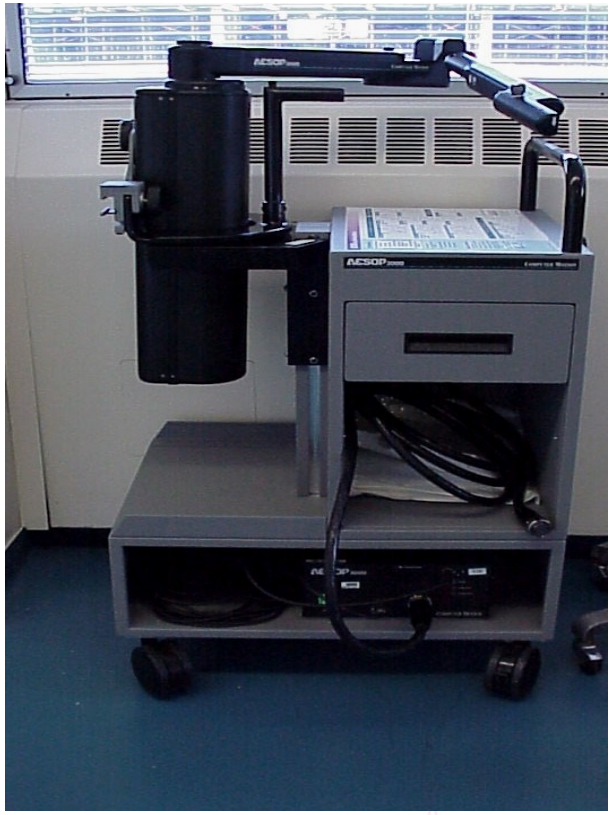
Robotic Telemanipulation Systems

- 1995– Fredric Moll, MD, Robert Young, and John Freund, MD, formed intuitive surgical

PAST

AESOP





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AESOP

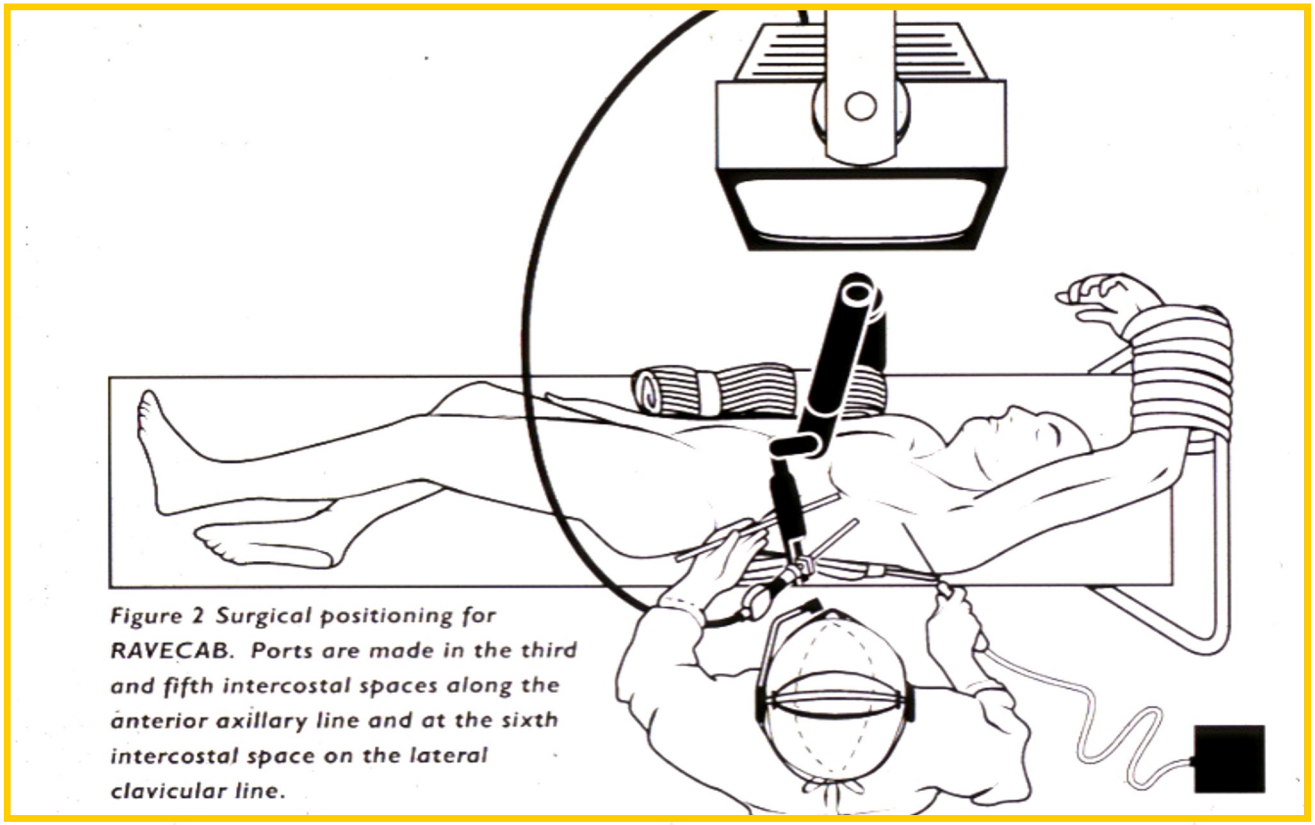
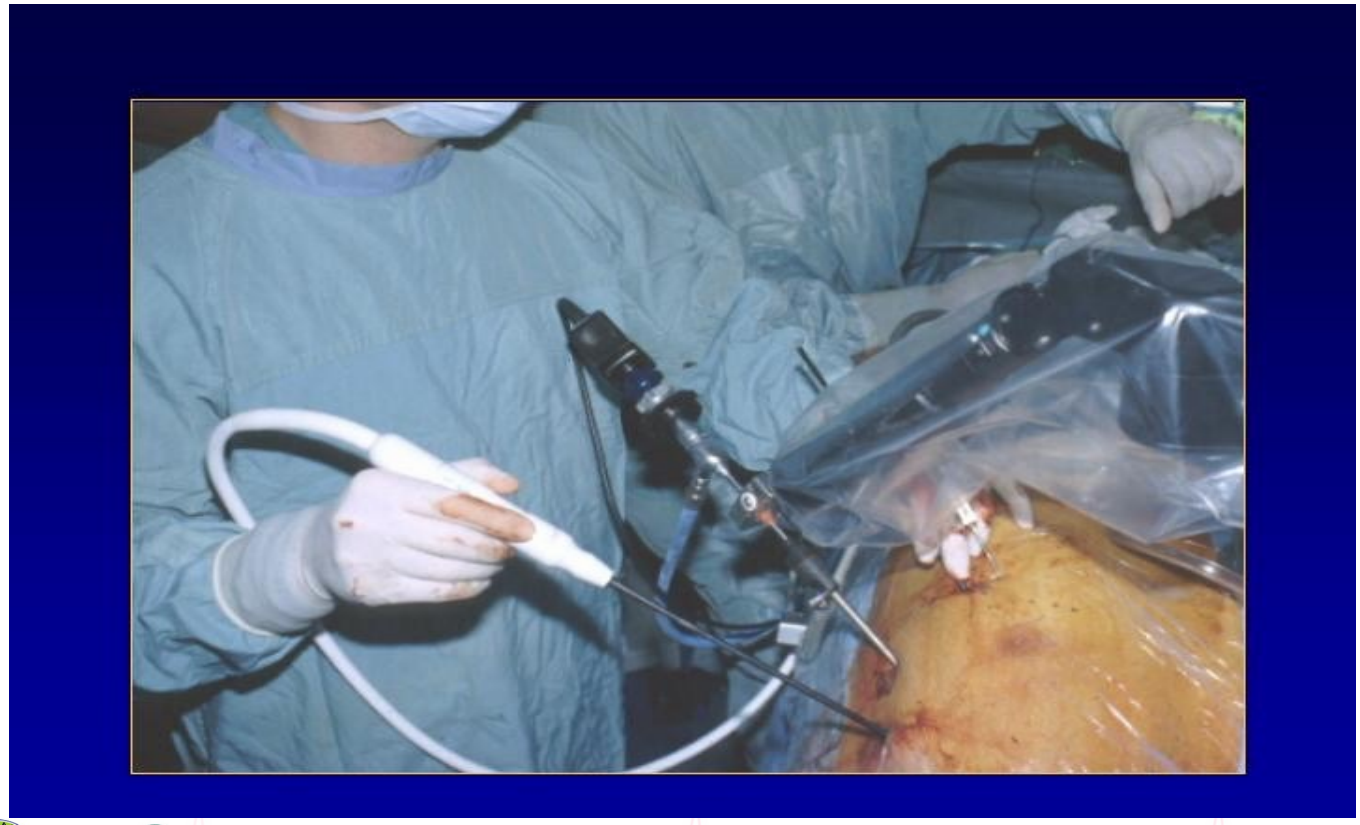
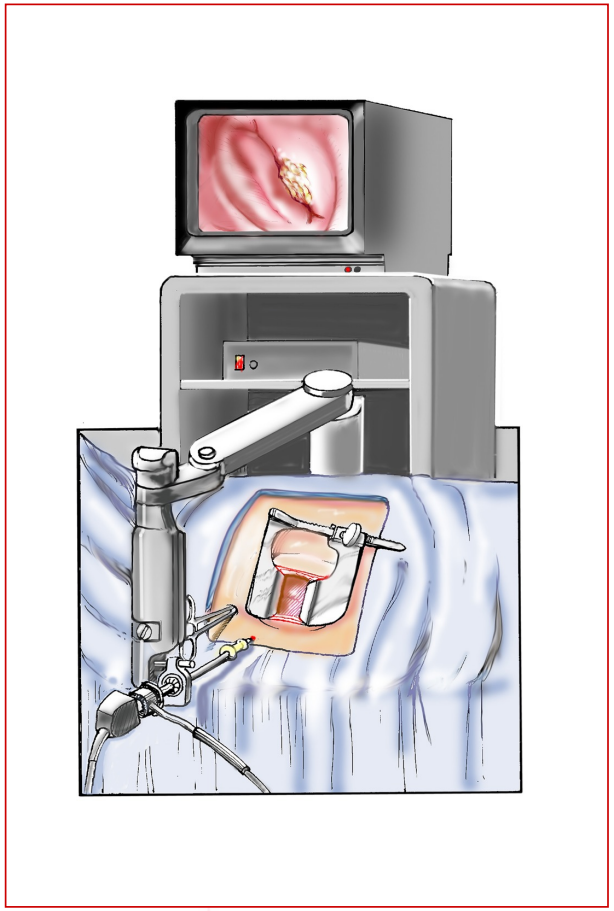
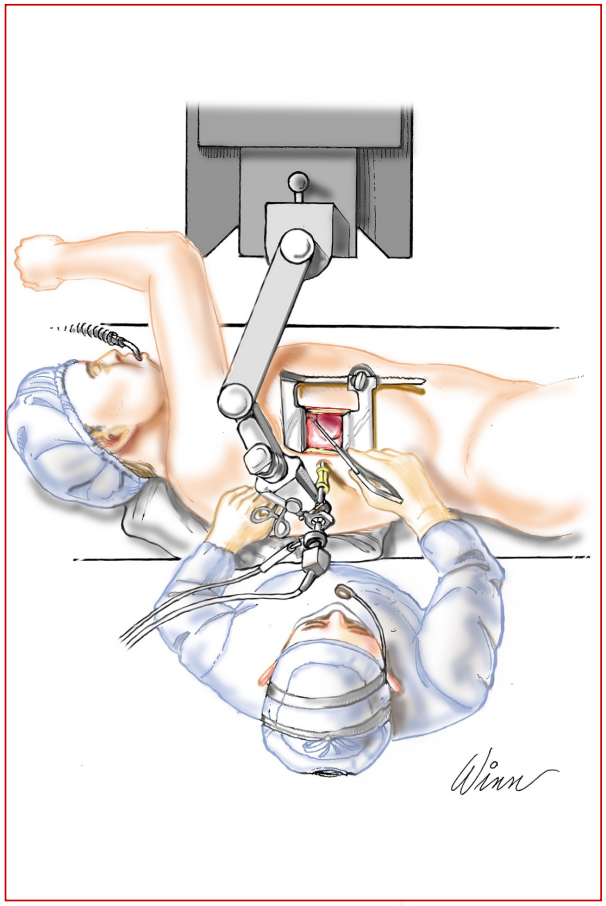


Figure 2 Surgical positioning for RAVECAB. Ports are made in the third and fifth intercostal spaces along the anterior axillary line and at the sixth intercostal space on the lateral clavicular line.

AESOP







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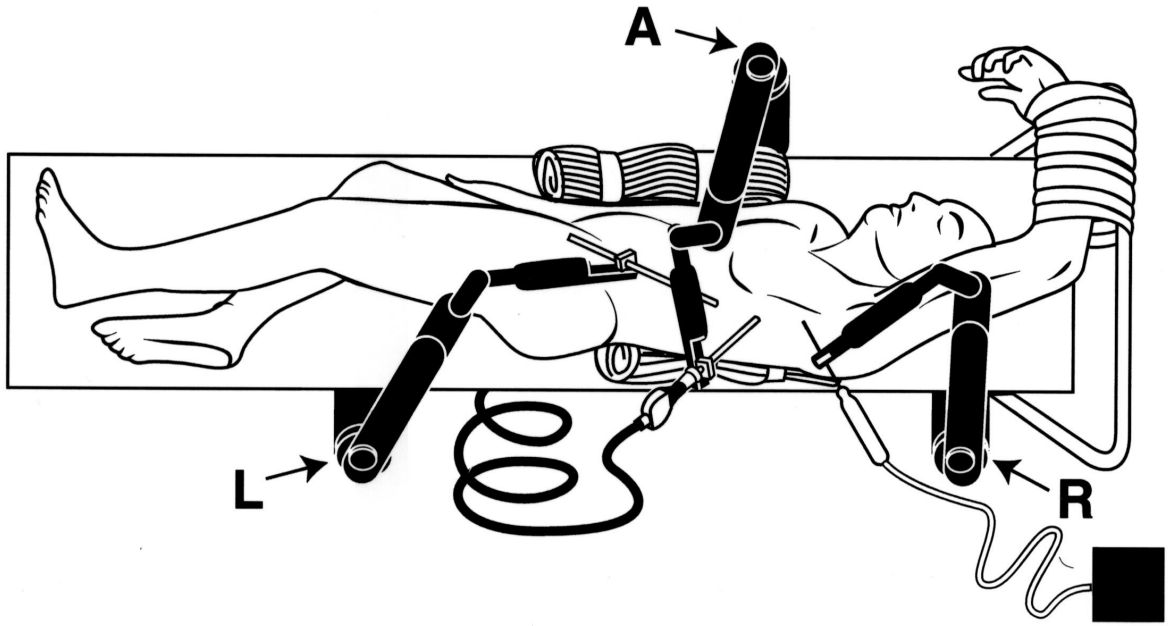
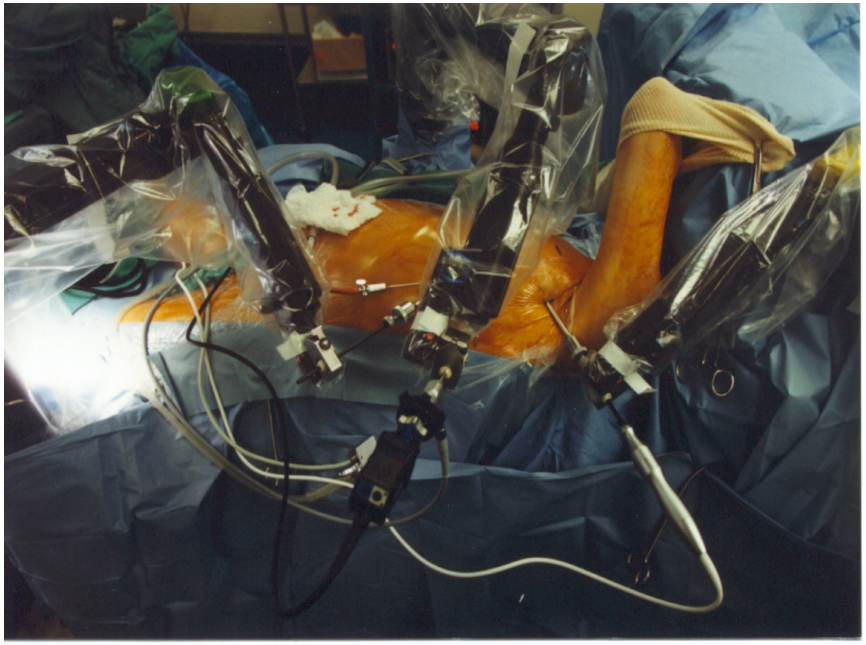
ZEUS



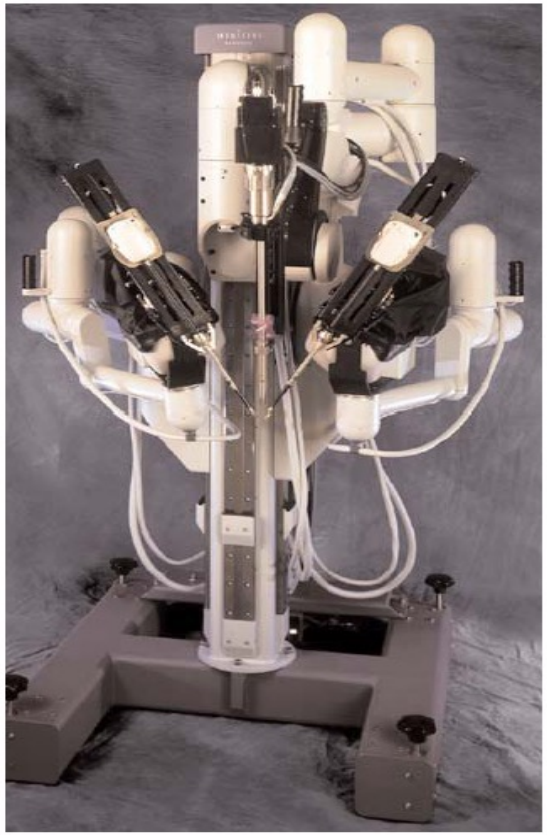
ZEUS



Microwrist Handle of ZEUS

Surgical Robots

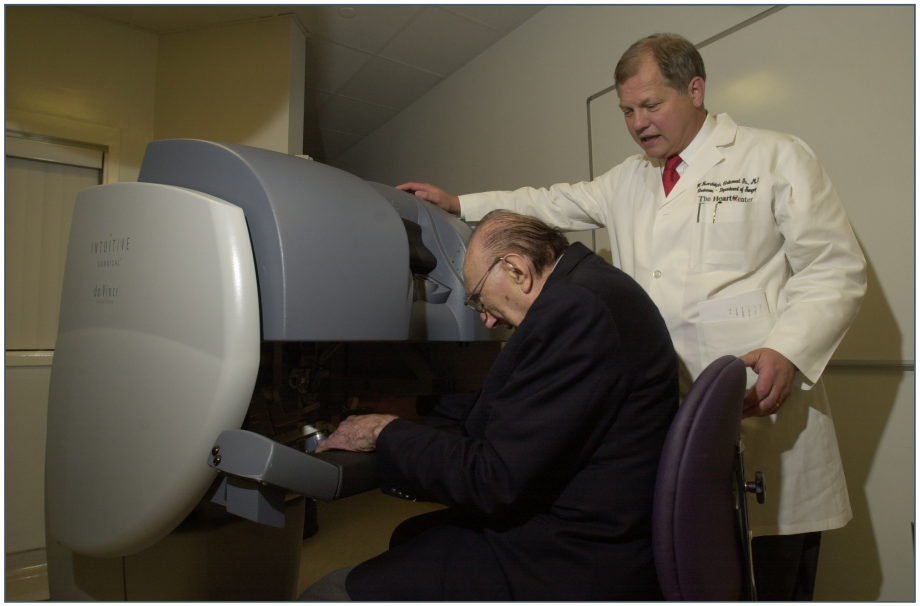
- A collection of wristed “servant” tools called manipulators receive digital instructions from interfaced computer, monitored by “bed-side” surgeon



Surgical Robots

- The “master” surgeon sits at the ergonomically designed video console with 3-dimentional display
- Digital instructions from sophisticated hand grips with seven degrees of freedom (pitch, yaw, “pincer-like” movements)

97 Year Old Surgeon



Dr. Michael DeBakey and da Vinci Robot

PRESENT

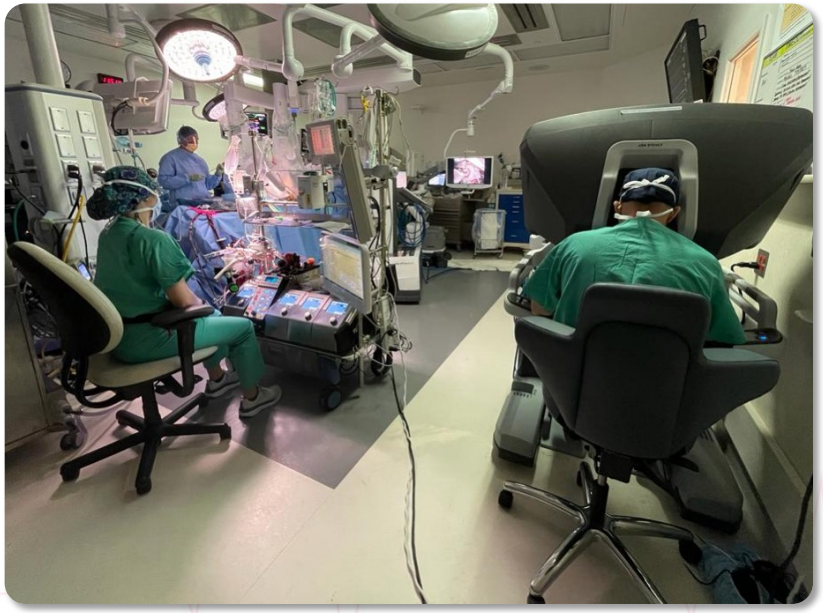
da Vinci Robotic System only Approved for Cardiac Surgery

Benefits

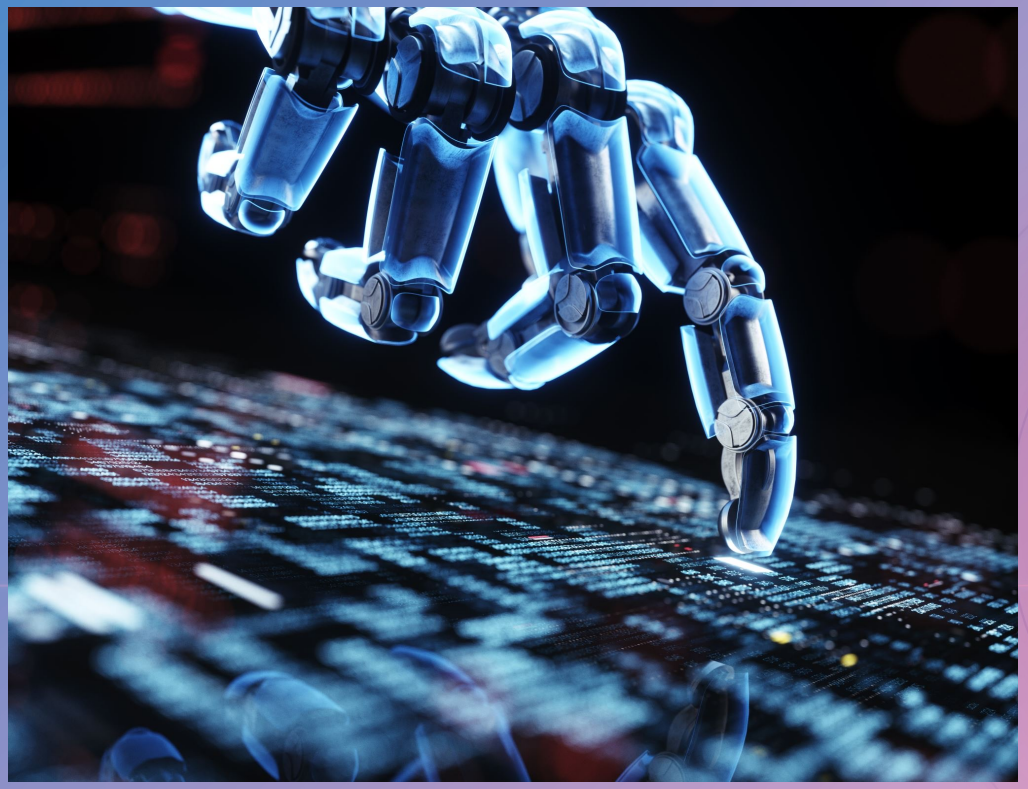
- Enhanced 3D - HD imaging – Depth perception
- Improved dexterity
- Greater Surgical Precision - Tissue planes able to be visualized more clearly
- Improves access in unaccommodating places
- Increased range of motion
- Reproducibility

Present Cardiac Procedures

- Endoscopic Coronary artery Bypass
  - MIDCAB, TECAB
- Mitral Valve Surgery
- Atrial Septal Defect Closure
- Removal of Left Cardiac Tumors
  - Myxoma
- Left Atrial Appendage Ligation
- Epicardial Ventricular Lead Placement



FUTURE



Potential of Robotics in the Future

- Training - Acquired Data insights will enhance technology training for surgical residents and fellows
- Enhance and Augment surgeon capabilities
  - Marriage of advanced hardware, software, and digital intelligence to enhance surgeon senses
  - Informed, real-time decision making, and help advance the possibility of ever more positive and reproducible patient outcomes for surgeons and care providers.
  - Augment, inform, and extend surgeon and care team capabilities.
  - Enhance surgical outcomes by reducing injury to important structures

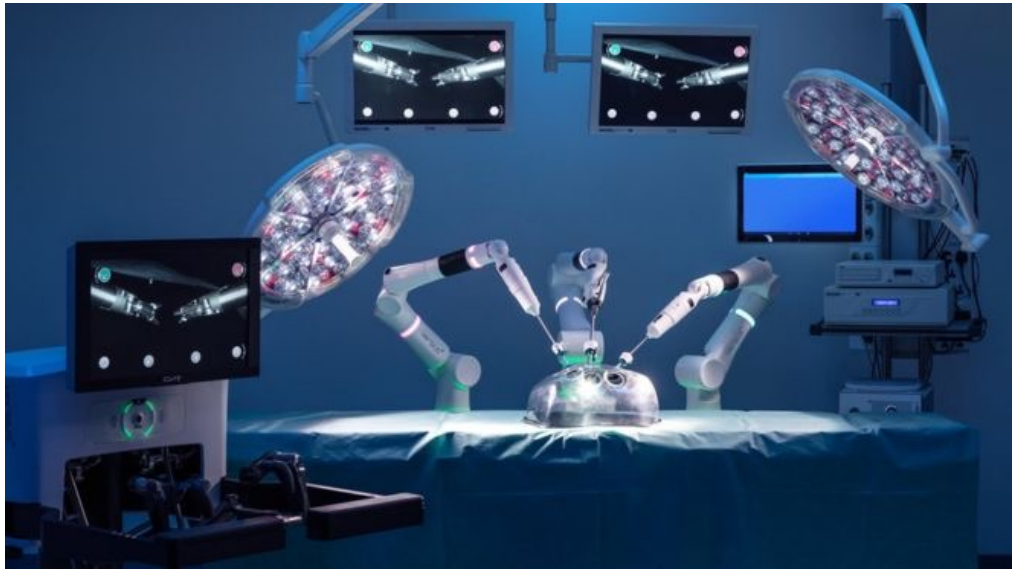
Capabilities of Robotics in the Future

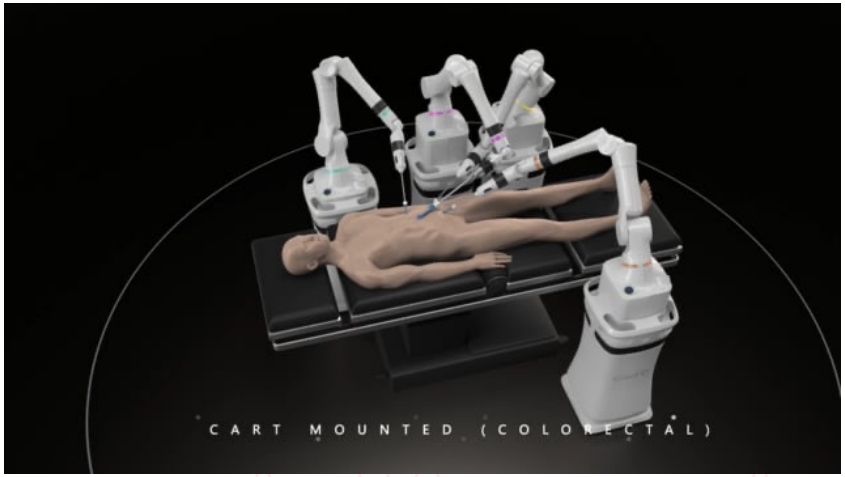
- Technology-enabled and digitally interface
- Augmenting sensory information while the surgeon is using robotic instruments

- Tremendous potential to harness future innovations:
  - Artificial intelligence (AI), Machine learning (ML), and
  - Advanced visualization to address Challenges facing surgeons, physicians, care teams, and the institutions where they practice.
  - Perform complex procedures with greater assurance

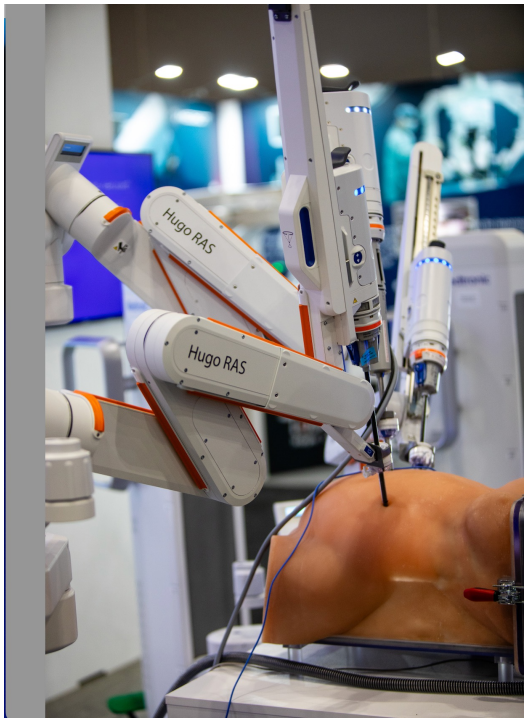
Future of Robotic Platforms

Cambridge Medical ‘Versius’ Robot





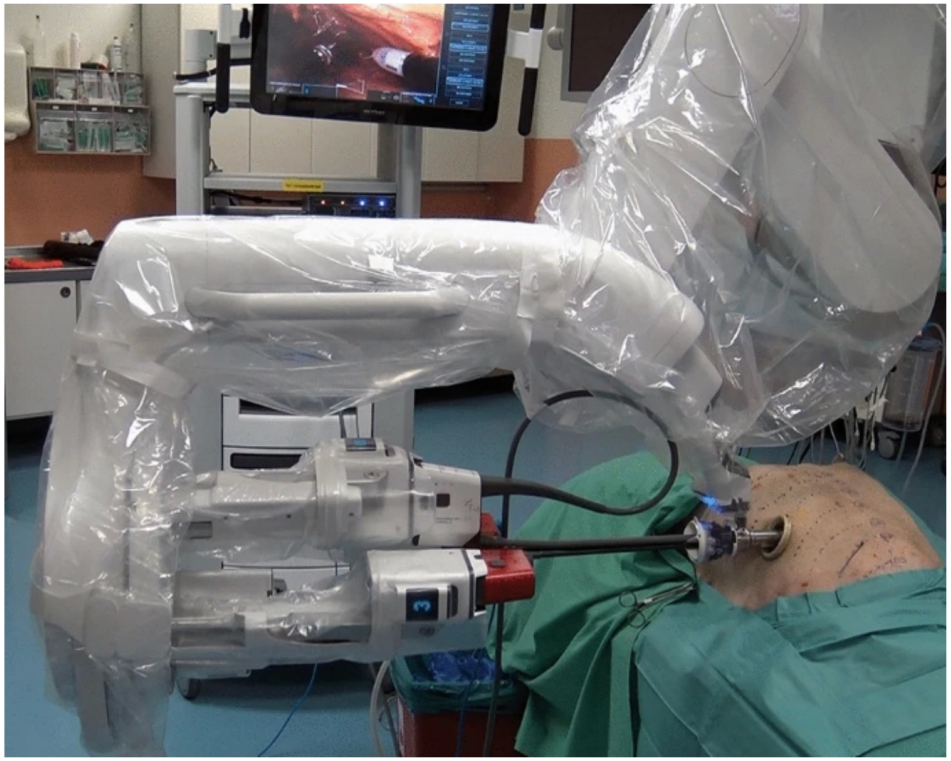
Medtronic Surgical Robot ‘Hugo’



Medicaroid Hinotori robot

Da Vinci SP (Single Port)

Da Vinci SP (Single Port)



Feasibility of bilateral internal thoracic artery harvesting using the da Vinci SP system

Hubert Stein & Volkmar Falk

Da Vinci SP (Single Port)

Feasibility of bilateral internal thoracic artery harvesting using the da Vinci SP system

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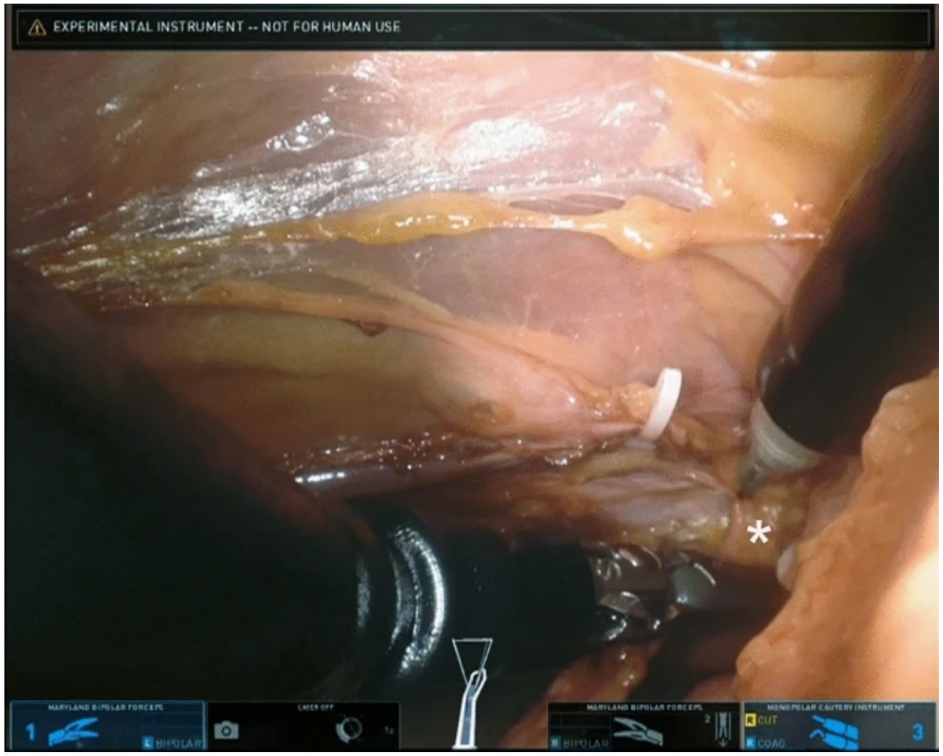
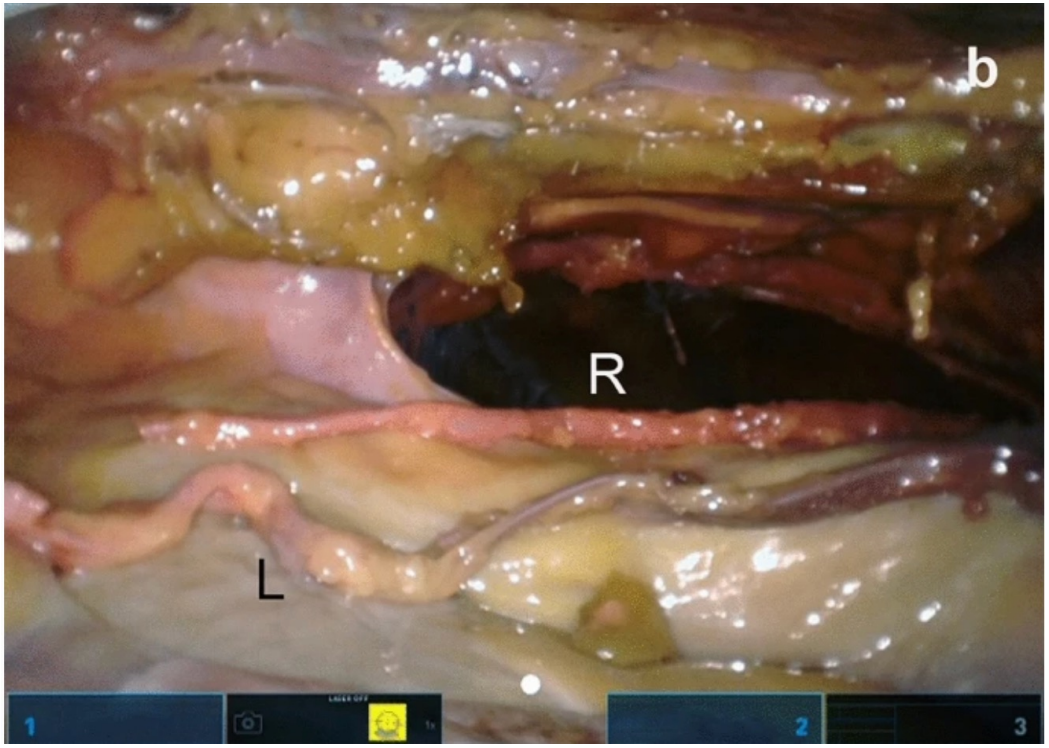
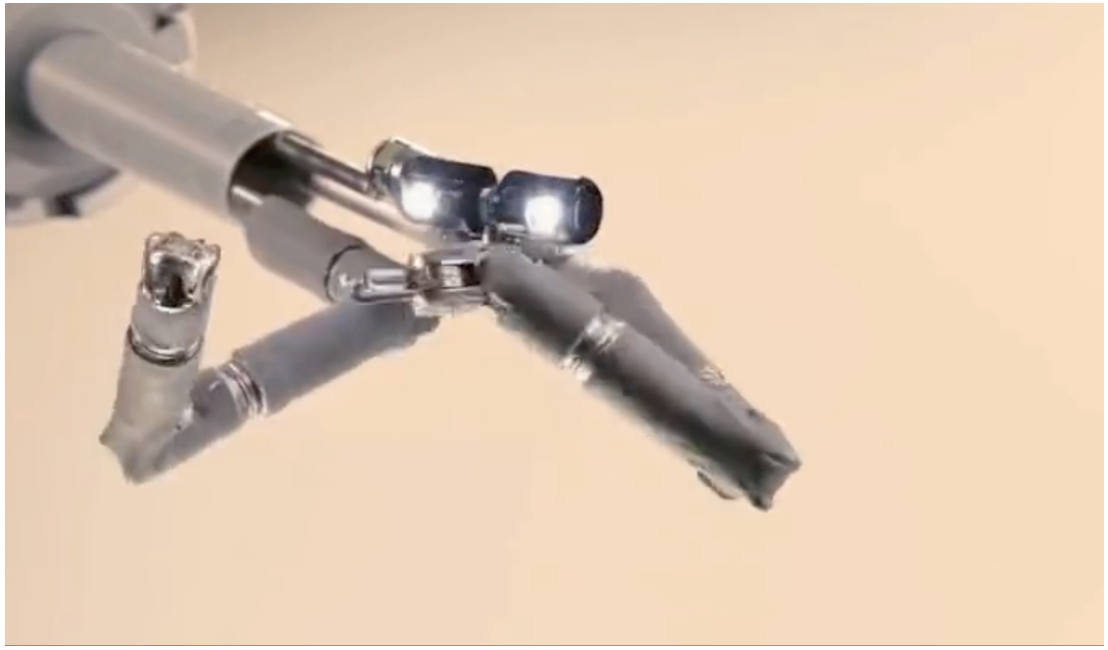
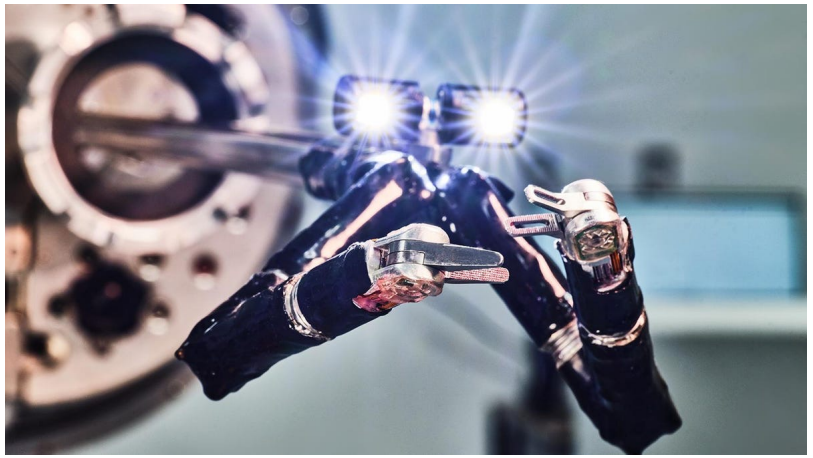




Shurui Single Port robot

Vicarious Surgical





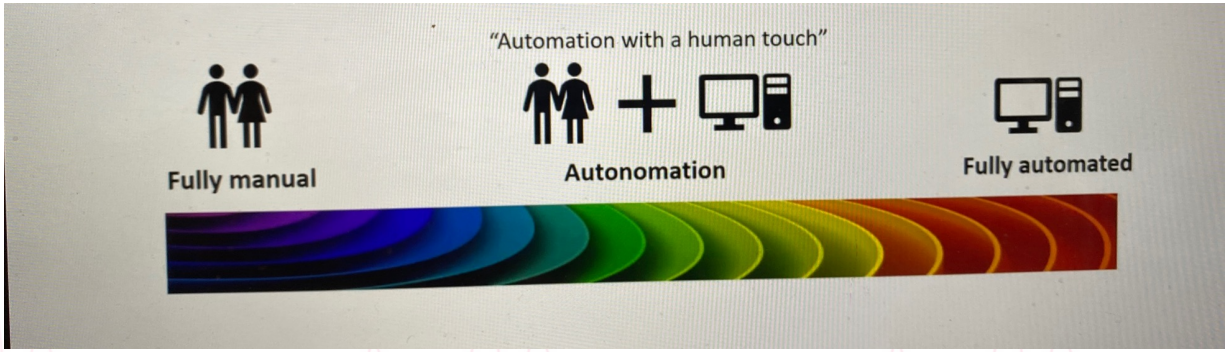
SSI Surgical Robot ‘Mantra’

Surgeon Console

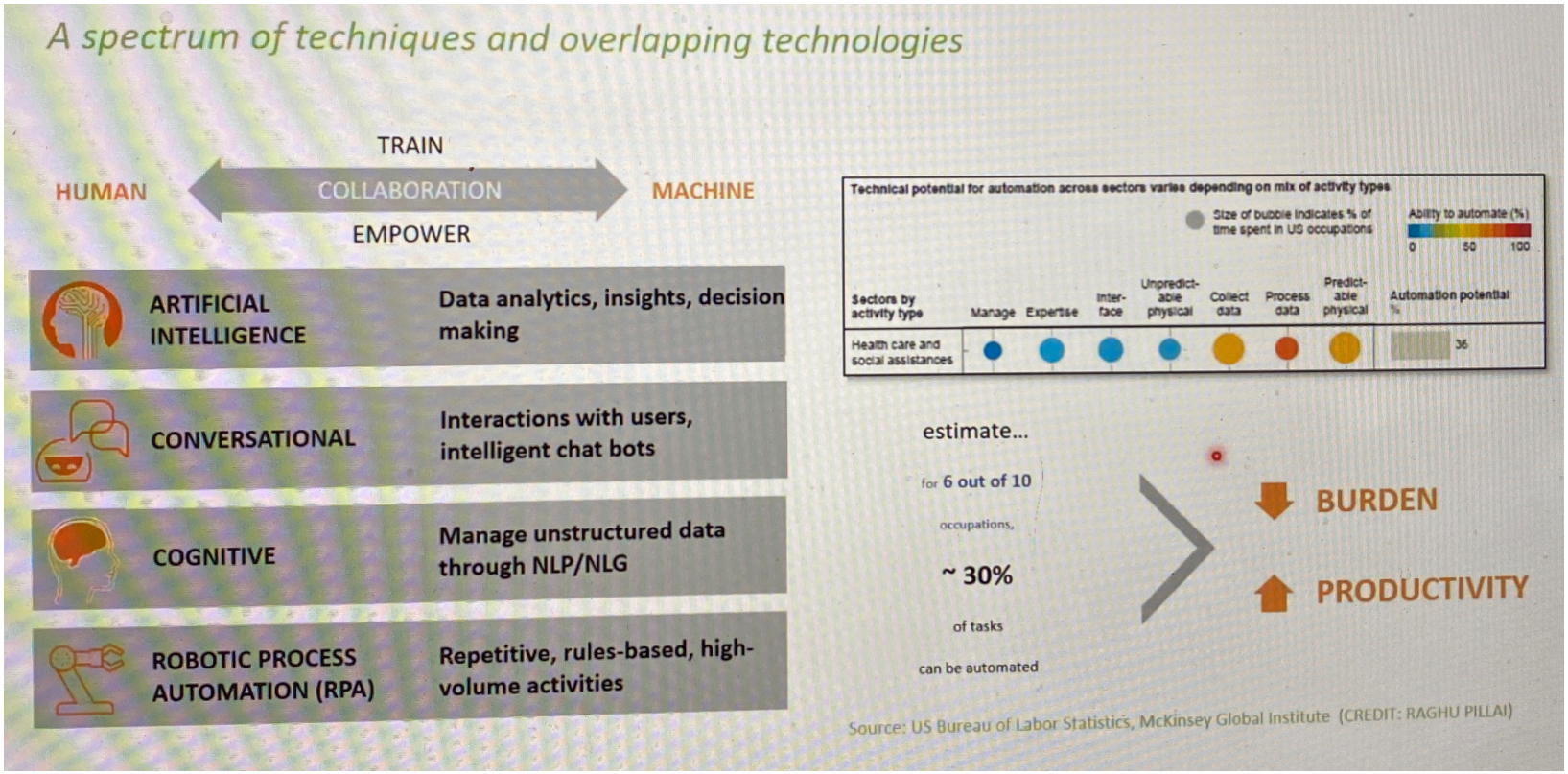
Vision Cart

Robotic Cardiac Surgery In the Future:
Computer assisted Surgery and Automation

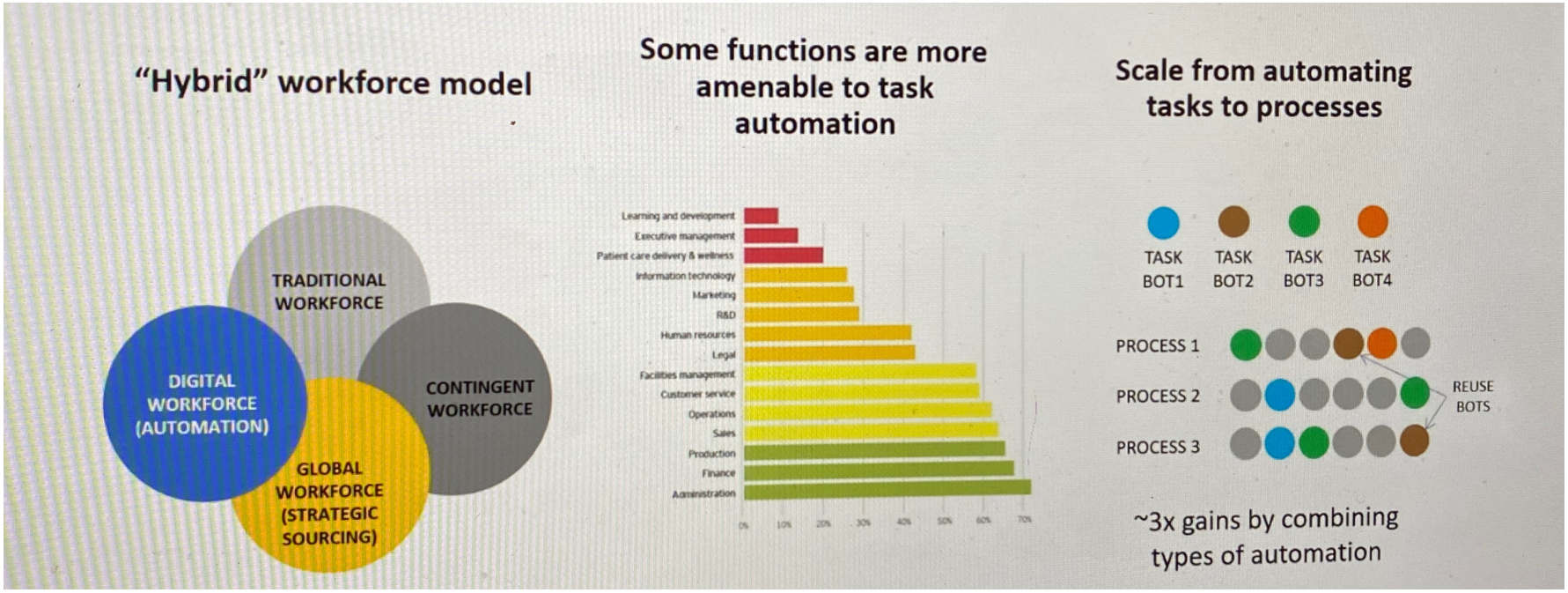
- Will Undergo Evolution with the addition of Automation
- Accept more risk taking and learn new approaches
- Advance from performing lower complex to more complex cases that address anomalies and complications.
- Automation will help reduce the impact of surgical variability and deliver better, more consistent outcomes.



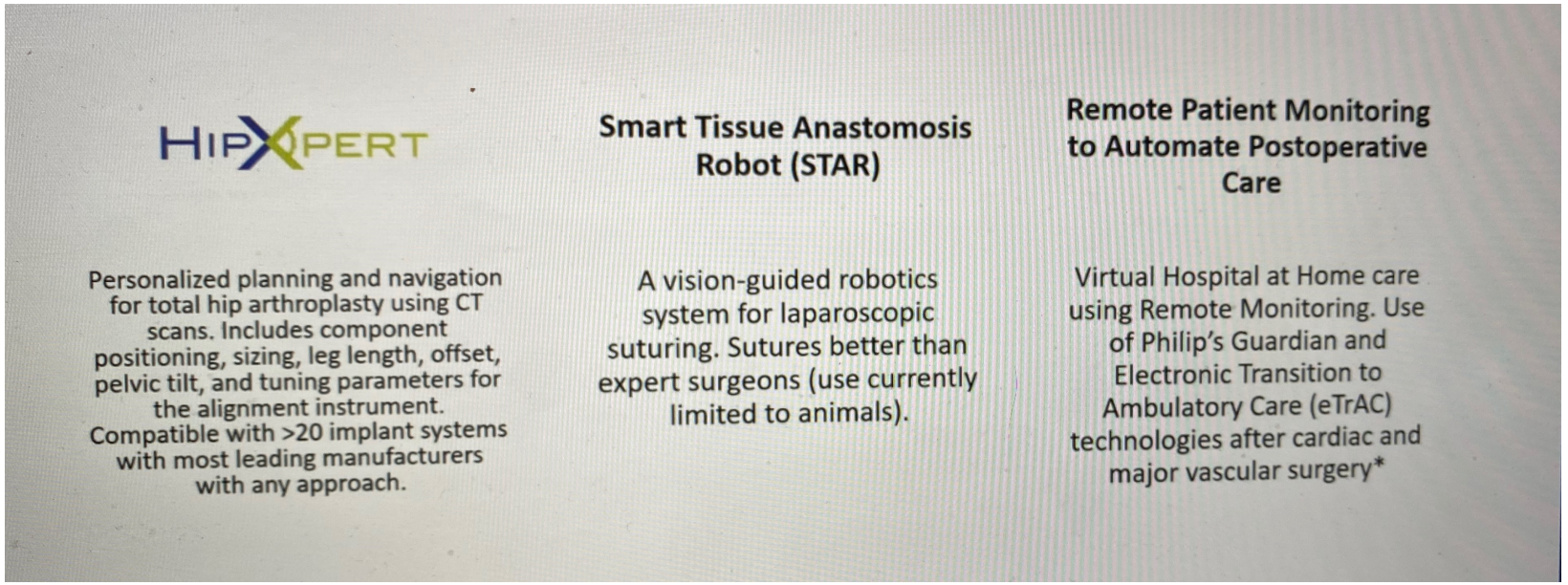
Automation and Artificial Intelligence
US Bureau of Labor Statistics



Hybrid Model of Automation



Automation And Surgeon



Robotics in The Future of Surgical Training

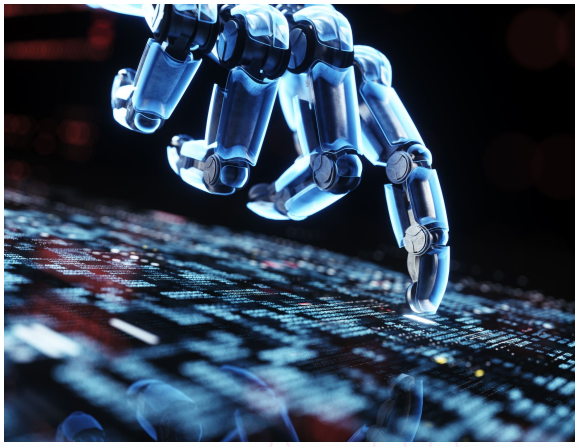
- The apprentice-based approach continues to hold tremendous value, it is also highly dependent upon student access to informed instruction.
- “See one, do one, teach one.” This has been the fundamental approach to surgical education for millennia
- Challenges
  - Availability of experienced surgeons to share their knowledge for new surgeons to hone their skills
  - The variability among educators can make it hard to prescribe detailed and objective training measures

Robotics to enhance training

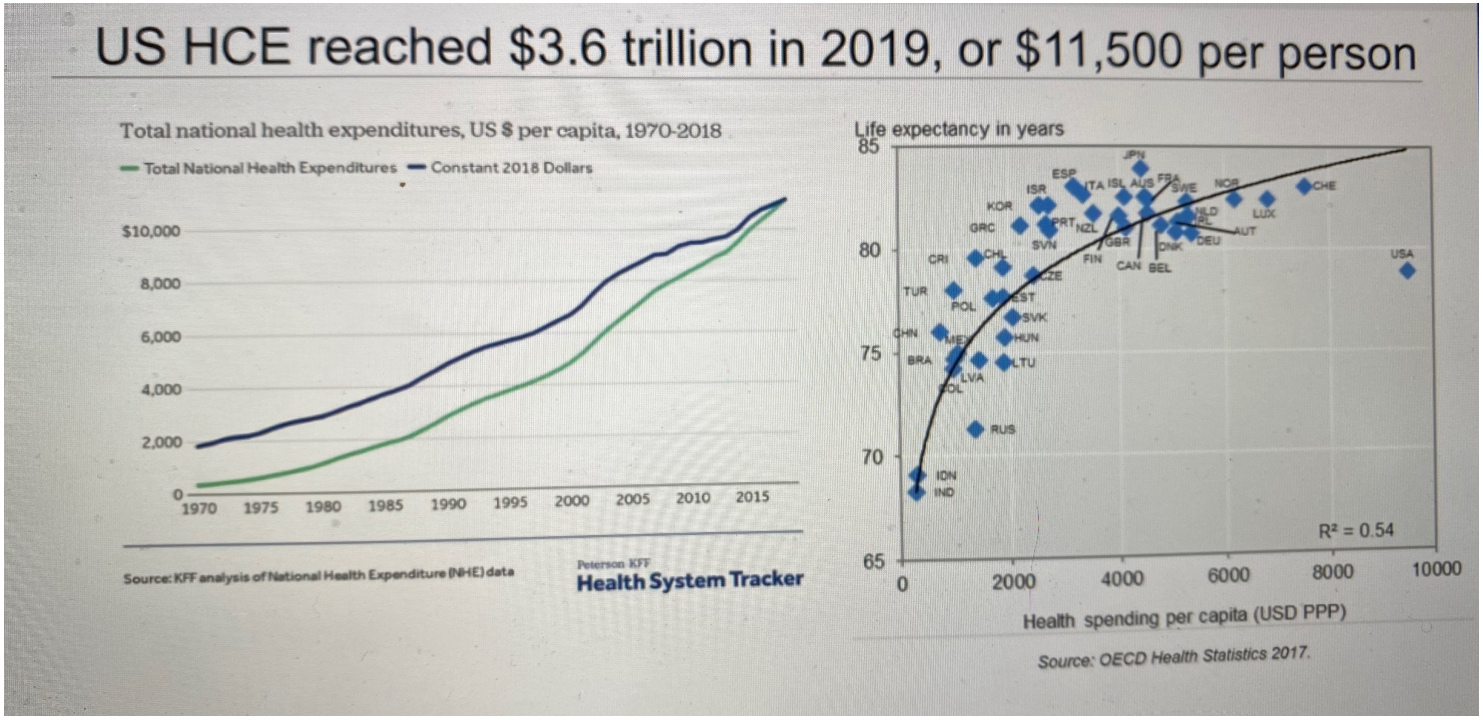
- Remote case proctoring, simulation tools, and advancements in pre-operative planning
- Increase the number of surgeons trained to use robotic systems for minimally invasive procedures and expand access to robotic surgery for patients globally.

Challeges with Robotic

- Worldwide Complex and pivotal Healthcare systems
- Challenges with rising costs and addressing staffing global health issues.
- Seemingly, our major risks today have become the costs associated with deploying new technology for the care of our patients.



US Healthcare Expenditure

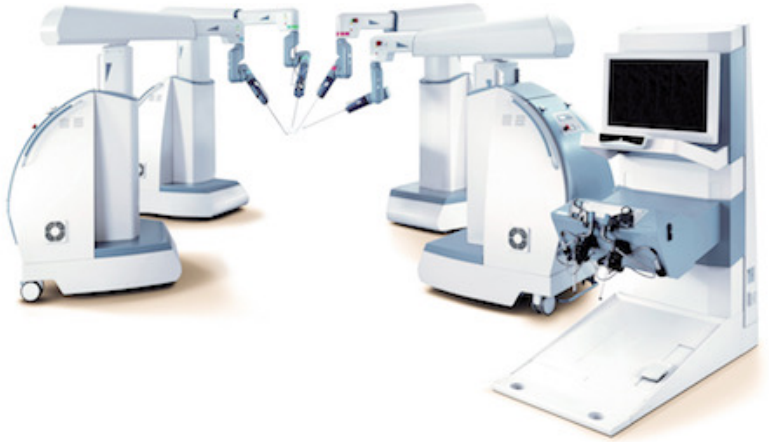


National health expenditures (NHE), which includes both public and private spending on healthcare, are projected to climb from $4.4 trillion, or $13,413 per person, in 2022 to $7.2 trillion, or $20,425 per person, in 2031

Careful Risk Taking

- Only do a procedure when indicated.
- Develop & follow protocols.
- Involved with Guidelines
- Collect data meticulously.
  - Analyze periodically
  - Self-evaluate
  - Mid-course corrections
- Full IRB approval & Local Health regulatory

Future of Surgery



Innovations in Robotic Surgery 2020-2030: Technologies, Players & Markets
Surgical robots, robotic catheter and endoscope navigation, robotic positioning of surgical tools, robotic systems for intra-operative camera manipulation, artificial intelligence in robotic surgery, haptic feedback mechanisms in surgical robots

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Conclusion
Cardiac Care 2030

- Operating room in 2030

- A true mixture of a multidisciplinary approach
- Catheter and Surgical platform

- Computer assisted procedures
- Artificial Intelligence
- Automation

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