Surgical Robots:
Capabilities & Promises

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We teach your surgeon to use surgical robots.
Evolution of Perception

- Terrified of the robotic monster replacing their human surgeon
- Requesting robotic augmentation and extension of surgeon capabilities
- The future holds dozens of surgical robots, all of them unique in form and function.

LinkedIn Robot-of-the-Day (#ROTD)
In recent years, robotic surgery has become the most preferred surgical method for many types of procedures.
Mechanical Turk - robotic chess

1770
In Classic Science Fiction ...

1942

ASTOUNDING
Science Fiction 25c

WALDO
By Anson Macdonald
A STREET AND SMITH PUBLICATION
AUGUST 1942

1988

ISAAC ASIMOV
Author of FANTASTIC VOYAGE II: DESTINATION BRAIN
NEARLY 2,000,000 COPIES IN PRINT
FANTASTIC VOYAGE
FOUR MEN AND ONE WOMAN
JOURNEY INTO THE LIVING BODY OF A MAN!
Based on a screenplay by Harry Kleiner. Adaptation by David Duncan.
Based on a story by Otto Klemment and Jay Lewis Bloch.
In the Movies...

Star Wars:
Empire Strikes Back
Return of the Jedi

Prometheus
Robotic Motivations

- **FIDELITY**: Improve Fine Movement
- **EFFICIENCY**: Improve Throughput
- **SAFETY**: Improve Surgeon Health
- **ACCURACY**: Reduce Variation
- **LESS INVASIVE**: Reduce Patient Impact
- **NATIONALITY**: Improve Economic Position
AESOP - voice controlled lap camera

1994
ZEUS - two handed remote surgery

1998
Operation Lindberg telesurgery

New York

2001

France
da Vinci - generations

Standard

Si

Xi

Std  S  Si  Xi  SP  FC
Essential da Vinci Components

- Stereo Vision
- Stereo Mag Endoscope
- 7-DOF Instrument
- Ergonomic Station
- Diverse, Small Instruments
- Fine Control
da Vinci System Installed Base

4,271 Worldwide as of September 30, 2017

USA  
2,770

Europe  
719

Asia  
561

Rest of World: 221

Source: Intuitive Investor Presentation, December 2017
Worldwide Procedure Trend

2012: 0
2013: 200,000
2014: 400,000
2015: 600,000
2016: 800,000
2017: 1,000,000
2018: 1,200,000

2017: 16% Growth
2018 Guidance: 11-15% Growth

Source: Intuitive Investor Presentation, December 2017
da Vinci Future Directions

Enhanced imaging

Intelligent systems

Less invasive approaches

Data analytics

Optimized learning

Source: Intuitive Surgical

Firefly Fluorescence

Overlays

Path to Expertise

Table 1: Patient Characteristic and Outcomes

<table>
<thead>
<tr>
<th>Pre-operative Data</th>
<th>Open Surgery (n=20)</th>
<th>Robotic (n=29)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60 (36-83)</td>
<td>55 (38-66)</td>
<td>0.392</td>
</tr>
<tr>
<td>Male</td>
<td>11 (55%)</td>
<td>15 (52%)</td>
<td>0.363</td>
</tr>
<tr>
<td>Marital Status</td>
<td>3 (15%)</td>
<td>1 (4%)</td>
<td>0.231</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3 (15%)</td>
<td>2 (7%)</td>
<td>0.187</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4 (20%)</td>
<td>14 (48%)</td>
<td>0.07</td>
</tr>
<tr>
<td>Prior Robotic</td>
<td>3 (15%)</td>
<td>13 (45%)</td>
<td>0.035</td>
</tr>
<tr>
<td>Ischemic Heart Disease</td>
<td>1 (5%)</td>
<td>0</td>
<td>0.408</td>
</tr>
</tbody>
</table>

Operative Data

<table>
<thead>
<tr>
<th>Operative Time (min)</th>
<th>Open Surgery (n=20)</th>
<th>Robotic (n=29)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU Stay (days)</td>
<td>1 (0-3)</td>
<td>0 (0-3)</td>
<td>0.001</td>
</tr>
<tr>
<td>Post-operative stay (days)</td>
<td>5 (4-8)</td>
<td>2 (2-5)</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Histopathology

<table>
<thead>
<tr>
<th>Tumor Type</th>
<th>Open Surgery (n=20)</th>
<th>Robotic (n=29)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid</td>
<td>13 (65%)</td>
<td>12 (41%)</td>
<td>0.019</td>
</tr>
<tr>
<td>Oat cell</td>
<td>0</td>
<td>8</td>
<td>0.007</td>
</tr>
<tr>
<td>Benign</td>
<td>2</td>
<td>5</td>
<td>0.022</td>
</tr>
</tbody>
</table>
TransEnterix SenHance

2017
South Korean Ministry of Food and Drug Safety (MFDS):
“We expect the successful localization of surgical robots will significantly reduce financial burdens of patients who need endoscopic surgery through the import substitution effect...“ (Aug 2017)
Stryker Mako

2009
Stereotaxis Niobe & V-Drive

2008

2015
ARTAS Hair Restoration

2011
Titan Medical SPORT

2019
2019

USMI Canady Surgical Robot
FlexDex Endowristed Lap 2019
CMR Versius abdominal robot

2020
Digital Surgery:
- Networked Cloud Services
- AI Surgeon Assistance
- Surg Robot O/S Ecosystem

“Android for Surgical Robotics”
Auris Surgical Robotics
AVRA – Skin Ablation

2020
Axsis Cataract Eye Surgery

2018
Yomi Dental Implant Robot

2017
Robot Services

- Action Transfer
  - Intuitive, TransEnterix, Titan

- AI Assistance
  - Verb, Intuitive

- Independent Action
  - Restoration, Veebot, Accuray

- Planning & Guidance
  - Mazor, Globus

- Steering Instrument
  - Auris, Corindus, Stereotaxis

- Planning & Control
  - Mako, Neocis

Independent Robot Services
Adoption Challenges
Hospital Capacity for Robots?

Personal Computers ... Cellphones ... Automobile Companies
Future Tech

360° VISION

Multi-finger Instruments

Machine Learning

Artificial Intelligence

Cloud Computing
Not just at the hospital
Questions?