Robotics in Surgery

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Definition of a Robot

- Machine that resembles a human and does mechanical, routine tasks on command
- Any mechanical device that operates automatically with human-like skill
- “A robot is not a machine....it is an information system with arms”
Robots: Better Than Humans?
Robots: Better Than Humans?
Types of Robots

- Passive
  - Retractor system
  - Position the tool and then hold

- Active
  - Robot would actively move the tool upon the surgeons command
Surgical Robots in 2007

- AESOP (Automated Endoscopic System for Optimal Positioning)
  - Voice activated mechanical arm
  - Steadier than human, never tires
- daVinci
  - FDA approval in 2002
  - Laparoscopic instrumentation controlled by the surgeon positioned remotely at a console
Development of daVinci

- Defense Advanced Research Projects Agency (DARPA) for military research of remote battlefield surgery
- Cholecystectomy performed remotely via telesurgery from 300 miles away
- Intuitive Surgical created in 1999 after acquiring patent rights from military
- First robotic prostatectomy performed in 2001
“Operation Lindberg”: Remote Transatlantic Telesurgery
Advantages of Laparoscopic Surgery

- Shorter hospital stay
- Less pain
- Less risk of infection
- Less blood loss and transfusions
- Less scarring
- Faster recovery
- Quicker return to normal activities
Challenges of Laparoscopic Prostatectomy

- Prostate located in fixed confines of pelvis
- Laparoscopic instruments limited in articulated movements
- Approximation of bladder-urethral anastomosis difficult to suture
- French experience: >300 cases reported, learning curve >100
- Oklahoma experience: 1 case, 19 hours, patient died
Advantages of daVinci Robot

- Magnified (12x), stereoscopic 3-D vision
- Robotic wrist with 6 degrees of freedom
- Movements are scaled, filtered, translated
daVinci Robotic System
Disadvantages of daVinci Robot

- Expensive
  - $1.4 million cost for machine
  - $120,000 annual maintenance contract
  - Disposable instruments $2000/case
  - Hospital reimbursement same DRG
- Steep surgical learning curve
- Increased staff training/competence
- Increased OR set-up/turnover time
Robotic Disbelievers

• “No long term data”
  - Margin positive rates equivalent
  - No difference in risk for incontinence and erectile dysfunction
• “Loss of tactile feedback”
  - Improved vision
  - Haptic feedback: visual resistance
• ENABLER: same operation, new tool
<table>
<thead>
<tr>
<th></th>
<th>Open</th>
<th>Robotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR time</td>
<td>3 hrs</td>
<td>2-4 hrs</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>3 days</td>
<td>24 hrs</td>
</tr>
<tr>
<td>Foley catheter</td>
<td>14 days</td>
<td>7 days</td>
</tr>
<tr>
<td>Blood loss</td>
<td>600 ml</td>
<td>&lt;100ml</td>
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<tr>
<td>Recovery</td>
<td>4-6 wks</td>
<td>2-3 wks</td>
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## Margin Positivity

<table>
<thead>
<tr>
<th>Series</th>
<th>% Positive margins</th>
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<tbody>
<tr>
<td>Soloway (Open)</td>
<td>28 %</td>
</tr>
<tr>
<td>Lepor (Open)</td>
<td>26 %</td>
</tr>
<tr>
<td>Guillonneau (Laparoscopic)</td>
<td>13.7 %</td>
</tr>
<tr>
<td>Abbou (Laparoscopic)</td>
<td>20%</td>
</tr>
<tr>
<td>Rassweiler (Laparoscopic)</td>
<td>24 %</td>
</tr>
<tr>
<td>Turk (Laparoscopic)</td>
<td>26 %</td>
</tr>
<tr>
<td>Bollens (Laparoscopic)</td>
<td>22 %</td>
</tr>
<tr>
<td>Sulser (Laparoscopic)</td>
<td>18%</td>
</tr>
<tr>
<td>Menon (Robotic)</td>
<td>26%, 17%, 6%</td>
</tr>
<tr>
<td>Ahlering (Robotic)</td>
<td>17%</td>
</tr>
<tr>
<td>Lee (Robotic)</td>
<td>21%</td>
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## Continence Data

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>3 mo</th>
<th>6 mo</th>
<th>12 mo</th>
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<tbody>
<tr>
<td>Walsh (Open)</td>
<td>54 %</td>
<td>80 %</td>
<td>93 %</td>
</tr>
<tr>
<td>Abbou (Laparoscopic)</td>
<td>58 %</td>
<td>69 %</td>
<td>78 %</td>
</tr>
<tr>
<td>Guillonneau (Laparoscopic)</td>
<td>N/A</td>
<td>N/A</td>
<td>85 %</td>
</tr>
<tr>
<td>Rassweiler (Laparoscopic)</td>
<td>54%</td>
<td>74%</td>
<td>97%</td>
</tr>
<tr>
<td>Menon (Robotic)</td>
<td>N/A</td>
<td>96%</td>
<td>N/A</td>
</tr>
<tr>
<td>Ahlering (Robotic)</td>
<td>76%</td>
<td>91%</td>
<td>94%</td>
</tr>
<tr>
<td>Lee (Robotic)</td>
<td>60%</td>
<td>82%</td>
<td>N/A</td>
</tr>
<tr>
<td>Author</td>
<td>Capable of Intercourse</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Walsh (age 60 to 67)</td>
<td>(Open)</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>Catalona (60’s/70’s)</td>
<td>(Open)</td>
<td>60% / 47%</td>
<td></td>
</tr>
<tr>
<td>Guillonneau</td>
<td>(Laparoscopic)</td>
<td>66% overall</td>
<td></td>
</tr>
<tr>
<td>Abbou</td>
<td>(Laparoscopic)</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>Turk</td>
<td>(Laparoscopic)</td>
<td>59%</td>
<td></td>
</tr>
<tr>
<td>Menon</td>
<td>(Robotic)</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>Ahlering</td>
<td>(Robotic)</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>Lee</td>
<td>(Robotic)</td>
<td>Too early</td>
<td></td>
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Tulsa daVinci Experience

- Machine located at St. John
- >130 prostatectomies performed to date
- Average operative time 2-3 hours
- >95% patients discharged in <24 hours
- No conversions to open surgery
- Complications: 2 post-op bleed, 1 port site hernia, 1 anastomotic stricture
daVinci Clinical Applications

- **Urology:** radical prostatectomy, dismembered pyeloplasty, radical cystectomy, cyst decortication
- **Cardiac:** mitral and aortic valve replacement, aorto-iliac bypass, off-pump synchronized bypass
- **GYN:** hysterectomy, prolapse repair, tubal reversals, fistula repair, myomectomy
- **General:** gastric bypass, Nissen
daVinci Clinical Limitations

- No advantage over standard laparoscopic approach for cholecystectomy, spleenectomy, colectomy
- Increased operative time observed
- Precise dissection not necessary
- Open space: limitations with broad sweeping motions
daVinci vs. Laparoscopy

- Laparoscopic surgical fellow at Stanford
- First 50 Roux-en-Y procedures randomized laparoscopic or robotic with DaVinci
- Both surgery with hand-sewn anastomosis
- OR time: 149 min (lap) vs 131 min (robot)
- No difference for complications, LOS, EBL
- Conclusion: Robot is an ENABLER
Off-pump CABG

- 30 patients, 2.6 grafts/patient
- Majority: IMA to LAD
- 15/30 discharged <24 hours
- Complications:
  - 2 return to OR for bleeding
  - 1 converted to open
  - 2 readmits: pleural effusion, wound infection
- No mortality
Advanced Endoscopy
Natural Orifice Surgery

EXPANDABLE ENDOSCOPE OVERTURE

PLEURALITY OF WORKING CHANNELS WHICH COLLAPSE & SEAL WHEN INSTRUMENT IS NOT IN CHANNEL

ENDOSCOPE

OVER-TUBE

OVER-TUBE EXPANDS RADIALLY OUTWARD

ENDO-LOOP

Pleurality of Accessories Inc.

Balloon & Punchure Device

Ethicon Endo-Surgery, Inc.

Bill Keating, M.D. 1985

Courtesy of N Reddy, Hyderabad India  20005
Peroral Transgastric Endoscopic Surgery
Natural Orifice Transluminal Endoscopic Surgery (NOTES)
Trans-gastric Appendectomy
Climbing the Learning Curve

- Standard surgery: “see one, do one, teach one”
- Robotic surgery: “see one, do one, kill one”
- Requires entirely new skill set beyond traditional surgical and laparoscopic training
- Training opportunities limited
- Animal labs helpful
- Cases require outside proctor to determine competency
- Credentialing challenges??
Surgical Simulation
Surgical Simulation
Red Dragon/Blue Dragon
Hand Motion Assessment
Robotic Rounding
Robotic Scrub Nurse “Penelope”
Robotic Scrub Nurse
Operating Room of the Future
Moral Dilemma

- Technology is neutral - it is neither good or evil
- It is up to us to breathe the moral and ethical life into these technologies
- And then apply them with empathy and compassion for each and every patient
Conclusions

- The rate of discovery of new technology is outpacing the ability of business, society, and healthcare to integrate and apply.
- Robotic surgery is but one example of such technology that MAY reduce operative morbidity, hospital stay, and recovery, while POTENTIALLY improving clinical outcomes, but at what point do the BENEFITS justify the increased EXPENSE?