Novel non-robotic, robotic technology for minimally invasive surgery

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Disclosures:

• **Dr Swanstrom**
  – Is involved in developmental research on the Carnegie-Melon snake robot
  – Was involved in the early development of the Computer Motion/Intuitive Medical robotics platform
  – Receives research support from Olympus and Boston Scientific
Robots have inherent promise for medical use:

• Integration of Image guided surgery
• Automatization of routine tasks
• The “perfect assistant”
• Remote telementoring
• Improved hand instrumentation
  – Laparoscopic
  – NOTES
  – (If they are inexpensive...)
Robots are clever and cute
Telemanipulation

2 million dollar laparoscopic suturing device?
New technology and health care costs--the case of robot-assisted surgery.

• “to date, there have been no large-scale randomized trials of robot-assisted surgery, and the limited evidence fails to show that the long-term outcomes of robot assisted surgery are superior to those of conventional procedures”
Comparison among robotic, laparoscopic, and open hysterectomy for endometrial cancer.

Barnett JC, Judd JP, Wu JM, Scales CD Jr, Myers ER, Havrilesky LJ.

• In the hospital perspective, plus robot costs model, laparoscopy was least expensive ($6,581) followed by open ($7,009) and robotic hysterectomy ($8,770);
Economics are a Problem

- **Average loss to hospital per case = $2,800**

New technology and health care costs--the case of robot-assisted surgery.


- No definite clinical advantage
- Added cost $2,300 - $3,100/case
Maybe even selective use as a $2 million laparoscopic needle holder...

- Very advanced cases scheduled for laparoscopic surgery
- All exploration, dissection, mobilization and simple anastamosis performed laparoscopically
- For very difficult portions of dissection or difficult anastamosis – the robot is brought in, docked, that portion done and the robot is taken out so the case can be resumed laparoscopically
Can we capture the advantages of current robotics in a cost effective format?

• Using robotic features to enable suturing
• Enabling inadequate tool formats (flexible endoscopy)
JAiMY® iD the only 5mm motorized laparoscopic instrument

The first motorized articulating laparoscopic instrument with iD-intelligent Dexterity, designed to enable surgeons to overcome the unique challenges presented by single incision and conventional laparoscopic surgery.

Thumb Control to activate motorized distal bending & rotation.

End-effector movements:
1. 80° bending
2. Unlimited rotation
3. Open/closed

Control Unit.

MOTORIZED LAPAROSCOPIC INSTRUMENT

80°
360°
ASGE/SAGES Working Group on Natural Orifice Translumenal Endoscopic Surgery
White Paper
October 2005

Volume 63, No. 2 : 2006 GASTROINTESTINAL ENDOSCOPY

• N natural
• O orifice
• T translumenal
• E endoscopic
• S surgery
NOTES Platforms to Enhance Dexterity: Are They Needed?

Yes!

• Feasibility
• Operative time
• Mental workload
• Ergonomics
• Teachability
Current endoscopes are optimized for diagnostics:

- Scope instability – counter-forces
- Floppy instruments
- Limited visual orientation
- Small and few instrument channels ("one-handed" surgery)
- Lack of controlled insufflation
- Inadequate tissue approximators
- Poor resolution
Inherent problems with an endoscopic paradigm

- Poor ergonomics
- 2 assistants
- Un-shared workload
... Versus a ‘Laparoscopic Paradigm’

Laparoscopic paradigm
- triangulation
- ergonomics
- separation optics
- shared workload
A comparison of the initial learning curves for open, laparoscopic and endoscopic devices in complex bimanual coordination

Georg O. Spaun, MD, Bin Zheng, MD, PhD, Daniel V. Martinec, BS, Brittany N. Arnold, BS, Lee L. Swanström, MD, FACS

Open surgery 13 sec ± 1
Laparoscopy 28 sec ± 3
Endoscopy 202 sec ± 82; \( P < 0.001 \)

\[ P = 0.149 \]

\[ P = 0.434 \] for accuracy.
<table>
<thead>
<tr>
<th>Liabilities</th>
<th>Potential benefit</th>
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<tbody>
<tr>
<td>• Size</td>
<td>• Miniaturization</td>
</tr>
<tr>
<td>• Optical quality</td>
<td>• Increased strength</td>
</tr>
<tr>
<td>• Robustness</td>
<td>• Improved precision</td>
</tr>
<tr>
<td>• Limited instrumentation</td>
<td>• <em>Addition of computer interface</em></td>
</tr>
<tr>
<td>• Precision</td>
<td>– Preprogramming</td>
</tr>
<tr>
<td>• Cost?</td>
<td>– Image synthesizing</td>
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<td>– Positioning systems</td>
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Endovia
Neoguide
Carnegie-Melon “Snake Robot”
Mechanical systems
A new Generation of flexible endoscope design

- High – resolution optics
- Table mounted (two handed operation)
- Triangulating instruments
- Ergonomic user interface
- Low cost

“Cobra” 2005

...the laparoscopic paradigm
2nd generation Transport (USGI Medical)
Large instrument channels

Flexibility

Controlled CO2 insufflation
Currently used for Cholecystectomy
3d Generation Endoscope Design
EOS (USGI)
Olympus EndoSamurai
Capability to suture
Anubis Scope
Storz
Anubiscope: Storz
A Multitasking Platform for NOTES: A bench top comparison of a new device for flexible endoscopic surgery and a standard dual channel endoscope

Spaun, Zheng, Swanström

Surgical Endoscopy 2009

EndoSAMURAI (304 ± 125 sec) vs. DCE (867 ± 312 sec) $P < 0.001$
Separating Vision and Instrument Motions Improves Performance of Endoscopic Surgery

Danny V. Martinez, BS, Bin Zheng, MD, PhD
Christy M. Brown, MD, Lee L. Swain, MD
Legacy Health System, Portland, Oregon

Results:
- Task performance with the DDES system was significantly faster than performance with the SCE ($p < .001$). Average time to complete the task with the DDES was $24.9 \pm 8.8$ s. Average time to complete the task with the SCE was $61.7 \pm 27.7$ s (Figure 3).
3d gen endoscopes

Benefits
• Laparoscopic paradigm
  – Table mounted
  – Ergonomic
  – Triangulation
  – Shared workload
  – Separated optics

• Moderate pricing

Liabilities
• Size
• Optical quality
• Robustness
• Limited instrumentation
• Precision
• Cost?
Laparoscopy

Evolution of NOTES

NOTES

Mini-scope Diagnostic NOTES (eg POEM)

Mega-scope Surgical resection/reconstruction

Therapeutic endoscopy
Others

- Transenterix
- Others?
Conclusions:

• A new generation of flexible endoscopes may be needed to safely and effectively perform advanced endolumenal procedures and NOTES.
• Flexible endoscopic instruments need to replicate the abilities of laparoscopic tools.
• A shift from the endoscopic to a laparoscopic paradigm will be necessary.
Conclusion

• Robotics will undoubtedly play a role in surgical instrument design from now on – particularly in technology leveraged approaches like NOTES and single port
• Currently cost (development and manufacturing) is a major impediment to new robotic instrumentation
• Mechanical “robotic” systems may represent an intermediate step in instrument evolution
• Miniaturized “robotic enabled” hand instruments may be the future of laparoscopic tools
Thank you