What is new in Robotics?

Christopher J. Kane MD, FACS
Professor and Chair of Urology
C Lowell and JoEllen Parsons Endowed Chair in Urology
UC San Diego School of Medicine
Outline

- Enhanced system Xi review
- Enhanced fluorescent imaging
  - sentinel lymph node identification
  - Tumor identification
  - Nerve identification
- Increased public reporting of outcomes
  - Likely leading to increased regionalization of elective procedures
- New Robotic companies and systems
  - Titan Medical (single port robotics)
  - TransEnterix (robotics and flexible instruments)
  - Avra Surgical robotics (modular light weight robotics)
  - Mako Robotics (joint replacement)
2009

**da Vinci® Si™**
- Dual Console option
- Enhanced HD Vision (1080i)
- Upgradable architecture

2006

**da Vinci® S™**
- 3D HD Vision (720p)
- Cross-quadrant access
- Streamlined set-up

1999

**da Vinci®**
- Eliminates lap compromises
- Simple instruments

2014

**da Vinci® Xi™**
- Multi-quadrant access
- Crystal clear 3D HD vision
- Platform for future technologies

- FIREFLY™ (EXPECTED MID 2014)
- XI SKILLS SIMULATOR™ (AVAILABLE NOW)
- INTEGRATED ENERGY (AVAILABLE NOW)
- VESSEL SEALER (AVAILABLE NOW)
- STAPLER (EXPECTED MID 2014)
- FUTURE INNOVATION
  SINGLE PORT SURGERY
Redesigned patient cart
  - Supporting flexible positioning around patient and efficient, four-quadrant access

Same vision cart design as Si
  - With enhanced support for new endoscope

Same surgeon console design as Si
da Vinci Xi Patient Cart Components

**Boom** – adjustable, rotating support structure that moves the arms into position

**Arms** (1, 2, 3, 4) - hold and move the endoscope and instruments

**Column** – moves the boom up or down to adjust the height of the system

**Helm** – enables cart drive functions, boom positioning and provides a touchpad for system messages and guided menu options

**Base** - includes a motorized cart drive for positioning and transportation
Redesigned *da Vinci Xi* Patient Cart Arms

**Thin, long arms**

**Greater range of motion**
Accesses a significant intraoperative surgical workspace (120 degrees)

**Supports longer instruments**
1.75” longer than Si
da Vinci Xi Patient Cart Helm Controls

Helm

Touchpad

Emergency Stop

Handle bars

Cart drive enable switch

Easy to maneuver cart

Boom position control

Power

Boom height control

Manual Control of Boom
Laser Targeting System

**Target laser** is mounted at the center of the boom and assists with alignment of cart to target anatomy.

**Horizontal laser** projects a horizontal line in front of the Patient Cart, highlighting possible collisions during cart movement.
Xi Endoscope

New vision architecture

- Optics mounted at the tip of the scope, putting the camera inside of the patient
- Minimizes image degradation to provide crystal clear image of target anatomy

8 mm and 12 mm endoscope

- **NOTE: 12 mm scope is not available at launch**
- 8 mm scope allows for port-hopping
- Significantly lighter assembly allows for easy handheld use
  - 1.3 lbs vs 3.5 lbs for Si
- Auto-focus
- 80 degree field of view

Quick vision set up

- Plug and Play: power on endoscope with camera
- Automatic white balance
- Automatic 3D calibration
  - Universal alignment target no longer needed
Xi Endoscope Connection to Vision Cart

**Vision Cart Holder**
- Endoscope storage when not in use

**Endoscope cable connector**
- Single connection for vision and light

**Endoscope Controller**

**Video Processor**
- Enables still image capture with USB

UC San Diego HEALTH SYSTEM
Integrated ERBE VIO dV Energy System User Interface
Xi Surgeon Console

[Diagram showing Xi Surgeon Console features and ergonomics settings]
Advanced Technology

EndoWrist Stapler*
No cable or motorpack
Blue/Green Reloads

EndoWrist Vessel Sealer*

Enabled for FireFly™ Fluorescence Imaging**
Will be standard on Xi

*These technologies are currently pending FDA 510(k) clearance for the da Vinci Xi Surgical System.

**FireFly is not currently FDA 510(k) cleared for the da Vinci Xi Surgical System.
New Sentinel Lymph node imaging agent
Lymphoseek

- \([^{99m}\text{Tc}]\text{Tilmanocept} \ (\text{Lymphoseek})\)

Dextran Backbone

Rapid entry in lymph channels
Binds to CD206 on RE cells and macrophages
The Molecular Target:
CD206
Mannose Binding Protein Receptor

- Specific for mannose-terminated macromolecules
- Cells with Macrophage Function
  - Reticuloendothelial Cells
  - Dendritic Cells
  - Mesangial Cells
  - M2 Macrophage Cells
  - Microglial Cells
- High capacity
Prostate Cancer and Bladder Cancer

- High potential impact
- Very extensive node dissections now the standard of care
- Potential utility
  - avoid extensive dissection if SLN negative
  - identify LN mets outside of template
- Operative time
- Cost
- Morbidity
- Lap and robotics common modalities making fluorescent probes attractive
Currently available fluorescent agent

- **Indocyanine Green (ICG) Fluorescence**
  - In Europe mixed with Nanocol
    - Blood based and not available in the US
  - Binds to plasma protein
  - Dissipates fairly rapidly
  - Needs to be done intra-operatively
  - Limited time to perform dissection
  - Goes to all lymph nodes

Four GU development studies


New Agent - Lymphoseek

Technecium 99m labeled Tilmanocept
First receptor-targeted SNL agent
Dextra core binds to dextra-mannose receptors

IRDye 800CW-Ester
Near Infrared Spectrum
(Li-Core Biosciences)
Bright Field: Right Popliteal Lymph Node

Popliteal Lymph Node
Bright Field OFF, Fluorescence only
Preclinical PETCT and Robotic PLND study

• Prostate Injection
• Incorporation of PETCT preoperative imaging
• Robotic visualization and optimization
• Robotic dissection with Si with mods
• Laser and robotic capture modified for IR 800
Dog Prostate

TRUS image

Needle Placement
PET/CT Scan at 1 hour post prostate injection

Arrow = Pre-Sacral Lymph Node
Surgery: 36 Hours Post Injection
Conclusions

Tilmanocept labeled with IRDye 800CW and T99m

- T99m allows PET CT 3D targeting of sentinel LN
- Intra-operative identification of sentinel lymph nodes
- Is dose dependent without over saturation at tested doses
- Can be retained in SNL for at least 36 hours

Robotic-assisted fluorescence sentinel lymph node mapping using multimodal image guidance in an animal model.
Robotic-Assisted Sentinel Lymph Node Mapping
Multi-Modal Imaging Strategy

• Use preoperative imaging to guide SLN mapping
• Cancers
  • prostate
  • bladder
  • cervical/endometrial
  • colon/rectal/esophageal
• Logistics
  • inject $^{68}\text{Ga}$- or $^{99m}\text{Tc}$-$\text{IRDye800CW}$-tilmanocept
  • PET/CT or SPECT/CT at 1 hr post-injection
  • robotic-Assisted SLN Mapping many days post-injection
Research Team

- David Vera PhD
- Mike Liss MD
- Carl Hoh MD
- David Hall PhD
- Jonathan Sorger PhD

- DoD/USAMRMC (Vera DR and Kane CJ) 6/1/2014 – 5/31/16 DoD Prostate Cancer Research Program (PCRP)
- Intuitive Technology Research Grant (Vera DR and Kane CJ)
Incredible advances in fluorescent labeling of tumors and nerves

• Roger Y. Tsien PhD 2008 Nobel Prize in chemistry "for his discovery and development of the green fluorescent protein (GFP)

• Quyen Nguyen, MD, PhD In 2014, Dr. Nguyen was chosen by President Barack Obama to receive the Presidential Early Career Award for Scientists and Engineers (PECASE, award date April 15 2014)
Ted talk on fluorescent surgery

- https://www.youtube.com/watch?v=zG9-7UiKxcQ&feature=youtu.be
NP41 can highlight buried nerve branches invisible by standard illumination. (A-C) Right facial nerve and its arborizations in a thy1-YFP mouse treated with Cy5-NP41, viewed by (A) white light reflectance, (B) Cy5 fluorescence (pseudocolored cyan) overlaid on reflectance, and (C) YFP fluorescence (pseudocolored yellow), also overlaid on reflectance. (D-F) Left sciatic nerve (arrow) and its arborization in a mouse with a syngeneic 8119 mammary tumor graft (17,18), viewed by (D) white light reflectance, (E) FAM fluorescence 2 hours after IV injection of NP41 (150 nmoles) (pseudocolored cyan, overlaid on reflectance), and (F) Cy5-fluorescence (pseudocolored green, overlaid on reflectance) from conjugates of activatable cell-penetrating peptides and dendrimers (ACPPDs). The large arrowheads in (D) and (E) point to a nerve branch buried under tumor visible only by FAM fluorescence. Small arrowheads in (F) denote tumor (From Whitney et al, 2011)
NP 41 does cause fluorescence of autonomic nerve but contrast is currently poor.
CHRISTOPHER KANE
200 WEST ARBOR DR, SAN DIEGO, CALIFORNIA 92103-8201 | 619-543-5904
(address information updated Aug. 14, 2007)

Related Hospitals:
UNIVERSITY OF CALIFORNIA SAN DIEGO MEDICAL CENTER

How we calculated these rates: Guided by top researchers and doctors, ProPublica used Medicare data from 2009-2013 to identify cases where a patient died in the hospital or had to be readmitted within 30 days for a problem related to one of these elective procedures. We then calculated complication rates for surgeons, carefully accounting for differences in patient health, age and hospital quality. These rates are calculated using data from Medicare records, which do not include patients with private insurance or in another program like Medicaid. A surgeon's rate spans all hospitals at which he or she operates and is not unique to a given hospital. Read our methodology »

Hover over underlined items to see details.

Prostate Removal
Radical prostatectomy (ICD-9-CM code 60.5)

This Surgeon
Prostate Removal
Radical prostatectomy (ICD-9-CM code 60.5)

The removal of the entire prostate gland via the open or laparoscopic or robotic method. Usually performed to treat prostate cancer. More information ➤

This Surgeon

<table>
<thead>
<tr>
<th>PERFORMED PROCEDURE</th>
<th>COMPLICATIONS</th>
<th>RAW COMPLICATION RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>107 times</td>
<td>1-10</td>
<td>Redacted</td>
</tr>
</tbody>
</table>

ADJUSTED COMPLICATION RATE
Low
Medium
High Adjusted Rate of Complications

3.1%

SURGEONS PERFORMING THIS PROCEDURE
WITHIN 25 MILES ➔
SEE AREA HOSPITALS ➔

This Surgeon

Prostate Resection

The resection and removal of a portion of the prostate through the urethra. This is most commonly done because of an enlarged prostate that may be restricting the flow of urine. More information ➤

This surgeon performed fewer than the 20 cases required to have an adjusted rate in Medicare.
Summary

• Intuitive surgical robots are evolving and improving. Improved simulation and safety

• The next horizon is fluorescent imaging for sentinel lymph node dissection and fluorescent imaging for tumor and nerve identification

• Laparoscopy and robotics are ideal for this application

• Public reporting of outcomes will lead to more regionalization of care driven by patients and payers