

What is new in Robotics?

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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)

EVOLUTION OF MIS TECHNOLOGY

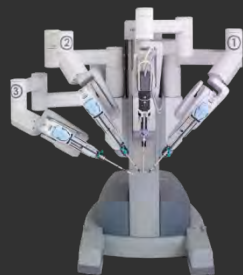
1999



da Vinci®

- Eliminates lap compromises
- Introduction of 4th arm (2003)
- Simple instruments

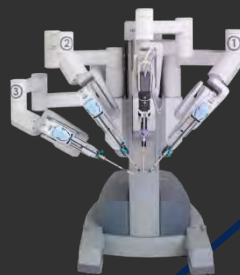
2006



da Vinci® S™

- 3D HD Vision (720p)
- Cross-quadrant access
- Streamlined set-up

2009



da Vinci® Si™

- Dual Console option
- Enhanced HD Vision (1080i)
- Upgradable architecture

2014



da Vinci® Xi™

- Multi-quadrant access
- Crystal clear 3D HD vision
- Platform for future technologies



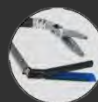
- FIREFLY™



- SINGLE-SITE™



- SKILLS® SIMULATOR™



- ADVANCED INSTRUMENTATION



- 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

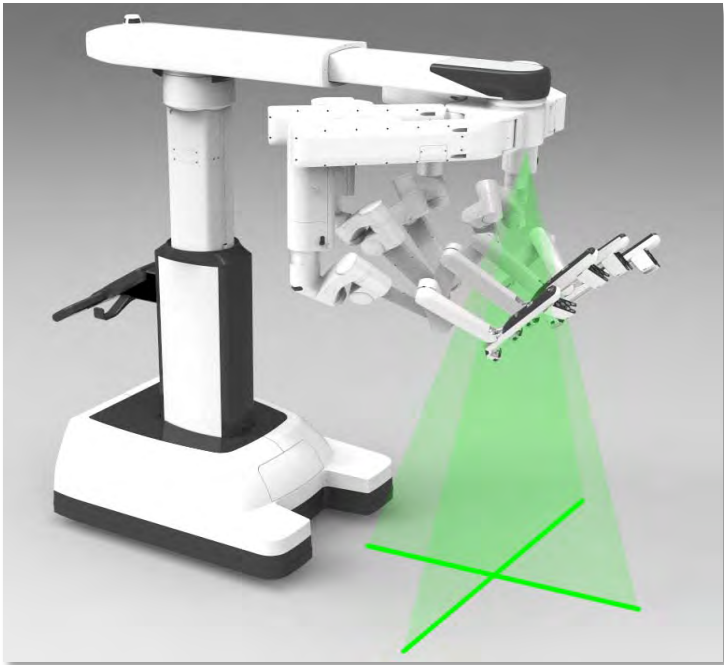
da Vinci Xi Patient Cart Helm Controls

Helm

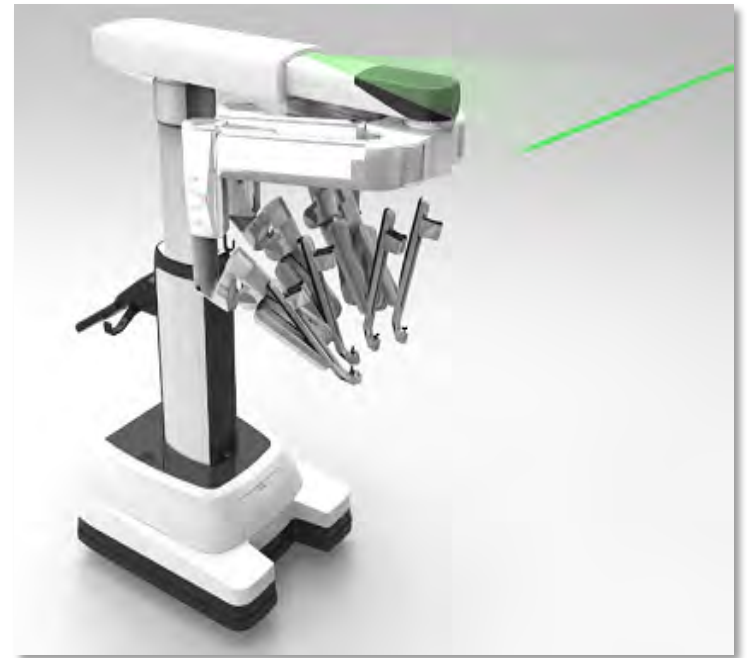


Manual Control
of Boom
UC San Diego
HEALTH SYSTEM

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**

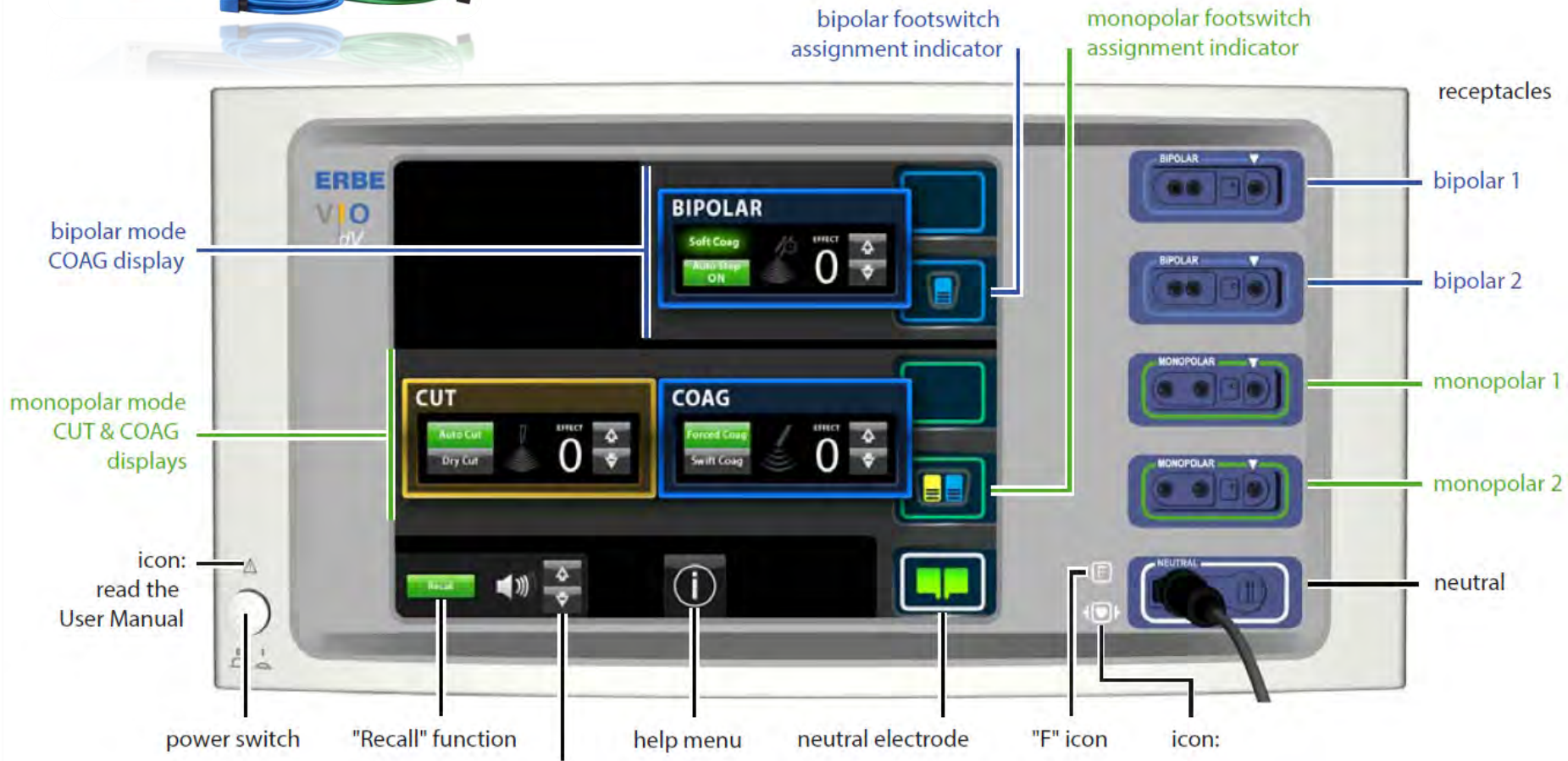
- Single connection for
vision and light

Endoscope Controller

Video Processor

- Enables all image
capture with USB
REALPH SYSTEM

Integrated ERBE VIO *dV* Energy System User Interface



Xi Surgeon Console



Advanced Technology



EndoWrist Stapler*

No cable or motorpack
Blue/Green Reloads

EndoWrist Vessel Sealer*

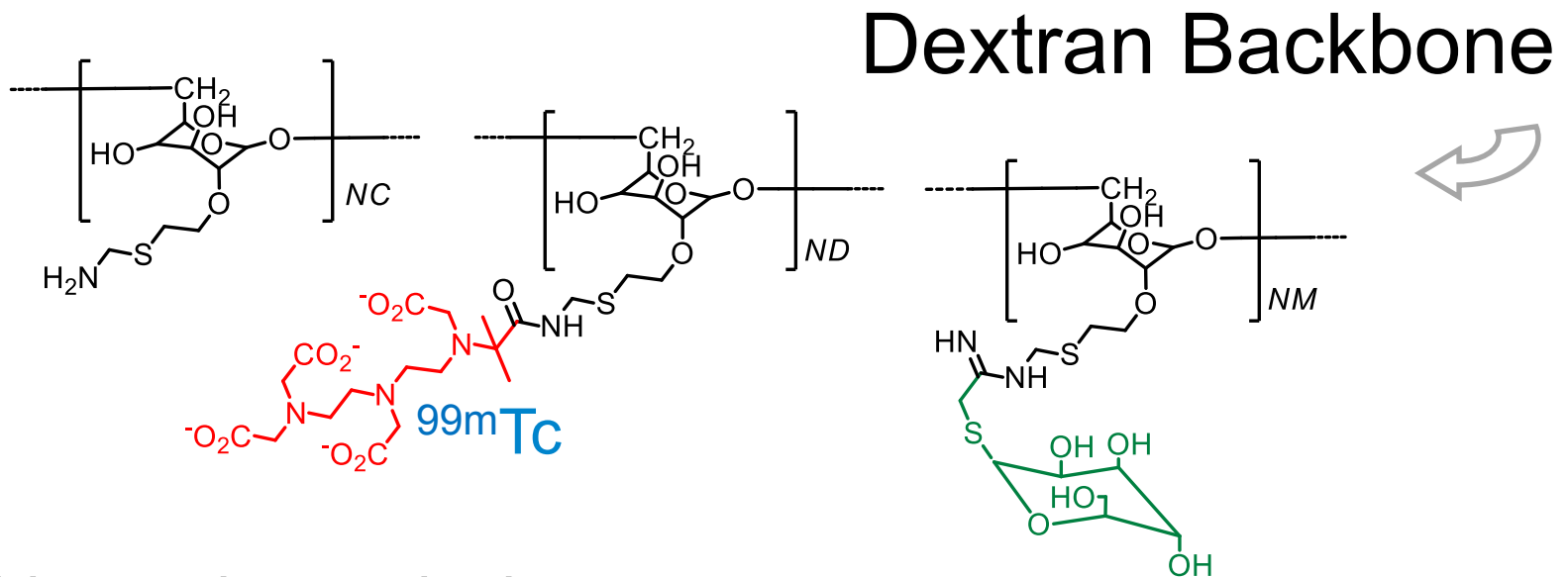


Enabled for *FireFly*[™] Fluorescence Imaging**

Will be standard on *Xi*

New Sentinel Lymph node imaging agent Lymphoseek

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



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

1. KleinJan GH...van der Poel HG. Eur Urol. 2014 Dec;66(6):991-8.
2. Van den Bergh et al Acta Oncol. 2015 Jan 16:1-7.

Four GU development studies

Preoperative sentinel **lymph node** mapping of the prostate using PET/CT fusion imaging and Ga-68-labeled tilmanocept in an animal model. Stroup SP et al. Clin Exp Metastasis. 2012 Oct;29(7):673-80

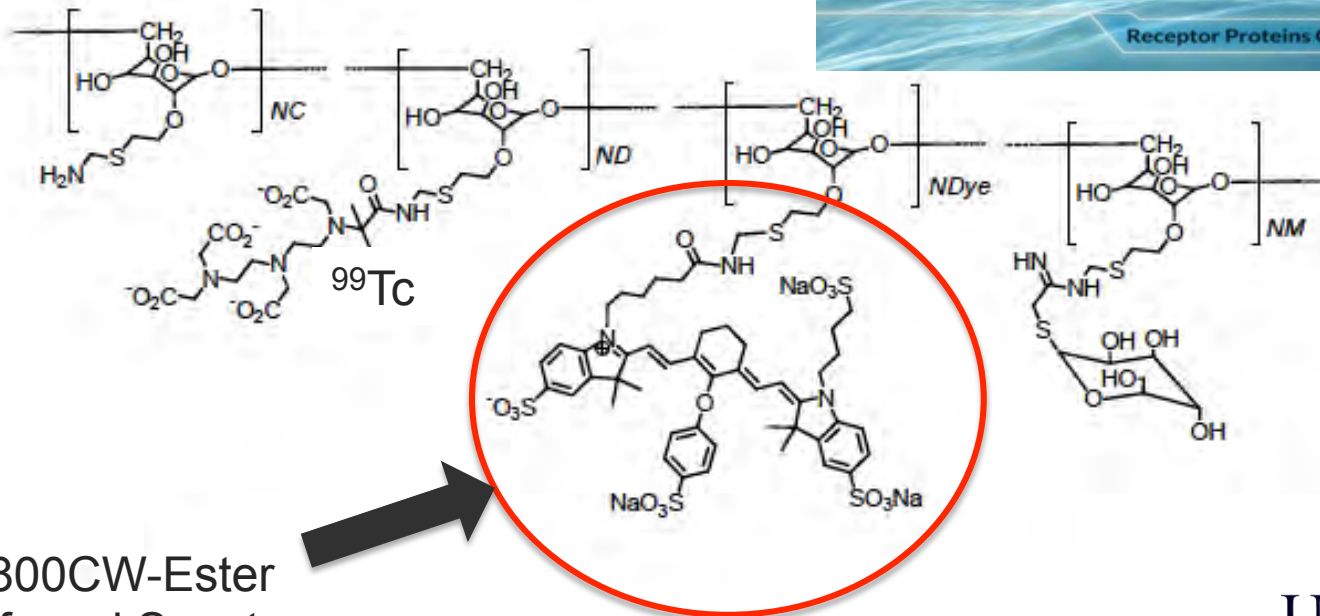
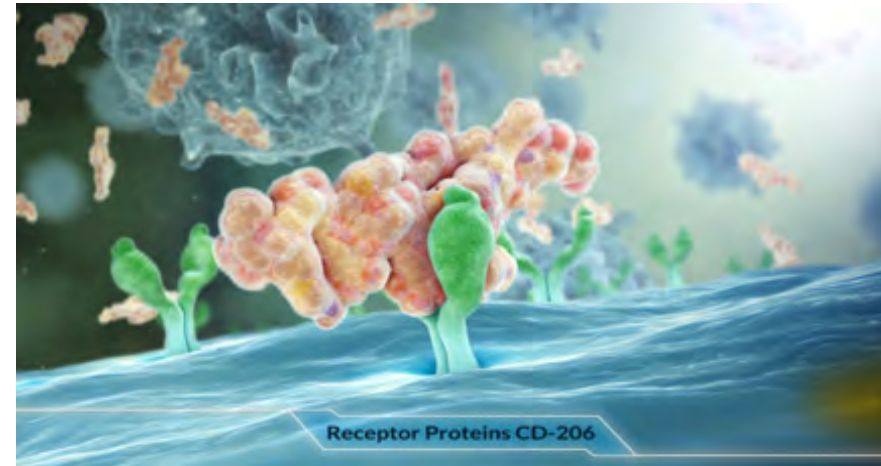
A receptor-targeted fluorescent radiopharmaceutical for multireporter sentinel **lymph node** imaging. Emerson DK et al. Radiology. 2012 Oct; 265(1):186-93.3.

Preclinical evaluation of robotic-assisted sentinel **lymph node** fluorescence imaging. Liss MA, Farshchi-Heydari S, Qin Z, Hickey SA, Hall DJ, **Kane CJ**, Vera DR. J Nucl Med. 2014 Sep;55(9):1552-6.

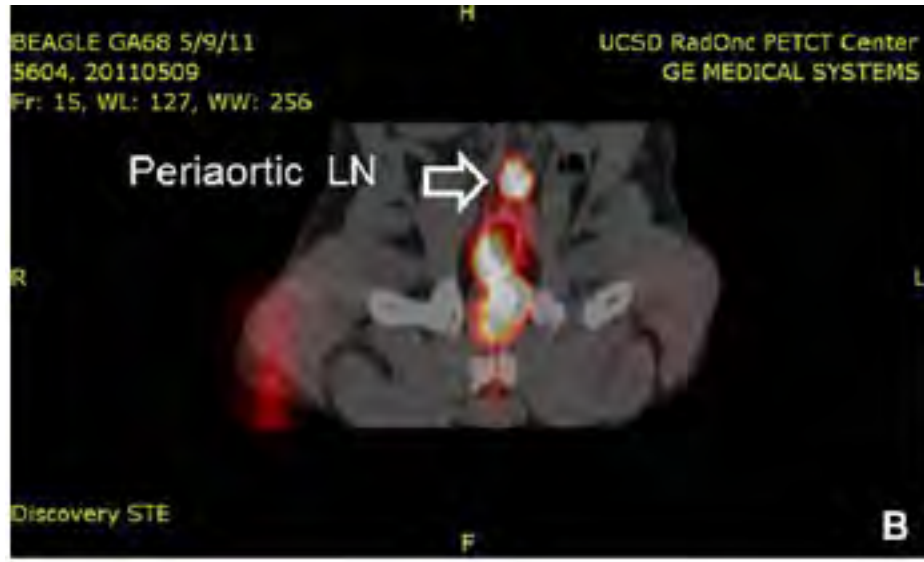
Robotic-assisted fluorescence sentinel **lymph node** mapping using multimodal image guidance in an animal model. Liss MA, Stroup SP, Qin Z, Hoh CK, Hall DJ, Vera DR, **Kane CJ**. Urology. 2014 Oct;84(4): 982.e9-14.

New Agent - Lymphoseek

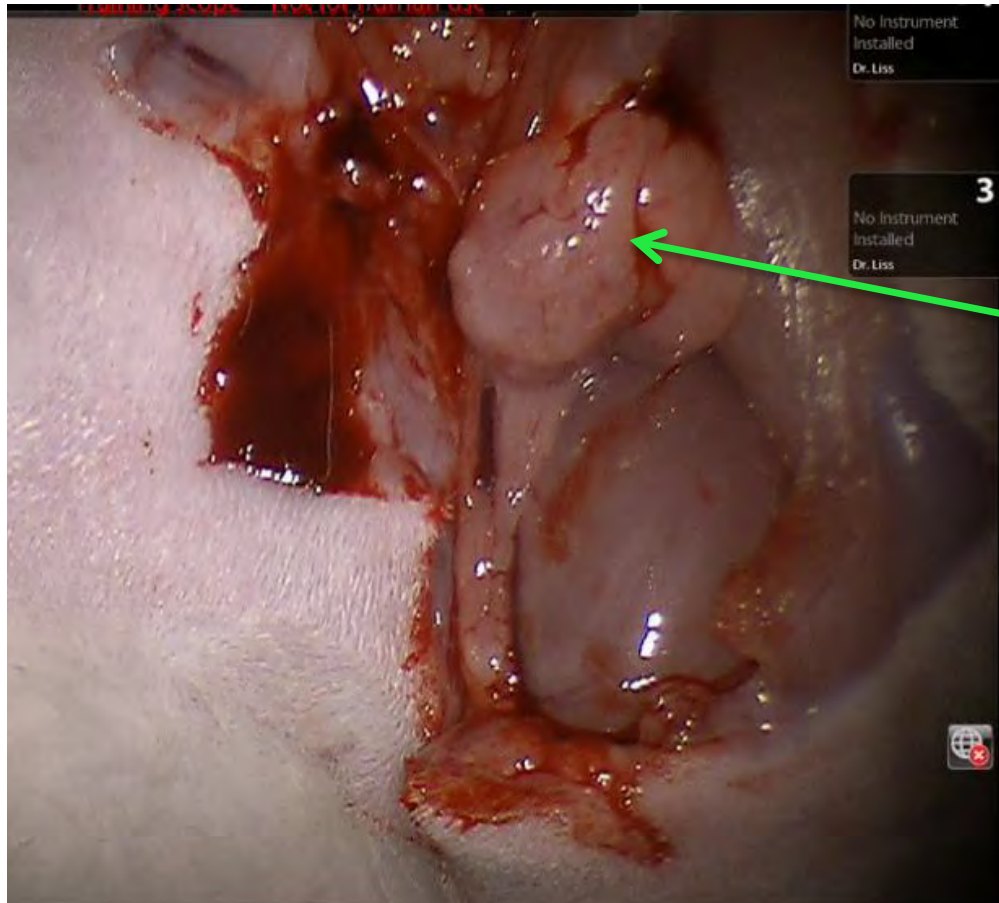
Technecium 99m labeled Tilmanocept
First receptor-targeted SNL agent
Dextra core binds to dextra-mannose receptors



IRDye 800CW-Ester
Near Infrared Spectrum
(Li⁹-Core Biosciences)



Bright Field: Right Popliteal Lymph Node



Popliteal
Lymph
Node

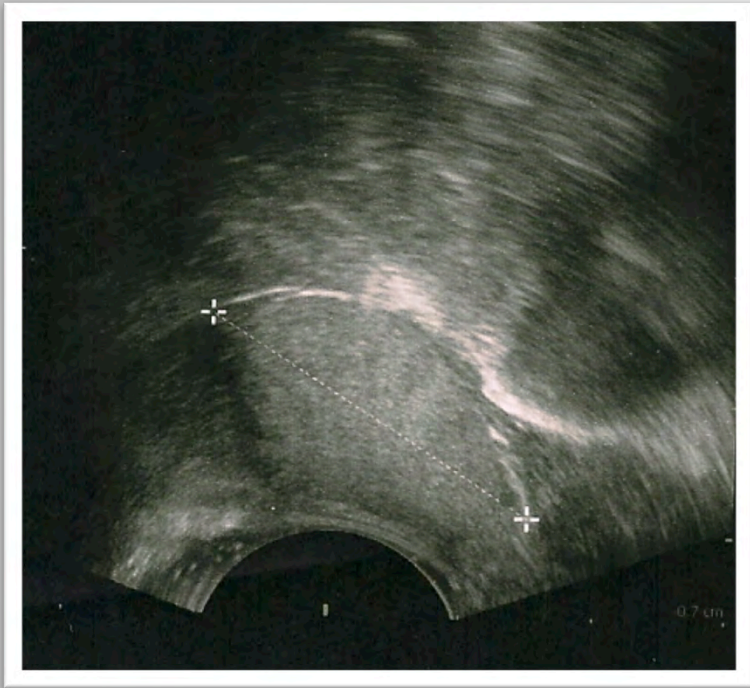
Bright Field OFF, Fluorescence only



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

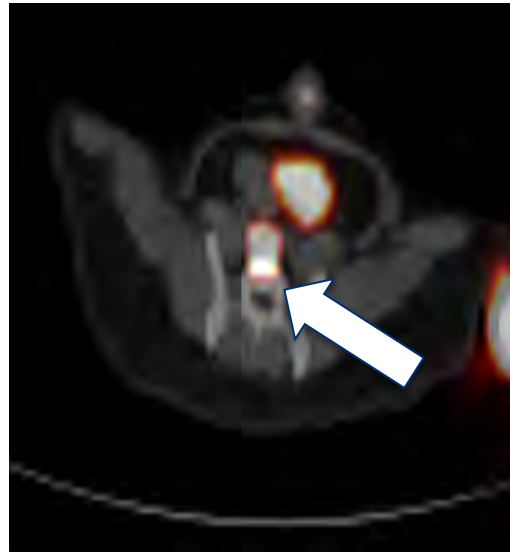
PET/CT Scan at 1 hour post prostate injection

Arrow = Pre-Sacral Lymph Node

Coronal



Axial



Sagittal



Surgery: 36 Hours Post Injection



Conclusions

Tilmanocept labeled with IRDye 800CW and T99m

- T99m allows PET CT 3 D 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.](#)

Liss MA, Stroup SP, Qin Z, Hoh CK, Hall DJ, Vera DR, **Kane CJ**.
Urology. 2014 Oct;84(4):982.

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}Ga]- or [$^{99\text{m}}\text{Tc}$]-*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 \(GFP\)](#)"



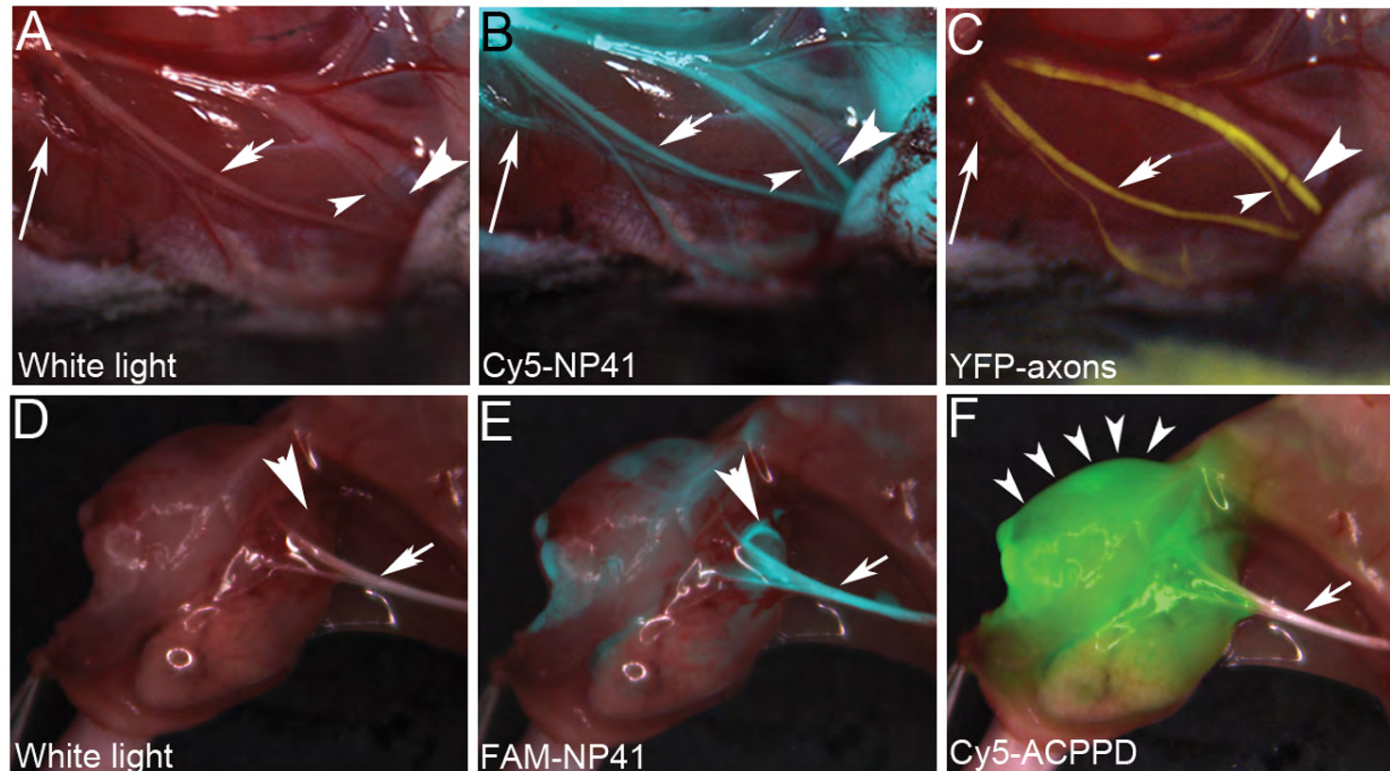
- **Quyen Nguyen, MD, PhD** In 2014, Dr. Nguyen was chosen by President Barack Obama to receive the Presidential Early Career Award for Scientists and Engineers (PECASE, award date April 15 2014)



Ted talk on fluorescent surgery

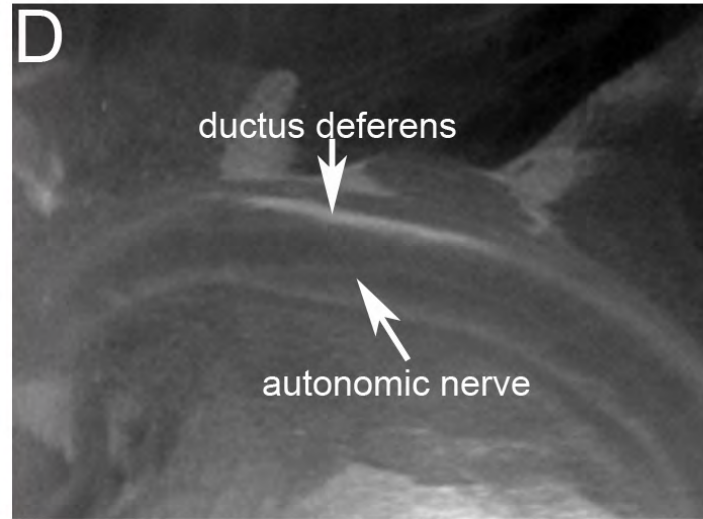
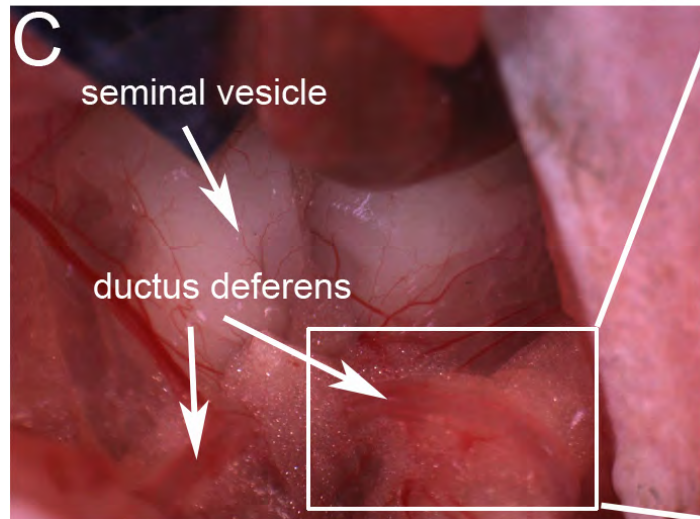
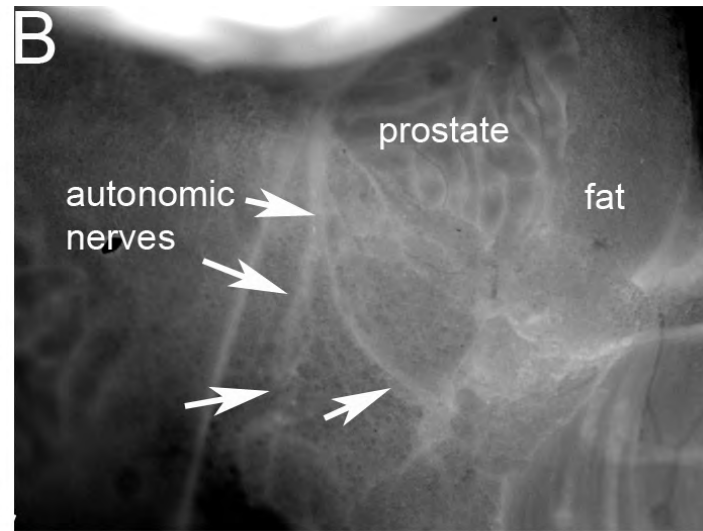
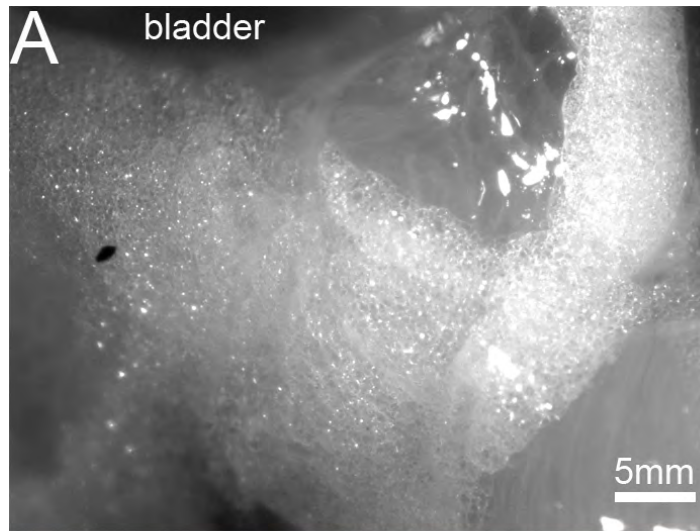
- <https://www.youtube.com/watch?v=zG9-7UiKxcQ&feature=youtu.be>

Nerve and Tumor Fluorescence



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



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CHRISTOPHER KANE

200 WEST ARBOR DR, SAN DIEGO, CALIFORNIA 92103-8201 |

619-543-5904

(address information updated Aug. 14, 2007)

Other Information

about this Surgeon

[See this surgeon's
prescriptions »](#)[See this provider's
other services in
Medicare in 2012 »](#)**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)

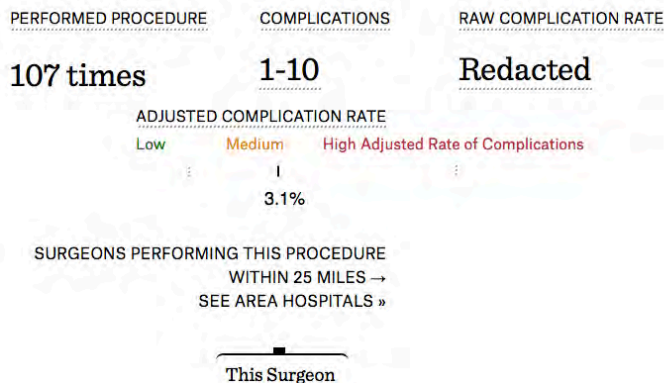
This Surgeon

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



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