Could a robotic tele-manipulator integrated to functional imaging be of help?

« I HAVE A DREAM »

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Disclosures

• CHU de Québec is an Elekta center of excellence

• Contribution to various advisory boards (pharmaceuticals) over the years

• Medical advisor for:
  – Polymer Robotics (no salary or shares)
History

• Prostate brachytherapy, from the start aimed at a focal target.
  – Proposed by Alexander Graham Bell in 1906 (?)
  – Ra$^{226}$ trans urethral appl. by O. Pasteau in 1913
  – Ra$^{226}$ trans perineal appl. by BS Barringner in 1917
  – Au$^{198}$ used by Rubin Flocks in 1952
  – I$^{125}$ through a retropubic freehand Whitmore 1972

History

– Hilaris & coll. Describe the technique\(^1\,^2\)
– With the faith of the surgeon’s eye and hands
– They missed the target (the cure)
  • Sub-optimal dosimetry
  • The technique was abandoned\(^3\)
– A transperineal approach was proposed by Dr Holm in 1981 \(^4\)

Introduction of a robotic delivery system

- With improved viewing TRUS
- We got the real 3D structure
  - A real target

Graciously: by Nucletron / Elekta

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Introduction of a robotic delivery system

- With the robotic delivery system

Graciously: by Nucletron / Elekta
Introduction of a robotic delivery system

CLINICAL INVESTIGATION

BYPASSING THE LEARNING CURVE IN PERMANENT SEED IMPLANTS USING STATE-OF-THE-ART TECHNOLOGY

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Fig. 2. Box plot representation of the 30-day postimplantation (30 days post plans) prostate D90, V100, and V200 for both Tom Baker Cancer Center and Centre Hospitalier Universitaire de Québec (CHUQ).

Fig. 4. American Urological Association (AUA) prostate symptom scores at baseline, 3 months, 6 months, and 12 months for patients treated at the Tom Baker Cancer Center (TBCC) and the Centre Hospitalier Universitaire de Québec (CHUQ). Error bars represent standard deviation.

Conclusion: State-of-the-art technology enables a new brachytherapy team to obtain excellent postplan dose distributions, similar to those achieved by an experienced team with proven long-term clinical results. The cost for bypassing the usual dosimetry learning curve is time, with increasing team experience resulting in shorter treatment times. © 2007 Elsevier Inc.
With a robotic delivery system

Le rôle de la curiethérapie prostatique guidée par imagerie 3D sur le ratio thérapeutique : l’expérience du CHU de Québec

The impact of 3D image guided prostate brachytherapy on therapeutic ratio: the Quebec University Hospital experience

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Cancer/Radiothérapie 11 (2007) 452-460

Fig. 2. Survie sans récidive biochimique (définition de Houston) en fonction des cohortes.

Updated from: Cancer/Radiothérapie 11 (2007) 452-460
With a robotic delivery system


Figure 3 Kaplan-Meier survival curves for patients with biochemical no evidence of disease (bNED) of the first 132 consecutive patients from each group. Number of patients at risk is shown against each time interval, PP, preplanning; iOP, intraoperative planning.

Matzkin et al. Radiat Oncol. 2013 Dec 17;8:288
With a robotic delivery system

Intraoperative Inverse planned (IPSA) 3D Image Guided Adaptive Brachytherapy

Dosimetry trial without and with the DIL Boost

Integration of robotics and imaging

• On a brachytherapy perspective:

  Once the local DFS are optimal,
  (at least for low and intermediate risk
  DFS being in the 90’s %)

  improvement on side effects
  is what’s left to do

Integration of robotics and imaging

• What structures do we need to avoid

  – Visual aid is needed
    • MRI visualization (Penile Bulb & other)
      – To better delineate our target
      – To differentiate it from adjacent structures
    • Tractography (NVB & neural structures)
      – To better define those structures in regards to our target
Integration of robotics and imaging

Ref: Institut National de la Santé et de la recherche médicale
http://www.inserm.fr/

Integration of robotics and imaging

And even nerve (penile bulb, etc...) sparing brachytherapy approach.

Right neuro-vascular bundle
Integration of robotics and imaging

And even nerve (bulb, etc...) sparing brachytherapy approach.

http://www.radiology.ucsf.edu/patient-care/sections/abdominal-imaging/research

Integration of robotics and imaging

• Can we be more specific on target?
  – Functional imaging to the rescue
    • Spectroscopy
    • Multiparametric MRI
    • PET
    • ...
    – To better define the target (DIL) within the gland
Integration of robotics and imaging

**Spectroscopy**

![Image of spectroscopy results]

Cancer

Normal

Courtesy of B. Picket

*Radiother Oncol. 2013 Nov;109(2):246-50*  

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Integration of robotics and imaging

**Multiparametric MRI with diffusion sequences**

![Image of multiparametric MRI]

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Integration of robotics and imaging

1st visualize the disease

- PET-MR

FIGURE 2. Results of PET/MRI fusion imaging in high-grade prostate cancer. Specific image information derived from 1C-choline PET (B), ADC DWI (C), HE histology (E), and parametric fusion PET/MRI using PGLA/CAD (F) is coregistered with transaxial T2-weighted MRI (A). Color bars indicate 1C-choline SUV (B) or PGLA/CAD (F), and inverted ADC (C). Zoomed registered HE histology slice is shown for increased clarity (E). At histology, Gleason 4 + 3 lesion is located in left lobe of prostate (red arrow) in peripheral and central zone, which is identified on registered imaging, whereas additional low-volume Gleason 3 + 3 lesion in right lobe is not identified (blue arrow).

Park & al. J Nucl Med April 1, 2012 vol. 53 no. 4 546-551

Integration of robotics and imaging

- Shall we re-invent the wheel?
- Let’s learn from the past and improve
- Try to combine and implement new technologies and modalities.
Integration of robotics and imaging

MR guided biopsies

• Guided to the lesion(s) & kept in memory
• Leave fiducial if wanted

http://urobotics.urology.jhu.edu/projects/MrBot/
Stoianovici D & al. Minimally Invasive Therapy. 2007; 16:4; 241–248

Integration of robotics and imaging

• Return with a planned approach
  – To avoid critical structures (penile bulb)

Reproduction authorised by Dr. Jean Pouliot (presentation of May 2014 @ CHU de Québec)
Integration of robotics and imaging

• Return to treat and cure
  – With a more focalized aim
    • And a robotic help to aim better, to hit right on the DIL
    • Robot replaces rigid templates
    • ➤ the degree of liberty with angular approach to target

Robotic guided prostate brachytherapy under TRUS visualization: A phantom experiment.

Integration of robotics and imaging

• Return to treat and cure
  – With a more focalized aim
    • And a robotic help to aim better
      – Anatomic localization transfer to needle guiding robot
Integration of robotics and imaging

• Evolving in treatments to cure

• This is called:

“IMAGE GUIDED ADAPTATIVE BRACHYTHERAPY”

– With a more focalized aim

• We could get right on with DIL Boost and eventual focal treatment

Integration of robotics and imaging

• Many systems are presently in development
  – EUCLIDIAN: Thomas Jefferson university, USA
  – MIRAB (multichannel Image-guided robotic agent for brachytherapy): Thomas Jefferson University, USA
  – MrBot (Curiethérapie sous IRM): University of Wisconsin, USA
  – BrachyGuide: University of British Columbia, Canada
  – Robarts Research Institute, Canada
  – University of western Ontario, Canada
  – Nucletron, Holland: Nucletron co.
  – UMCU: University Medical Center Utrecht, Pays Bas
  – PROSPER: TIMC, Grenoble, France
  – Sherbrook University: Polymer Robotics
Integration of robotics and imaging

- Will the physician be someday, the spectator of his prescribed treatment?

Figure 2. The MRBot robotic brachytherapy seed delivery system: (a) The robot is designed to fit inside a closed-bore MR system and is fully MR compatible, (b) the robot is attached to the control unit via air tubes and fiber optic cables.


Title

« I THINK THAT DREAMS ARE MEANT TO BE ACHIEVED »

Thank you.