BrachyNext
Working Together to Shape the Future of Brachytherapy

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[1]
  - Ra^{226} trans perineal appl. by BS Barringner in 1917[2]
  - Au^{198} used by Rubin Flocks in 1952[3]
  - I^{125} through a retropubic freehand Whitmore 1972[4]

1-Pasteau O, Degrais P. De l'emploi du radium dans le traitement des cancers de la prostate. J D'urologie Medicale et Chirurgicale 1913;4:341–366.
2-Barringer BS: Radium in the treatment of carcinoma of the bladder and prostate. JAMA 1917;68:1227–1230.
3-Flocks RH et al.: Treatment of carcinoma of the prostate by interstitial radiation with radioactive gold (Au 198): a preliminary report. J Urol 1952;68:510–22.
4-Whitmore WF Jr, Hilaris B, Grabstald H: Retropubic implantation of iodine 125 in the treatment of prostatic cancer. J Urol 1972;108:918–920.

History

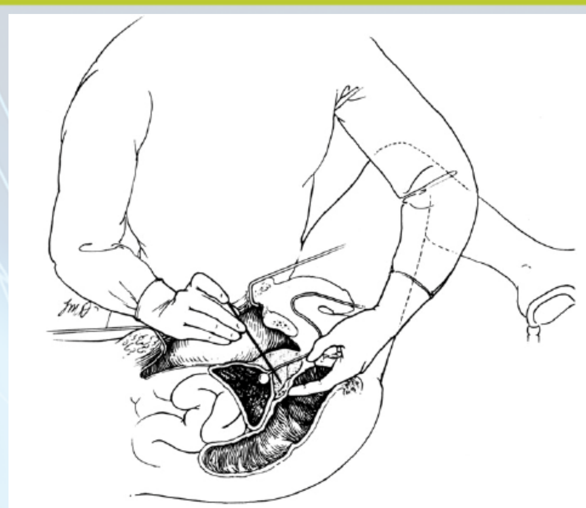


Fig. 4. Retropubic needle insertion.

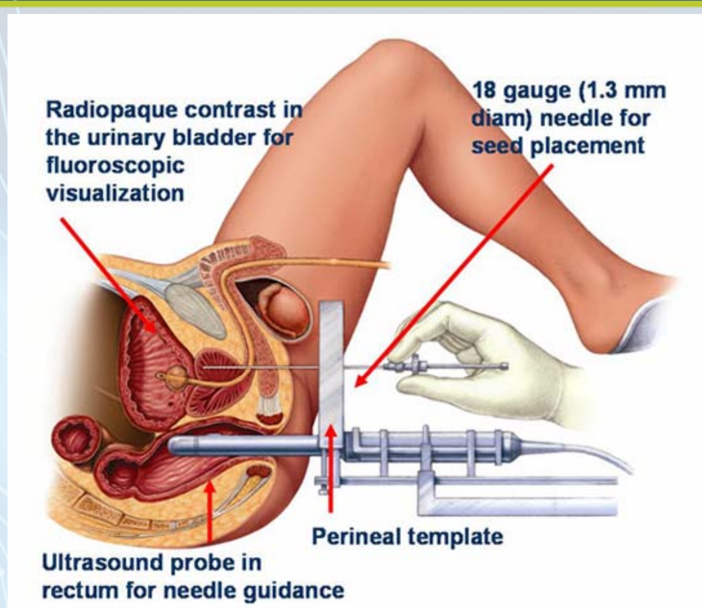
J.N. Aronowitz / Brachytherapy 11 (2012) 1570-162.
WhitmoreWF,Hilaris B,GrabstaldH. Retropubic implantation of iodine 125 in the treatment of prostatic cancer. J Urol 1972;108:918-20.

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]

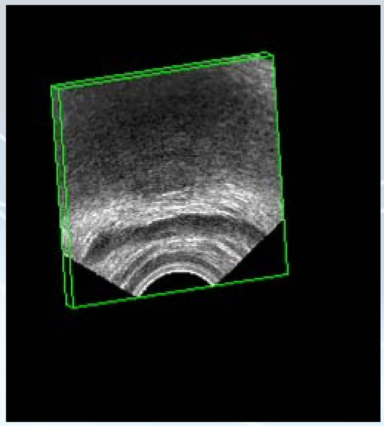
1-Hilaris BS et al. Radical radiation therapy of cancer of the prostate: A new approach using interstitial and external sources. Clin Bull 1972;2:94
2-Hilaris BS, Holt GJ, Germain JS. The use of iodine-125 for interstitial implants. Rockville, MD: Dept HEW; 1975.
3-Batata MA. Et al. Int J Radiat Oncol Biol Phys. 1980 Feb;6(2):149-53.
4-Holm HH et al. Ultrasonically guided percutaneous interstitial implantation of iodine 125 seeds in cancer therapy. Brit J Radiol 1981;54(644):665–670.

History



Introduction of a robotic delivery system

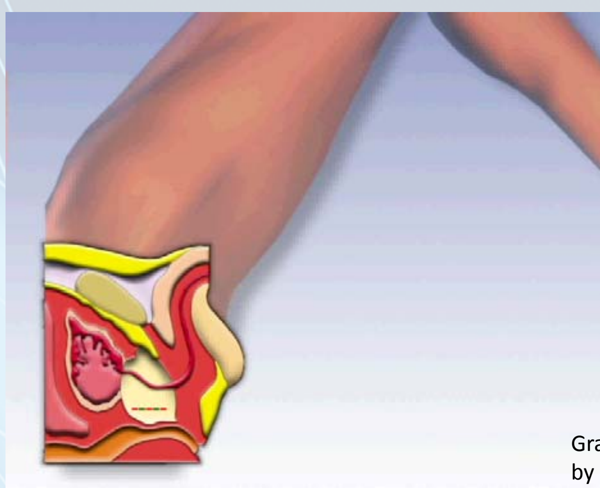
- With improved viewing TRUS
- We got the real 3D structure
  - A real target



Graciously :
by Nucletron / Elekta

Introduction of a robotic delivery system

- With the robotic delivery system



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Introduction of a robotic delivery system

Int. J. Radiation Oncology Biol. Phys., Vol. 67, No. 1, pp. 71–77, 2007

0360-3016/07/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2006.07.019

CLINICAL INVESTIGATION **Prostate**

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

Luc Beaulieu, Ph.D.,* Dee-Ann Radford Evans, M.Sc.,† Sylviane Aubin, M.Sc.,* Steven Angyalfi, M.D.,† Siraj Husain, M.D.,† Ian Kay, Ph.D.,† André-Guy Martin, M.D., M.Sc.,* Nicolas Varfalvy, M.Sc.,* Éric Vigneault, M.D., M.Sc.,* and Peter Dunscombe, Ph.D.†

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Introduction of a robotic delivery system

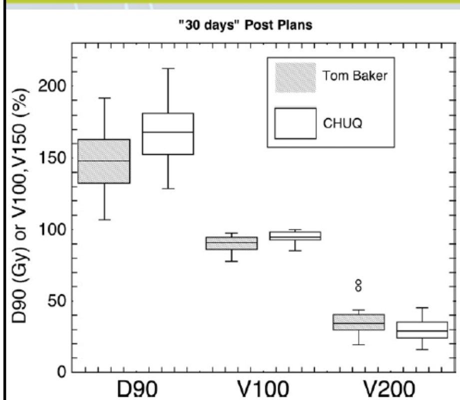

Fig. 2. Box plot representation of the 30-day postimplantation (30 days post plans) prostate D90, V100, and V200 for both Tom Baker Cancer Center and Centre Hospitalier Universitaire de Québec (CHUQ).

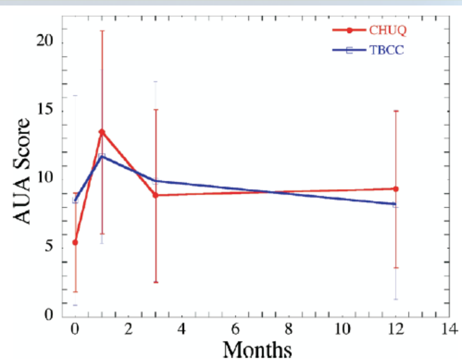

Fig. 4. American Urological Association (AUA) prostate symptom scores at baseline, 3 months, 6 months, and 12 months for patients treated at the Tom Baker Cancer Center (TBCC) and the Centre Hospitalier Universitaire de Québec (CHUQ). Error bars represent 1 standard deviation.

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.

With a robotic delivery system

Disponible en ligne sur www.sciencedirect.com
ScienceDirect
Cancer/Radiothérapie 11 (2007) 452–460
ELSEVIER MASSON
CANCER RADIOTHÉRAPIE
http://france.elsevier.com/direct/CANRAD/

Article original

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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[b] *Centre de recherche en cancérologie de l'université Laval, l'Hôtel-Dieu de Québec, 11, côte du Palais, G1R 2J6 Québec, Canada*
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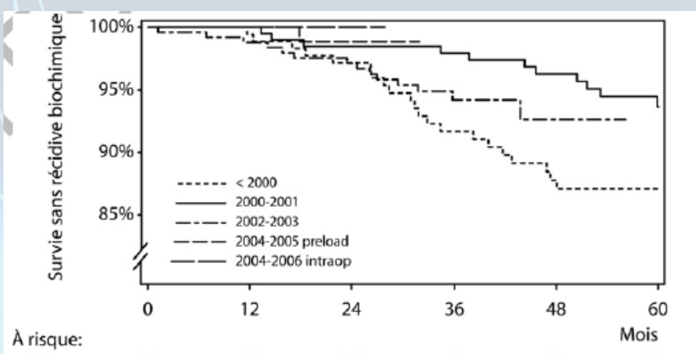
Cancer/Radiothérapie 11 (2007) 452-460

With a robotic delivery system



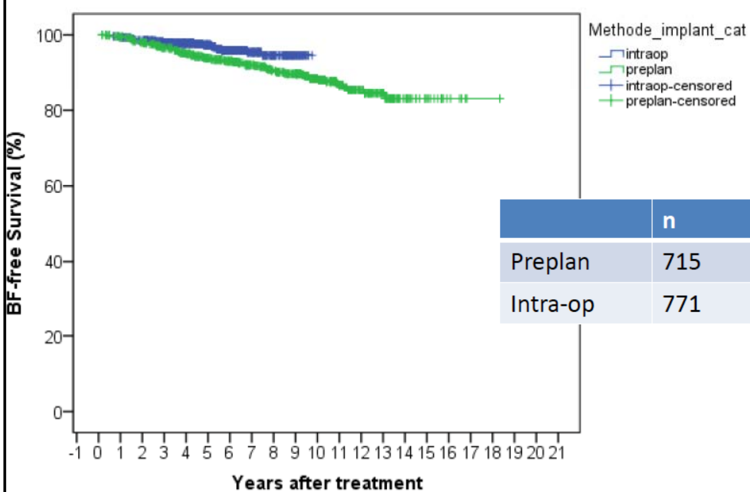
À risque:

	0	12	24	36	48	60
< 2000	191	177	167	147	128	109
2000-2001	205	198	194	183	166	110
2002-2003	254	243	228	135	32	0
2004-2005 preload	107	100	61	0	0	0
2004-2006 intraop	276	144	9	0	0	0

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

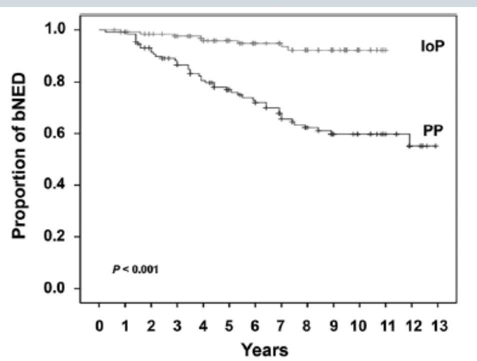


	n	7-bDFS
Preplan	715	92,1%
Intra-op	771	95,4%

P=0.007

Updated from: *Cancer/Radiothérapie 11 (2007) 452-460*

With a robotic delivery system



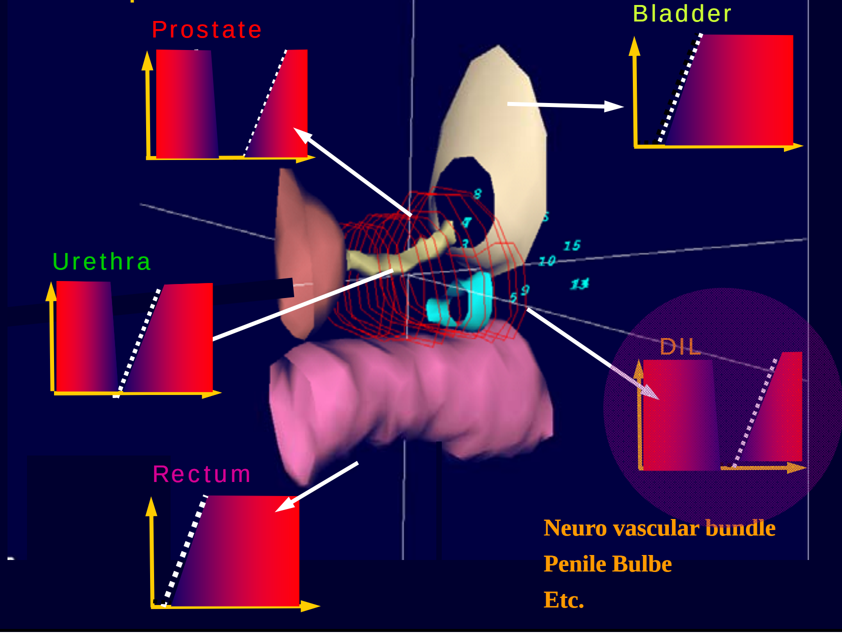
No. at risk

PP	132	131	116	106	93	80	74	61	50	42	35	17	6
IoP	132	129	125	119	107	93	82	74	66	53	19	1	
Time (years)	0	1	2	3	4	5	6	7	8	9	10	11	12

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.

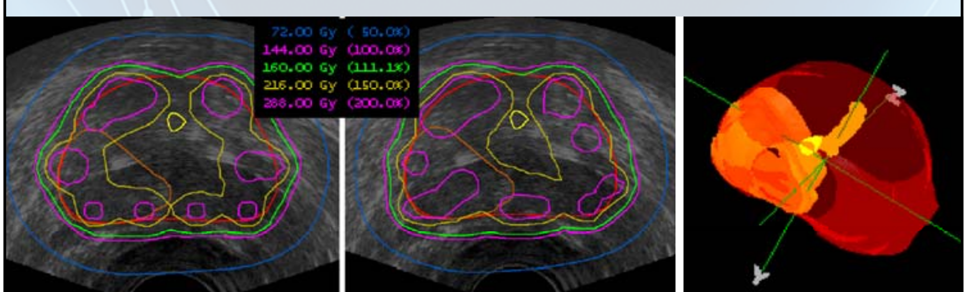
Matzkin et al. Radiat Oncol. 2013 Dec 17;8:288

IPSA
Simple cost function/Class solution



With a robotic delivery system

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



Dosimetry trial without and with the DIL Boost

Gaudet et al. Int J Radiat Oncol Biol Phys. 2010 May 1;77(1):153-9

Integration of robotics and imaging

- On a brachytherapy perspective:

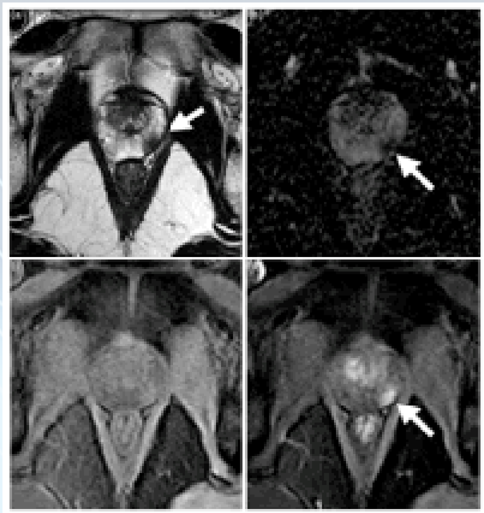
Once the local DFS are optimal,
(at least for low and intermediate risk
DFS being in the 90's %)

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 strutures)
      - To better define those structures in regards to our target

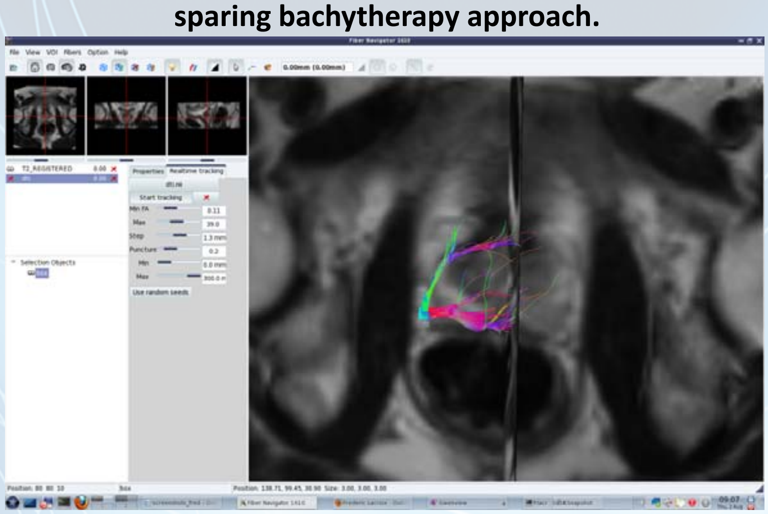
Integration of robotics and imaging



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

Integration of robotics and imaging

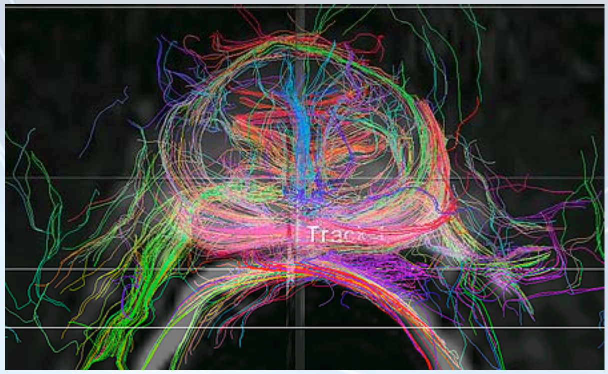
**And even nerve (penile bulb, etc…)
sparing bachytherapy approach.**



Right neuro-vascular bundle

Integration of robotics and imaging

**And even nerve (bulb, etc…)
sparing bachytherapy approach.**



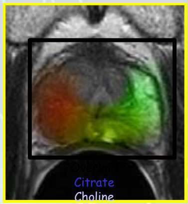
http://www.radiology.ucsf.edu/patient-care/sections/abdominal-imaging/research

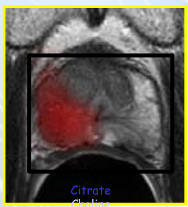
Integration of robotics and imaging

- 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

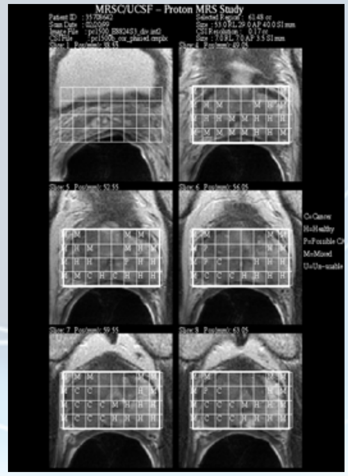
Spectroscopy





Cancer

Normal



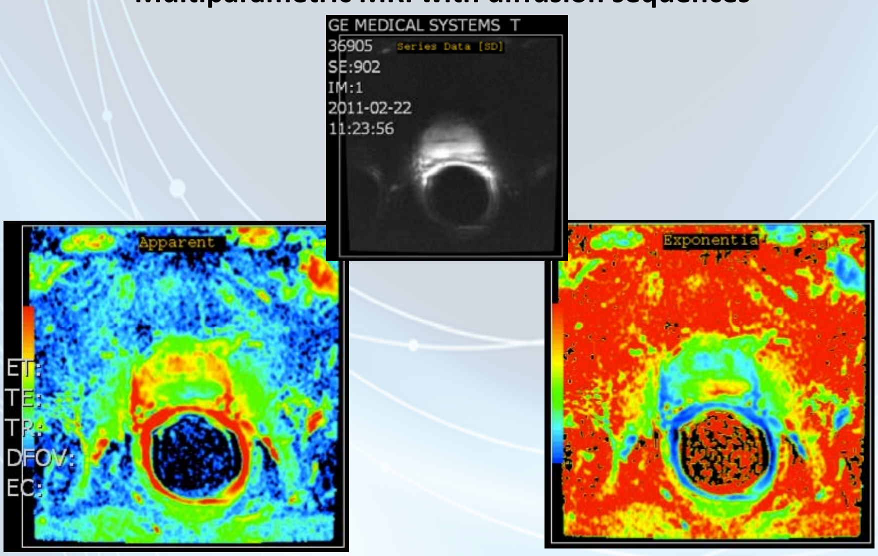
Courtesy of B. Picket

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

Int J Radiat Oncol Biol Phys. 2004 Jul 15;59(4):1196-207.

Integration of robotics and imaging

Multiparametric MRI with diffusion sequences

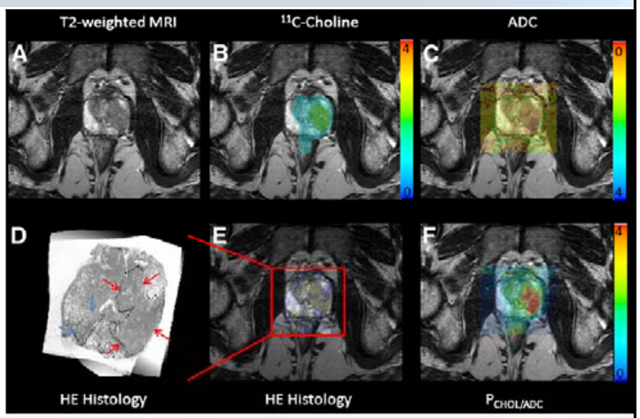


Integration of robotics and imaging

1st visualize the disease

- PET-MR

FIGURE 2. Results of PET/MRI fusion imaging in high-grade prostate cancer. Specific image information derived from ^{11}C-choline PET (B), ADC DWI (C), HE histology (E), and parametric fusion PET/MRI using $P_{CHOL/ADC}$ (F) is coregistered with transaxial T2-weighted MRI (A). Color bars indicate ^{11}C-choline SUV (B), $P_{CHOL/ADC}$ (F), and inverted ADC (C). Zoomed registered HE histology slice is shown for increased clarity (D). At histology, Gleason 4 + 3 lesion is located in left lobe of prostate (red arrows) 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 arrows).



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

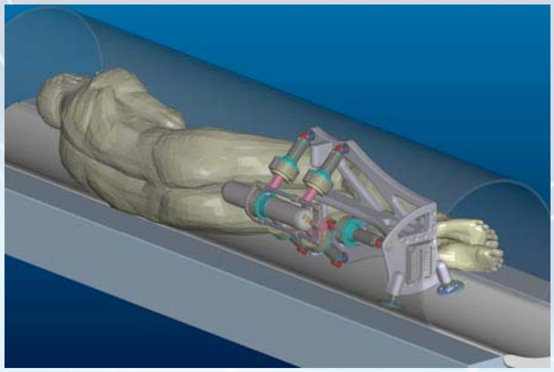
Integration of robotics and imaging

- 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

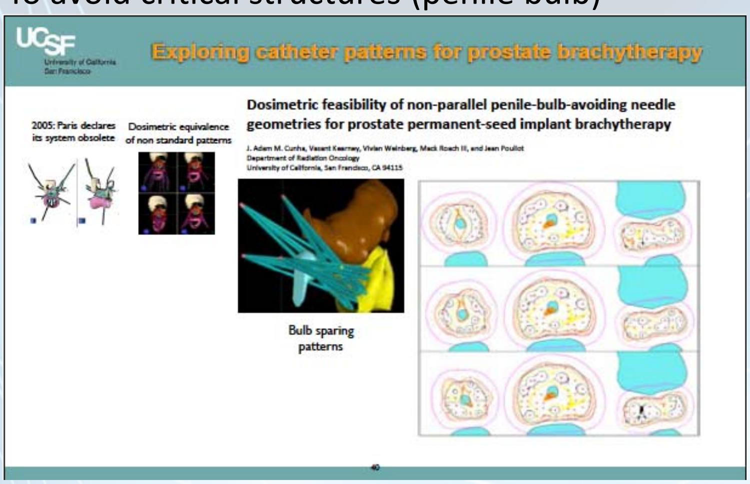
- Guided to the lesion(s) & kept in memory
- Leave fiducial if wanted



http://urobotics.urology.jhu.edu/projects/MrBot/
Cunha JA & al. Minimally Invasive Therapy. 2010;19:189–202
Muntener M & al. Urology. 2006;68(6):1313-7
Stoianovici D & al. Minimally Invasive Therapy. 2007; 16:4; 241–248

Integration of robotics and imaging

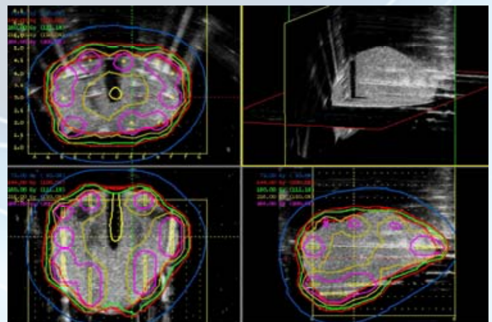
- Return with a planned approach
  - To avoid critical structures (penile bulb)



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

Integration of robotics and imaging

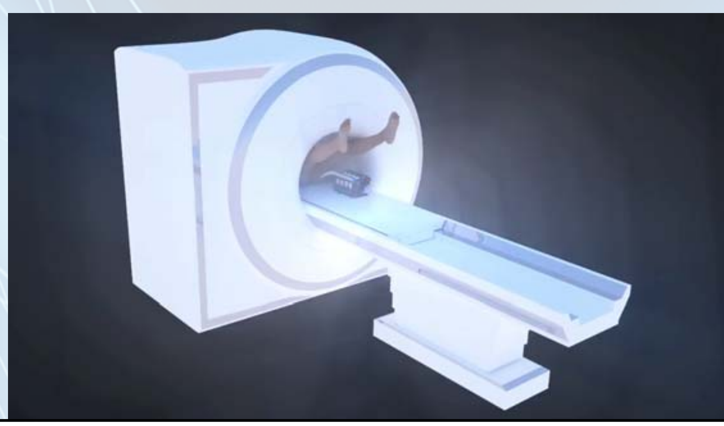
- Return to treat and cure
  - With a more focalized aim
    - And a robotic help to aim better, to hit right on the DIL
    - Robot replaces rigid templates
    - ➚ the degree of liberty with angular approach to target



Robotic guided prostate brachytherapy under TRUS visualization: A phantom experiment
A.G. Martin et al. PO-1032, ESTRO33, Vienne. *Radiother Oncol* **111**(supp 1), p. S417 (2014)

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): (formerly: John Hopkins University)
  - 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 ?

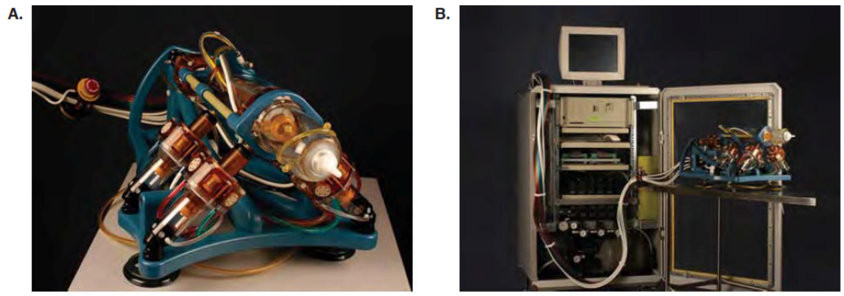


Figure 2. The MRBot robotic brachytherapy seed delivery system: (a) The robot is designed to fit inside a closed-bore MR system and is fully MR compatible, (b) the robot is attached to the control unit via air tubes and fiber optic cables.

Cunha JA, et al. Minimally Invasive Therapy. 2010;19:189–202

Title

« I THINK THAT DREAMS ARE MEANT TO BE ACHIEVED »

Thank you.