SAM-HDR Brachytherapy II: Integration of Real Time Imaging

US-based prostate brachytherapy: are we there yet?

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No conflict of interest

Learning objective:

to learn about the current status and future developments in US-based HDR prostate brachytherapy

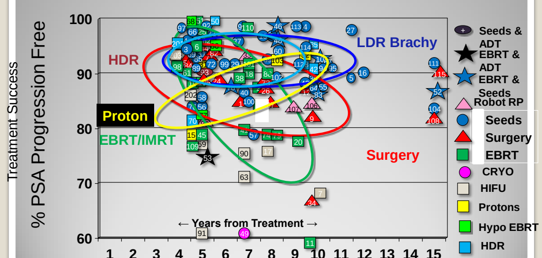
Outline

- Rationale
- Typical workflows. Variations
- Planning. TPS choices.
- Errors and Uncertainties
- Quality Assurance
- Future. Novel uses. Focal therapy.

LOW RISK RESULTS

Weighted

>40 months follow-up or less than 100 patients



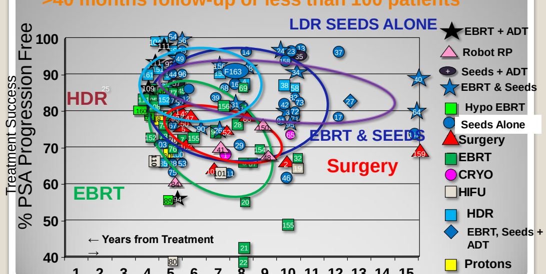
- Prostate Cancer Results Study Group
- Numbers within symbols refer to references

Update of BJU Int, 2012, Vol. 109(Supp 1) 7/23/2014 Prostate Cancer Center of Seattle

INTERMEDIATE RISK RESULTS

weighted

>40 months follow-up or less than 100 patients



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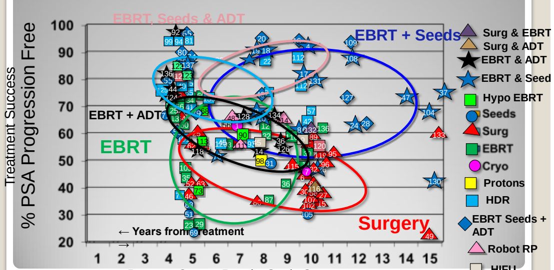
HIGH RISK RESULTS

Weighted

>40 months follow-up or less than 100 patients



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in their 2013 ACR Appropriateness Criteria® HIGH-DOSE-RATE BRACHYTHERAPY FOR PROSTATE CANCER Expert Panel on Radiation Oncology–Prostate: I-Chow Joe Hsu, MD; Yoshiya Yamada, MD; Gregory Merrick, MD; Dean G. Assimos, MD; Anthony V. D'Amico, MD; Brian J. Davis, MD, PhD; Steven J. Frank, MD; Alexander R. Gottschalk, MD, PhD; Gary S. Gustafson, MD; Patrick W. McLaughlin, MD; Paul L. Nguyen, MD; Seth A. Rosenthal, MD; Al V. Taira, MD; Neha Vapiwala, MD.

the experts state that "The transrectal ultrasound-guided implant technique is the backbone of modern prostate brachytherapy."

In the 2013 "**GEC/ESTRO recommendations on high dose rate afterloading brachytherapy for localised prostate cancer: An update**. Peter J. Hoskin , Alessandro Colombo , Ann Henry , Peter Niehoff , Taran Paulsen Hellebust ,Frank-Andre Siebert , Gyorgy Kovacs

"In prostate cancer real-time transrectal ultrasound (TRUS) guided transperineal template implant techniques represent the standard of care."

Usage

- Boost (together with EBRT, Androgen deprivation). Typically 1-2 Fractions
- Mono-therapy. Typically 2-4 Fractions but recent results from small clinical trials point towards a single fraction future.
- Salvage vs. Primary (initial) treatment

Usage

- From a "Survey of practice in Australia" we learn that:
  In Australia and New Zealand, 17 of 26 brachytherapy departments performed HDR-PB in 2010 and 2011. Nucletron's Oncentra TPS was used at 13 departments, one department used Nucletron's Plato TPS and three used Varian's BrachyVision TPS.

  Imaging modality for treatment planning

  Thirteen departments generated a treatment plan using computerised tomography data, and two departments used ultrasound (US) data. No departments reported using MRIs or fused data sets for treatment planning.

  All departments, except one, verified and corrected applicator displacement prior to each fraction or, in the case of real-time US planning and more than one fraction, subsequent fractions. Applicator displacement was corrected by one of three methods to replicate the original plan: eight departments adjusted applicator positions, four departments adjusted dwell positions and two departments created a new treatment plan.

Survey of high-dose-rate prostate brachytherapy practice in Australia and New Zealand, 2010–2011, Jane van Nieuwenhuysen, David Waterhouse, Sean Bydder, David Joseph, Martin Ebert and Nikki Caswell. Journal of Medical Imaging and Radiation Oncology 58 (2014) 101–108

- Eighty-nine percent (89%) of respondents performed LDR and 49% perform high-dose-rate brachytherapy.
- HDR monotherapy - Of the respondents who perform HDR, 31% (10/32) perform HDR monotherapy for low-risk patients and 19% (6/32) for intermediate-risk patients. The remaining 16 respondents (50%) do not perform HDR monotherapy.
- Imaging - Ultrasound remains the primary imaging modality. Ultrasound was in 83% vs. 84% in 1998, CT in 9%, MRI in 0%, X-ray in 0%, and fluoroscopy in 17%.
- Treatment planning - Pretreatment volume studies are performed with ultrasound in 94%, CT in 11%, and MRI in 6%. Twenty percent reported using more than one imaging modality as "primary" modality.
- LDR and HDR treatment planning software.
  The software used for planning was institutional custom developed software in 2% and commercially available in systems in 98%. The commercially available systems were: Prowess (Prowess Inc., Concord, CA, USA) in 4%, Variseed (Varian Medical Systems, Inc., Palo Alto, CA, USA) in 80%, Brachyvision (Varian Medical Systems) in 4%, and CMS (Elekta AB, Stockholm, Sweden) in 6%, Nucletron (Nucletron, Columbia, MD, USA) in 4%, Varisource (Varian Medical Systems) in 5%, Oncentra (Nucletron) in 2%, Varus (Varian Medical Systems) in 2%, and Plato (Nucletron) in 2% (percentages to not add to 100% owing to multiple systems for some respondents).

A survey of current clinical practice in permanent and temporary prostate brachytherapy: 2010 update. Mark K. Buyyounouski, Brian J. Davis, Bradley R. Prestidge, Thomas G. Shanahan,Richard G. Stock, Peter D. Grimm, D. Jeffrey Demanes, Marco Zaider, Eric M. Horwitz. Brachytherapy 11 (2012) 299-305

'Real-time' workflow

- Initial imaging
- Delineating structures
- Define needles/applicators pattern
- Needles/applicators Insertion
- Update images & structures
- Delineate applicators
- Plan & Optimize Dose
- QA for plan and applicators
- Treatment delivery

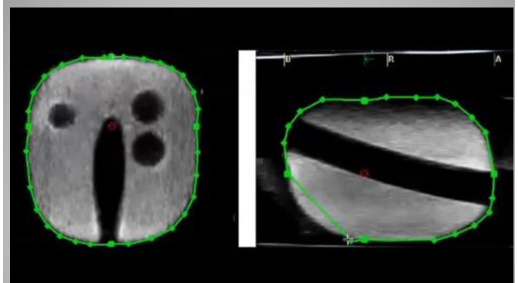

Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucleotron

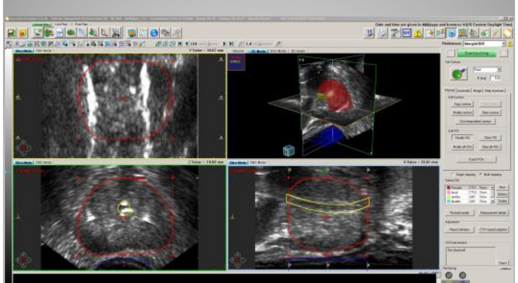

Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucleotron

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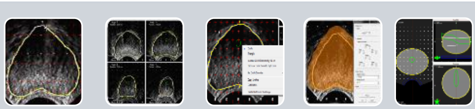
Contouring



Freehand	Real Time Interpolation	Shape Stamper	Margin	Review Contour
Draw & edit contours using a pen or brush tool	Draw necessary contours & Vitesse fills in the rest	Quickly draw urethra on transverse slices with single click	Create a symmetrical or non symmetrical margin structure	Sagittal & coronal contour review

Image courtesy of Kevin Spetz, Varian Brachytherapy

15 | VARIAN ONCOLOGY SYSTEMS

VARIAN medical systems

Vitesse

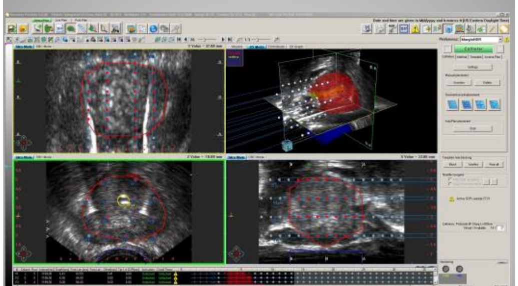


Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucletron

Needle Placement

- Place your initial needle positions using Needle Placement tool
  - Peripheral/interior

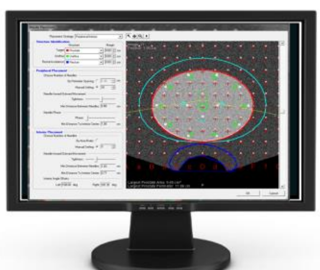


Image courtesy of Kevin Spetz, Varian Brachytherapy

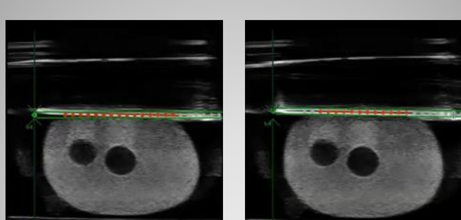


Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucletron

Needle Placement

- Adjust planned needle positions
- Change needle angle by aligning two nodes
- Bend needle to align with implanted needle

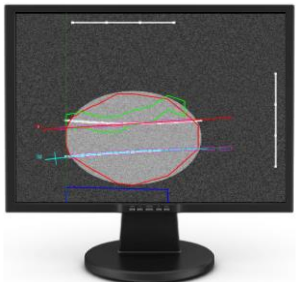


Image courtesy of Kevin Spetz, Varian Brachytherapy

Needle Tip Adjustment Tool

Assists in correctly aligning needle tips

Select reference needle(s) based on confidence of defined tip position

Enter exposed length of the reference needle(s) from the template

Select needle of concern

Enter exposed length of selected needle

Tool displays the determined offset of selected needle and allows adjustment

Live image of the needle and offset applied can be viewed before accepting the change

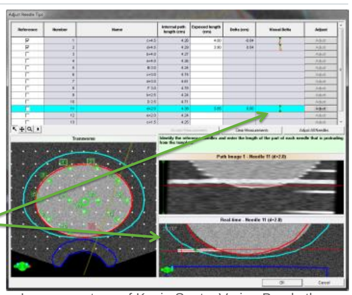


Image courtesy of Kevin Spetz, Varian Brachytherapy

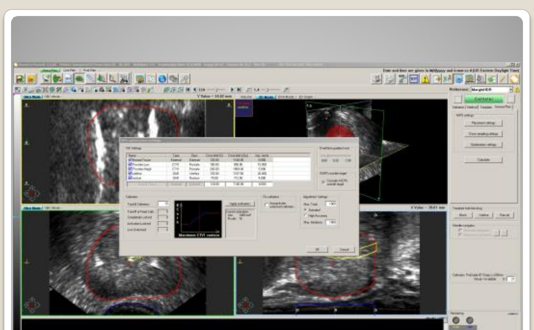


Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucletron

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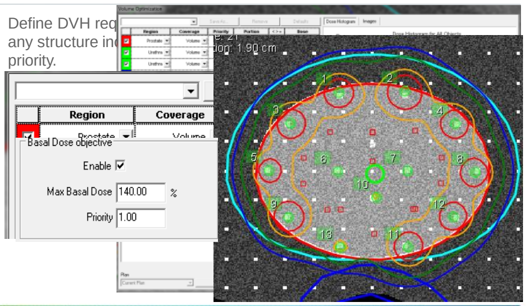
Volumetric Optimizer

- Define DVH req
any structure in
priority.



22 | VARIAN ONCOLOGY SYSTEMS

VARIAN medical systems

Vitesse

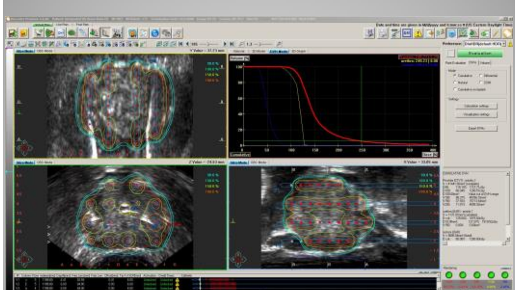


Image courtesy of Scott Campbell and Kim Chambers, Elekta/Nucletron

Errors and uncertainties

- Is an ultrasound based procedure as good as a CT-based one?

ELSEVIER

BRACHYTHERAPY

Validation study of ultrasound-based high-dose-rate prostate brachytherapy planning compared with CT-based planning

Deidre Batchelar, Miren Gaztañaga, Matt Schmid, Cynthia Araujo, François Bachand, Juanita Crook

RESULTS: A total of 574 needle tip positions have been compared between TRUS and CBCT. Of these, 59% agreed within 1 mm, 27% within 1-2 mm, and 11% agreed within 2-3 mm. The discrepancy between tip positions in the two modalities was greater than 3 mm for only 20 needles (3%).

CONCLUSIONS: The US needle tip identification in vivo is at least as accurate as CT identification, while providing all the advantages of a one-step procedure.

Errors and uncertainties

- During multifractionated HDR treatment, catheter migration could cause degradation of dosimetry. Various institutions had developed solutions to address this issue and they involve, catheters adjustments based on tip positions relative to fiducials, adjustments of dwell positions or creating a new plan.

Applicator verification/correction

Cranio-caudal displacement of the applicators during multi-fraction HDR-PB can compromise coverage of theCTV and introduce uncertainties in normal tissue doses. Tiong *et al.* assessed applicator displacements over a 12-month period (more than 270 treatment fractions), and concluded that <= 3 mm drift was tolerable with minimal detrimental impact upon tumour control probability. The ABS advises that if applicator drift cannot be repositioned or corrected with a new plan, treatment should be postponed.GEC/ESTRO-EAU advise to check the applicator geometry prior to treatment and, if necessary, to modify the dosimetry.

Quality Assurance

AAPM Task Group 128: Quality assurance tests for prostate brachytherapy ultrasound systems

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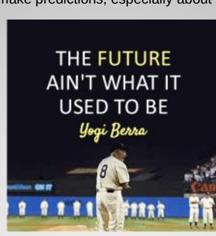
Future

'It's tough to make predictions, especially about the **future**.'



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Overview

Brachytherapy: Current Status and Future Strategies — Can High Dose Rate Replace Low Dose Rate and External Beam Radiotherapy?

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"The advantage of TRUS-based planning is that the entire procedure of catheter insertion, planning and treatment delivery can be carried out in a shielded brachytherapy suite without having to move the patient. This provides added confidence that the treatment delivered is exactly as planned.
If computed tomography or MRI is used for planning, the patient usually has to be transferred from the procedure room to the computed tomography or MRI scanner and then back again to a shielded room for treatment. Each step risks some displacement of the catheters and requires careful repositioning before treatment is delivered. "

"Focal therapy is gaining popularity with the ability of modern imaging (mpMRI) to identify dominant areas of the disease within the prostate and again HDRBT will have a major role to play in this area.

There is also increasing evidence for the role of HDRBT in local recurrence after external beam radiotherapy.

Future guidelines will seek to explore these areas as published evidence emerges."

THANK YOU

What is the most important advantage of Ultrasound-based HDR prostate brachytherapy?

20% 1. It is inexpensive and widely available.
20% 2. Allows needle insertion and treatment delivery without moving the patient, thus minimizing the uncertainty in delivery of intended treatment
20% 3. Allows for visual guidance during needle placement
20% 4. Both anatomical structures and applicators can be visualized
20% 5. It is now available in color.

10

Answer

- The correct answer is 2.
  While 1. 3. and 4. are also advantages one can argue that 2. is really the 'most important' advantage

- Ref: *"Brachytherapy: Current Status and Future Strategies: Can High Dose Rate Replace Low Dose Rate and External Beam Radiotherapy?"* *G.C. Morton, P.J. Hoskin, Clinical Oncology 25 (2013) 474-482*

What is the major source of uncertainty in Ultrasound-based HDR prostate brachytherapy?

20% 1. Contouring of anatomical structures
20% 2. Patient breathing
20% 3. Needles/catheters displacement
20% 4. Visualization and delineation of needles/catheters and specifically their tip
20% 5. Calibration of Ultrasound scanners

10

Answer:

- The correct answer is 3.
- This is a difficult question and I think arguments can be made for either 3. particularly if multiple fractions are to be delivered or 4. for the case of one fraction treatments. Contouring of prostate 1. would be a third partially correct answer, even though evidence is that comparisons between US and CT against the MR as gold standard are putting US relatively close to the MR.

- Ref: *"Validation study of ultrasound-based high-dose-rate prostate brachytherapy planning compared with CT-based planning", Deidre Batchelar, Miren Gaztanaga, Matt Schmid, Cynthia Araujo, Francois Bachand, Juanita Crook, Brachytherapy 13 (2014) 75-79*