Physics and Quality Assurance

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WAKE FOREST UNIVERSITY
SCHOOL of MEDICINE

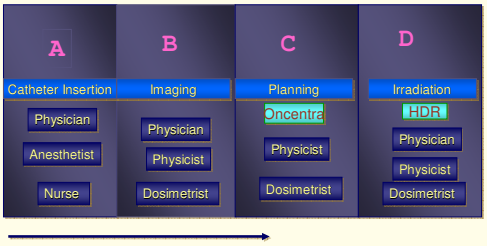
Disclosure

- Consultancy agreements with Nucletron, Hologic

Agenda

- Overview of Various Applicators
  - GYN (T & O, T & Ring, Cylinder)
  - Breast (Savi, MammoSite® ML, Contura®, Interstitial)
- Quality Assurance
  - Tools needed (check ruler, Source position simulator, Transfer tubes, etc.)

Current Treatment Workflow



GYN HDR

- Manual (Cs-137) - 2D
- LDR Afterloader - 2D
- HDR - 2D & 3D
  - Simulator
  - CT
  - MRI
  - US

Why Image Guided?

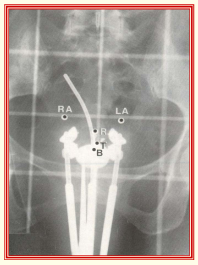
- Applicator displacement
- Organ At Risk (point dose vs volume)
- Prescription to a Point vs Volume
- Target definition

ICRU 38 (1985) - "Dose and Volume Specification for Reporting Intracavitary Therapy in Gynecology"

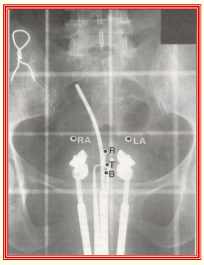
- Definitions of concepts:
  - LDR is dose rates between 0.4 and 2 Gy/h and HDR is > 12 Gy/h
  - Target Volume: tissues that are to be irradiated to a specified dose
  - Treatment Volume: volume enclosed by a relevant isodose surface selected by the radiation oncologist; encompasses at least the target volume
  - Reference Volume: volume enclosed by the reference isodose surface (based on agreed reference dose level)
  - Irradiated Volume: volume which receives an absorbed dose considered significant in relation to tissue tolerance; may be a percentage of reference dose
- Reference volume:
  - For LDR, should use absorbed dose level of 60 Gy; for HDR an equivalent (according to treating radiation oncologist) dose should be specified
  - Described by three parameters: height (dimension along intrauterine source), width (perpendicular to height in frontal plane), thickness (perpendicular to height in sagittal plane)
  - Absorbed dose at reference points:
    - Definitions apply when calculated from two perpendicular radiographs (AP/lateral)
    - Bladder reference point: Foley catheter is inserted; balloon filled with 7cm3 radio-opaque fluid. Catheter is pulled downward to bring the balloon against urethra. On lateral radiograph, reference point is on an anterio-posterior line drawn through the center of the balloon, at the posterior surface of the balloon. On AP radiograph, the reference point is at the center of the baloon
    - Rectal reference point: Visualize posterior vaginal wall with intravaginal mould or by opacification of the vaginal cavity with radio-opaque gauze used for packing. On lateral radiograph, a separate anterio-posterior line is drawn from the lower end of the intrauterine source (or the middle of the intravaginal source). Reference point is on this line, 5 mm behind posterior vaginal wall. On AP radiograph, the reference point is at the lower end of the intrauterine source (or the middle of the intravaginal source)

Applicator movement

Pre-Treatment



Post-Treatment



Pham et al Radiology 206:525-531,1998

Solution to avoid Displacement

- **Brachy Suite**
  - Eliminates the transport of patient from one room to another
  - Patient can be implanted, imaged and treated in the same position without any movement

Unfortunately, majority of Brachy Suites have a simulator (2D images)

Prescription to a Point vs volume

- Still in the US majority of the center prescribe the dose to Point A (2 cm above the os and 2 cm lateral)
- In most cases, this results in an under estimation of the target dose when 3D planning is performed

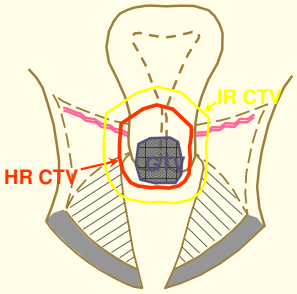
Target Definition: CT vs MRI

- Accurate definition and delineation
- Efficiency of 3D is limited by poor soft-tissue contrast
- CT is limited in differentiating tumors of cervix from normal cervical, uterine, and parametrial tissue
- CT over estimation of target volume

Target Definition: CT vs MRI

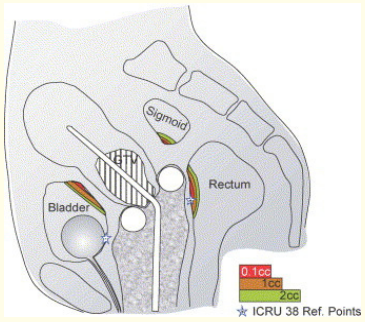
- EBRT decreases the contrast of tumors on CT
- MRI offers more accurate evaluation of the tumor volumes and OAR

- GTV – T2 bright areas
- HR-CTV – cervix + visible/palpable disease at brachy
- IR-CTV – 1 cm margin around HR-CTV + initial sites of involvement



GYN GEC ESTRO Recommendations (I) Radioth.Oncol. 2005, 74:235-245

GEC ESTRO recommended dose recording

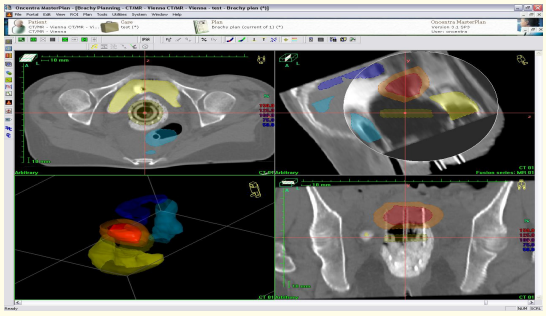


D0.1cc
D2cc

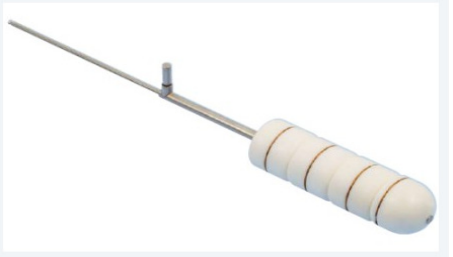
Recommendations…

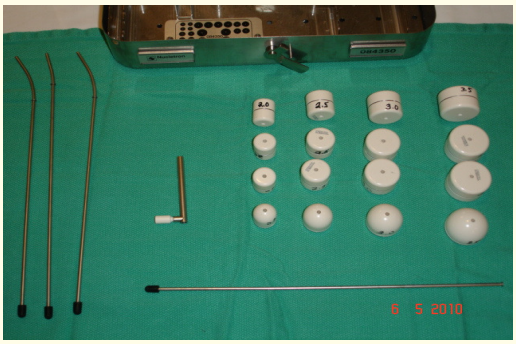
- **Ideally, it is recommended to repeat MRI prior to every brachytherapy implant**
- **In reality, this is very difficult to implement**
- **Not feasible for majority of Departments**

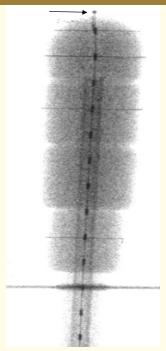
Image Fusion



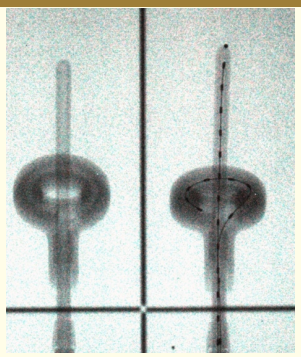
Vaginal Applicator Set







Ring CT-MR Applicator Set



Fletcher CT-MR Applicator Set

Capri Applicator

Applicators

Gyn Tubes channel specific & applicator specific

Fletcher style

- **Rt ovoid is channel 1**
- **Lt ovoid is channel 2**
- **IU tube is channel 3**

Ring style

- **Ring is channel 1**
- **IU tube is channel 3**

Applicators

Gyn Tubes (cont)

Metallic style cylinders
universal fit
Shielded cylinders
channel 3
CT-MR style cylinders
channel 3

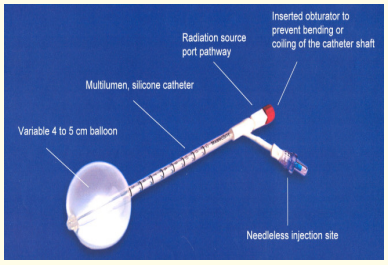
Applicators

- Safety Considerations
  - Inspection of applicator before insertion:
  - If fluid present inside applicator
    - DO NOT PROCEED

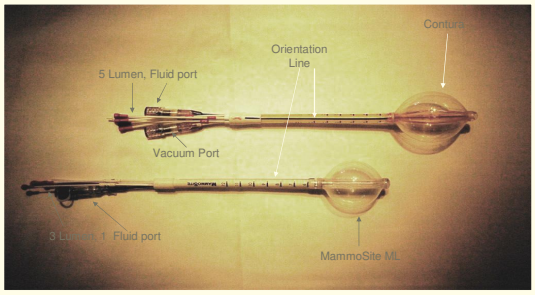
Breast Applicators

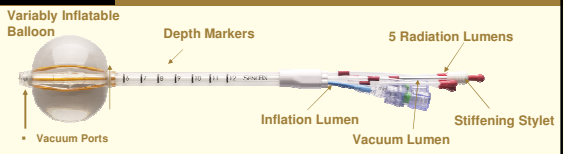
- MammoSite
- Contura
- Savi
- MammoSite ML
- Interstitial

Spherical Balloon



Device Photos





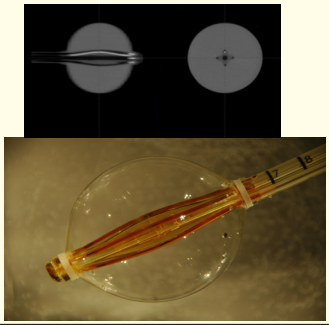
Available balloon sizes
4-5cm variable – 33cc to 58cc fill volume
4.5-6cm variable – 51cc to 108cc fill volume

- Orientation line on shaft – Lumen #1
- Shaft diameter – 8 mm, Shaft length – 16cm to hub

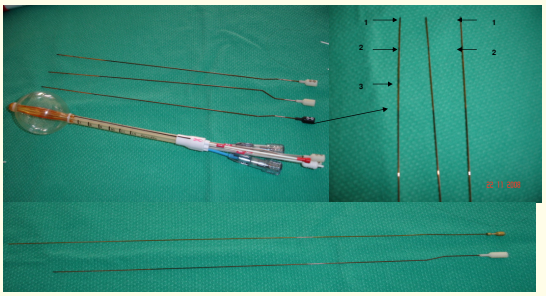
Five Treatment Lumens:
1 central, 4 offset from central
Rigid Geometry

Balloon Design Changes

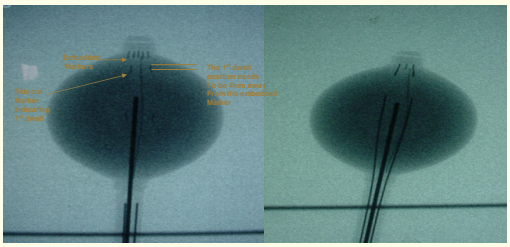
Nitinol wire demarcating lumen one



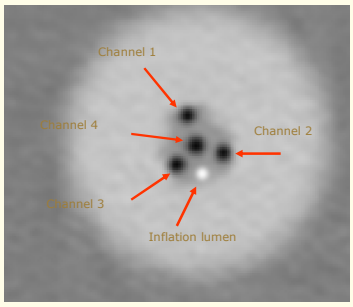
SenoRx CT Markers



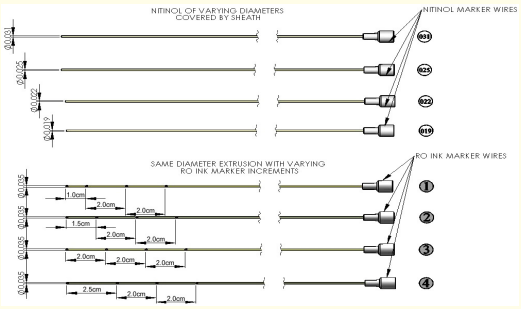
CT Markers

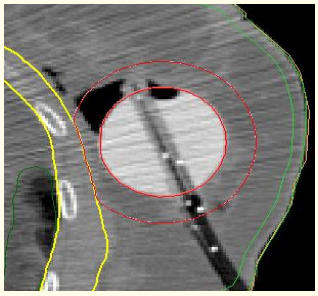


Applicator Reconstruction



Lumen Identification – Marker Wire Designs

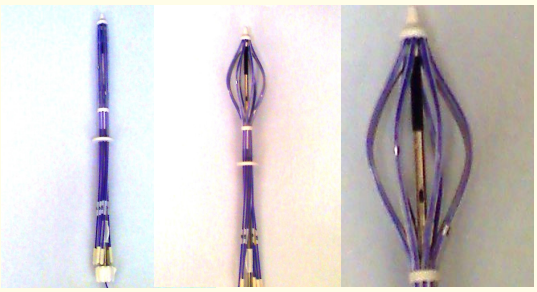




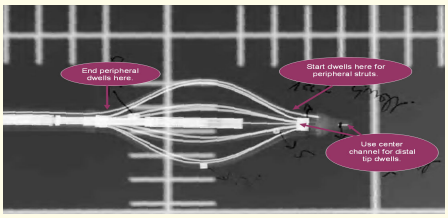
The SAVI Applicator

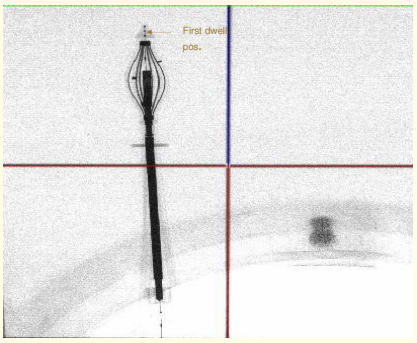
- Central lumen with 6, 8, or 10 equally spaced peripheral lumens
- Length varies from 5.0 cm to 7.5 cm
- Diameter varies from 2.4 cm to 5.0 cm
- Multiple dwell positions in each lumen

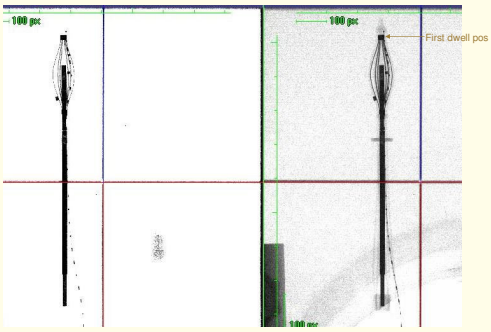
The SAVI Applicator



Setting dwell positions



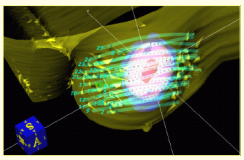




Interstitial & Comfort Catheters

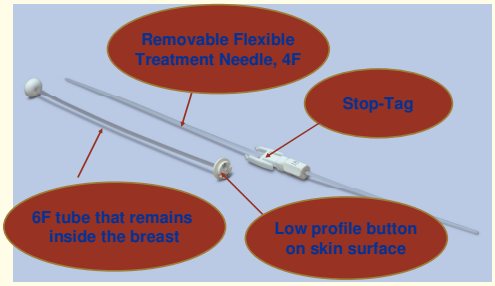
Multiple channels
Multiple dwell positions

Courtesy of Robert Kuske, MD



Courtesy of Rakesh Patel, MD

Comfort™ Catheter System



In between the Fractions …

- Only the outer catheter stays in the body
- Only buttons remain, no long catheters

Why QA?

- Why do we need to worry about Quality Assurance?

Because….

Before You Begin…

What you will need:

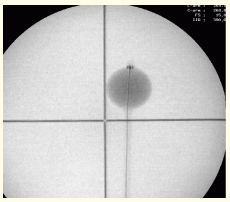
- *transfer tubes*
  6F (transfer tubes)
- *Markers*
- *Source Position Simulator or other measuring devices*

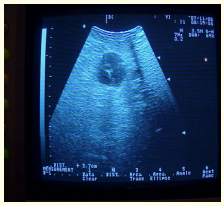
Quality Assurance: Balloon Volume

- *Measurement of balloon volume*
  - *How much of fluid injected in the balloon*
  - *Balloon volume by delineation (CT)*
  - *Should agree within ±5%*

Quality Assurance: Daily Imaging

- *Confirm that the balloon is inflated*
  - *Can be X-ray, ultrasound, CT (costly)*

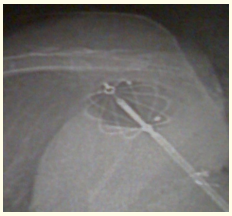




Savi daily QA

AP SAVI Scout

Lateral SAVI Scout



Identification of Skin Mark & Applicator Rotation

- *Evaluate balloon movement within cavity*
  - *Use vacuum lumen for more snug fit?*
  - *Increase inflation volume?*
  - *Document final fill volume*
- *Determine positioning of skin mark for QA*
  - *alignment point for longitudinal alignment marker (lumen #1)*
- *Use skin bb or pen mark*
- *Place tape over mark to secure*
- *Take baseline digital image for QA reference*

Conformance check:

Use of Vacuum Port

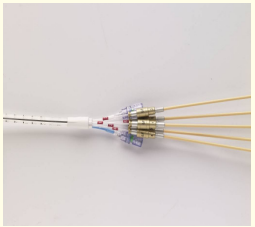
Savi Patient Setup

Alternate patient position for APBI

Patient Set-up Comfort™ Catheters

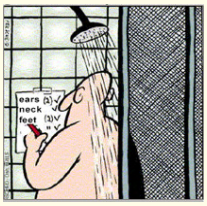
Quality Assurance: Transfer Tubes

- *Follow a protocol*
  - *Keep numbering the same as supplied by the vendor*
  - *Follow it in catheter reconstruction*
  - *Follow it in transfer tube connection*



Standardize

- Be sure to create your own institutional protocol for simulation
- Create and use a checklist for daily QA



Why Independent Plan Calculation Check?

- Prevention of catastrophic data input errors.
- Prevention of unexpected software errors
- Regulatory Compliance

  The NRC requires that brachytherapy calculations, either manually performed or computer or computer generated, must be checked.

Conclusion:

Systematizing quality assurance procedures

Each QA process should have its own checklist developed to both guide and document.

Everyone involved in HDR treatments should also be involved in QA.

NO PROCEDURE IS SO COMPLICATED THAT ITS CRITICAL COMPONENTS CANNOT BE EXPLAINED TO OTHERS.

Wake Forest University School of Medicine

Did I Do That?