The Consistency In Brachytherapy Treatments Of Endometrial And Vaginal Cancers And Consequences Of Lacking It

Silvia Pella¹²³, PhD, DABR
Mikko Hyvarinen⁴, MS, Nicolae Dumitru⁵, MS, Samantha Long¹, MS, Marjan Shojaei¹, Janeil Pinder¹,

¹. Florida Atlantic University, 2. 21st Century Radiation Oncology, 3 Advanced Radiation Therapy Inc., 4. University of Toronto, 5. University of Bucharest
Overview

- Gynecological (GYN) cancers
- Brachytherapy and applicators
- Treatment protocols
- Dose calculation in high dose rate (HDR) brachytherapy
- Planning for multi lumen (ML) cylinders in Oncentra
- Exporting the plan and delivering the treatment
- Composite results
- Conclusions and future plans
Gynecological cancers

GYN cancer

CDC\(^1\) estimates that each year 71,500 women in the US are diagnosed with gynecologic cancer and 26,500 women die from it.

Twice the number of women will be diagnosed with cervical (lower part of the uterus) than ovarian cancer.

Standard care

- Total abdominal hysterectomy with bilateral Salpino-oophorectomy (TAH-BSO) with or without lymph node dissection.
- Adjuvant external beam radiation therapy (EBRT) and/or brachytherapy\(^2\)

2. ABS consensus guidelines for adjuvant vaginal cuff brachytherapy after hysterectomy.
Selection of brachytherapy technique (intracavity vs interstitial) is based on the depth of vaginal invasion and the distribution of the disease

- Patients with superficial disease (< 5 mm) -> intracavity
- Patients with lesions invading a depth of > 5mm, interstitial techniques is recommended
- Combination EBRT and vaginal brachytherapy is recomended²
Brachytherapy and applicators

Applicators

Vaginal cylinder or ovoids: what area we treat

Many patients, postoperative vagina, roughly cylindrical

Cylinders

ABS recommends various lengths (2.0 - 4.0 cm diameters)

Only upper length of the vagina needs treatment

Initial cylinders had only 1 central catheters

Multichannel cylinder (3-4 cm) will reduce mucosal dose by having the sources deeper in the applicator and further away from the vaginal surface increasing the depth dose
Brachytherapy and applicators

Single channel cylinders

Miami applicator

Muppit applicator

Multi channel cylinder
Treatment protocols

- Dose specification depends on
  - The specification point
  - Length of the vagina treated
  - Had or not EBRT
- EBRT dose: 45 - 50.4 Gy to the whole pelvis
- Brachytherapy dose formulated to deliver 7 Gy x 3 to 5 mm which is equivalent to a low dose rate (LDR) of 60 Gy to the vaginal surface

- HDR

$$\text{BED} = N \cdot d \left(1 + \frac{d}{\alpha/\beta}\right)$$

- LDR

$$\text{BED} = N \cdot R \cdot t \left[1 + \frac{2R}{\mu \cdot (\alpha/\beta)} \cdot \left(1 - \frac{1 - e^{-\mu t}}{\mu t}\right)\right]$$
Treatment protocols

- Dose specification and timing
  - Recommended that the proximal 3-5 cm of the vagina to be treated
  - Grade 3 or patients with extensive Lymphovascular invasion can have the entire vagina
  - Optimization to deliver to the surface or 5 mm depth but reported both
  - No daily or weekly deliveries recommended as boost after EBRT only multiple fractions per week
  - Proper localization for scanning and treatment
Treatment protocols

Localization

To achieve a stable implant easy to reproduce and it will stay like that during planning and treatment.

CT scans are recommended and the critical structures (rectum, bladder and bowels) need to be contours although there is no consensus on the necessity of that.

Customized treatment plans for every fraction may not be necessary, it can be calculated for once and used for every fraction.

3. Holloway CL, Malkin EA, Cormack RA et al: Should the organs at risk be contoured in vaginal cuff brachytherapy 2011; 10-313-317
Dose calculations

- **Optimization**
- **Points or IPSA**

- Necessary to have optimization points at the apex and on the dome of the applicator in addition to the lateral vaginal mucosa.

- Source anisotropy can produce lower dose to the vaginal apex.

- Isotropic dose calculation model can result in 30% underdosage at the vaginal apex\(^4,^5\)

- Multichannel cylinders can be used to minimize the effect of anisotropy and to improve dosimetry\(^7,^8,^9\)

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5. Gore E, Gillin MT, Albano K et al, Comparison of high dose-rate and low dose-rate distributions for vaginal cylinders, Int J Radiat Oncol Biol Phys 1995
Planning for Multicatheter cylinder HDR

CT scan
- For each fraction, 1.25 mm slices, 140 kV to attenuate artifacts
- Catheters have markers inside identifying the first dwell position and the shape inside the cylinder
- Vaclock and underwear to fix the pelvis’ position and the applicator position respectively

Planning
- All organs reconstructed
- Cylinder used as CTV or PTV according to prescription
Patient selection

30 patients

- 15 with prescription to the applicator’s surface for 2/3 of the inserted cylinder measured from the tip. Rx: 5 x 5 Gy 2 times a week, post operative and post EBRT with 45 Gy.

- 10 with prescription to the surface for 40% of the applicator, Rx 3 x 6 Gy once a week, post operative and post EBRT with 45 Gy

- 5 with prescription to 5 mm from applicator’s surface for 40% of the applicator, Rx 3 x 7 Gy once a week post operative
Planning for Multicatheter cylinder HDR

PTV
- Generated from the cylinder if the prescription is to the surface
- Generated from the extension with 5 mm of the upper 40% of the cylinder. When extended critical organs are avoided and 1 mm is requested between the PTV and the organs at risk

Optimization dose using IPSA applying the dose constrains required by ABS for the tandem and ovoid (T&O) applicator
- Rectum and sigmoid point dose < 74%, $D_{2cc} < 70 - 75$ Gy EQD2
- Bladder point dose < 74% of prescribed dose, $D_{2cc} < 90$ Gy EQD2

Creating the data

- IPSA generated plans for each fraction
Creating the data

Image registration for all 5 CT scans - landmarks
Creating the data

- Re-contouring the structures for each of the 5 scans and sent them to the composite
Creating the data

- Sending all individual plans to Eclipse, register the image sets and create composites
Creating the data

Final dose analysis
Results and conclusions

PTV
- Our PTV is not the real one and should not be used for analysis
- The first 5 mm in the vicinity of PTV should analyzed
- The size varies from fraction to fraction experiencing a decrease in length as the treatment advances

Critical organs
- Their volume varies over the entire treatment depending on the patient’s alimentation and hydration
- Placement in reference to the PTV varies dramatically making some of the hot spots to increase over the entire duration of the treatment
Results and conclusions

- A CT scan for each treatment is necessary - no cylinder library
- Ideally a deformable registration should be applied for each fraction to make sure is conform to the first treatment
- Adaptive planning should follow to keep the same constrains but on the new surrounding environment.
- Immobilization devices should be looked at closely for a better fixation of the cylinder over the duration of the treatment
- Our work will continue with more data collection and a statistical analysis to increase awareness over consistency of treatments in GYN brachytherapy
Thank you

Questions?