Objectives

- Review and understand the advances and modernization of brachytherapy treatment in gynecologic cancers
- Review the indications for HDR brachytherapy in prostate cancers
- Understand the modality and indications of brachytherapy as a role in gynecologic and prostate cancer radiation therapy

Types of Radiation Therapy

- Linear Accelerator: External Beam Radiation Therapy
- Brachytherapy: Internal Radiation

What is Brachytherapy?

- Internal Radiation Therapy
- Radioactive source is placed inside or next to an area requiring treatment
- Giving a higher dose of radiation to a tumor while sparing or reducing radiation exposure to other organs

Historical Perspective

Low Dose Rate vs High Dose Rate

- **Seeds**
  - Dose given off from a decaying source placed inside a patient
  - Usually seeds left in patient to decay over time
  - Depending on source can take up to 6 months to deliver dose
  - Dose given off quickly from a temporary source
  - Applicator placed and source comes through an afterloader
  - Treatment takes minutes
  - No radiation left in patient

Dose Rates:

- HDR: 0.3-2 Gy/h
- 10 Gy/day
- HDT: >12 Gy/h
- 10 Gy/min
Indications for Brachytherapy in Cancer

- Cervical Cancer
  - Definitive
  - Standard of Care Chemotherapy-XRT
  - Adjuvant tx for early stage

- Endometrial Cancer
  - Adjuvant therapy after surgery to prevent recurrence at the vaginal cuff
  - Definitive early stage

- Vaginal Cancer
  - Concurrent chemo EBRT + brachy

- Prostate Cancer
  - Monotherapy
  - Boost Treatment for high risk

Gynecologic Cancers

Cervical Cancer

- 4th most common cancer in women worldwide
- Leading cause of cancer death in women in many countries

Cervical Cancer Treatment Overview

- Early stages (IA1-IB1): LEEP/CKC, Trachelectomy, Hysterectomy
- Advanced Stage (IB2-IVA): Chemotherapy and Radiation Therapy

3D Conformal Radiation Therapy


IMRT/VMAT for Cervical Cancer

Organ Motion during Treatment

Post-op GYN: IMRT vs 4 Field 3D
- Showed reduced gastrointestinal and genitourinary toxicity with IMRT compared with 4-field approach
- Must be careful because of variation in bladder and rectal position

External Beam is not Enough

Why does brachytherapy work?

Local Control Increase with Higher Doses

Brachytherapy Declining Utilization and Survival
Brachytherapy Applicators

Tandem and Ovoids/Ring

Insertion – Practice Patterns

- Most (97%) of respondents' patients receive anesthesia:
  - General (46%)
  - Spinal (27%)
  - Intravenous conscious sedation (28%)
  - and/or oral pain medication (14%)

Comfort is Important

- PTSD in 41% for brachytherapy
  - Pain
  - Organizational problems
  - Immobility
- Helpful Experiences
  - Treatment team
  - Psychological support
  - Positive attitude

Goals of the Implant

- Good internal geometry
- Proper position relative to the cervix (dose to target)
- Minimize dose to organs at risk (rectum, bladder, small intestines)
- Mechanical stability
- Minimization of discomfort
Implant Technique Impacts Control

<table>
<thead>
<tr>
<th></th>
<th>Acceptable</th>
<th>Unacceptable</th>
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<tbody>
<tr>
<td>Local Control (5yr)</td>
<td>68%</td>
<td>35%</td>
</tr>
<tr>
<td>Overall Survival (5 yr)</td>
<td>82%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Corn et al. Gyn Onc 1994

2D planning: Point A

3D Planning

CT vs MRI

Mayr et al 1997:
- 43 patients underwent MRI
- Correlation between Exam and MR is poor and decreases with increasing size

Integrating MRI
Integrating MRI

Staging
- accuracy up to 80%\textsuperscript{1}
- superior to CT and clinical examination for uterine body involvement and tumor size and evaluation of parametrial involvement\textsuperscript{2}

Clinical Utility
- incorporated to guide treatment decisions and design
- Assess recurrence due alterations physical exam due to radiation changes

3D to MRI planning

Volumetric Planning

MRI Guided Brachytherapy

Brachytherapy: MR guidance
- Prospective trial of 56 patients with Stage I-IVA cervical cancer
  - 27 patients CT guided and 29 patients MR guided
  - 2 year LC: 87% vs 96%
  - 2 year OS: 56% vs 84%
  - No difference in toxicity

MRI Based Brachytherapy
- 370 practitioners surveyed
  - 95% always use CT
  - 34% always use MRI

\textsuperscript{1} MRI and cone beam volumetric assessment compared to CT and MRI Imaging. Radiology. 1998 March;198(3):719-22
\textsuperscript{2} MRI and cone beam volumetric assessment compared to CT and MRI Imaging. Dept Radiology and Imaging Sciences, Indiana University School of Medicine, Indianapolis, IN 2001; 15(2): 13-19


\textsuperscript{4} Groen et al. Radiol Oncol 2013

Brachytherapy with and without Interstitial Needles

Survival is impacted by Advances in Brachytherapy

Interstitial Needles improves Tumor Coverage

Image Guided Brachytherapy
- Improves pelvic control and survival
- Local Control: 91%
- Pelvic Control: 87%
- Overall Survival: 74%

Image Guidance = More Interstitial Brachytherapy
**Interstitial Template**

- Needles inserted under laparoscopic guidance
- Will stay in place for 3 days (2 nights)
- 5 radiation treatments, at least 6 hours apart

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**Toxicity**

- 2D planning has increased dose to vagina, sigmoid, bladder, and rectum
- This matters because increasing dose to these organs has higher rates of rectal and vaginal toxicity

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**Brachytherapy: 2D vs 3D**

- Prospective clinical trial with 705 patients
  - Group 1: Brachytherapy (BT), surgery
  - Group 2: EBRT, BT, surgery
  - Group 3: EBRT, BT
- 3D less Grade 3-4 toxicity than 2D planning
  - (22.7% (2D) vs 2.6% (3D))
- Improved local relapse-free survival at 24 months compared to 2D imaging (78.5% vs. 73.9%)

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**Endometrial Cancer**

- Most common gynecologic cancer in US
- 4th most common malignancy in women

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**Endometrial Cancer Treatment Overview**

- Surgical Resection
- Adjuvant Treatment (Based on Risk of Recurrence/Node involvement)
  - Early Stage (Stage I, II)
  - Advanced Stage (Stage III, IV)
  - Chemo +/- pelvic RT, EBRT +/- Brachytherapy
  - Observe, Vaginal Brachytherapy +/- Pelvic RT +/- Chemo

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Whole Pelvis and Vaginal Brachy

- GOG 99 and PORTEC 1
- WPRT vs Observation
- RT in early stage intermediate risk endometrial cancer decreases the risk of recurrence in the High Intermediate Risk groups

- PORTEC 2
- WPRT vs Brachytherapy
- Brachytherapy should be the treatment of choice for patients with intermediate risk endometrial cancer

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<thead>
<tr>
<th>Stage</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
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<tbody>
<tr>
<td>IA non invasive</td>
<td>Obs</td>
<td>Obs or VB*</td>
<td>VB</td>
</tr>
<tr>
<td>IA invasive</td>
<td>Obs or VB*</td>
<td>VB</td>
<td>VB</td>
</tr>
<tr>
<td>IB</td>
<td>VB</td>
<td>VB</td>
<td>WPRT</td>
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</table>

*VB if MMI, LVSI, or >60

Endometrial Cancer

- Early Stage VBT

Vaginal Cuff Brachytherapy

Inoperable Endometrial Cancer

Radiation Therapy Side Effects

Schwarz 2015 Brachytherapy
Prostate Cancer

Risk Groups

- **Very Low Risk**
  - All the following: T1c, Gleason 6, PSA < 10, < 3 positive cores, <=50% in any 1 core, PSA density <= 0.15 ng/ml
- **Low Risk**: PSA <=10 ng/ml, Gleason <=6, T1c-T2a
- **Intermediate Risk**: PSA 10-20 ng/ml, Gleason 7, T2b-T2c
- **High Risk**: T3a or Gleason score 8-10 or PSA > 20
- **Very High Risk**: T3b -T4, Primary Gleason pattern 5 or > 4 cores with Gleason 8-10

Low Risk Prostate Cancer

- Active Surveillance**
- Radical Prostatectomy
- External Beam Radiation Therapy
- Stereotactic Body Radiation Therapy
- Brachytherapy

Intermediate Risk Prostate Cancer

- Radical Prostatectomy
- Brachytherapy
- EBRT +/- ADT
- EBRT + Brachytherapy
- SBRT

High Risk Prostate Cancer

- Radical Prostatectomy
- EBRT + ADT
- EBRT + ADT + Brachytherapy
- SBRT*

1920s and 1930’s Prostate Implants
Monotherapy Brachytherapy = Surgery

- Close to 80% of men 4-5 years after LDR prostate brachytherapy will achieve a PSA of <0.2
- PSA <0.2 is associated with 97-99% freedom from prostate cancer recurrence at 10-15 years

Prostate Brachytherapy

- Highly Effective Treatment for Prostate Cancer
  - Can be used as monotherapy for low or favorable intermediate risk prostate cancer
  - Boost for unfavorable intermediate or high risk prostate cancer
  - Salvage treatment for prior EBRT
- Concern around toxicity
  - How can we use modern imaging to reduce brachytherapy toxicity and still maintain high cure rates?

Who are Candidates for brachytherapy?

- Good KPS
- Urinary symptoms: favorable AUA
- Anatomy: Gland Size, ureteral position, bladder and rectum proximity
LDR vs HDR

Low Dose Rate

High Dose Rate

Brachytherapy Procedure

Implant

Implant
Planning

LDR vs HDR

Low Dose Rate

High Dose Rate

LDR brachytherapy

Imaging in Prostate Brachytherapy

Implant-Ultrasound based planning

Why is improvement of imaging important?

• Urinary Toxicity

Boyle-Fappiano et al 2020 Brachytherapy
MRI in Prostate Cancer

Boosting a Nodule

MRI based planning

Side Effects from Brachytherapy

Prostate Brachytherapy
- Can be utilized as monotherapy
- Can be utilized as a boost for higher risk
- Integrating more imaging modalities such as MRI helps to dose escalate

Conclusions
- Gynecologic malignancies such as cervical cancer increase control and survival with improved imaging techniques
- Using imaging techniques helps to guide brachytherapy placement and accuracy of treatment
OHSU Brachytherapy Program

- Started August 2020
- Hybrid and Interstitial Brachytherapy Program started Nov 2020
- Prostate HDR Brachytherapy: Starting May 2021
- Marquam Hill: Kohler Pavilion

Thank you

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Questions?